Clinical Results of Combined Meniscus and Femoral Osteochondral Allograft Transplantation: Minimum 2-Year Follow-up

Geoffrey D. Abrams, M.D., Kristen E. Hussey, B.S., Joshua D. Harris, M.D., and Brian J. Cole, M.D., M.B.A.

Purpose: To determine clinical results after combined femoral osteochondral allograft and meniscus transplantation. **Methods:** Thirty-two patients with a minimum 2-year follow-up were identified who had previously undergone combined meniscus allograft transplantation and fresh osteochondral allograft transplantation. Demographic and intraoperative data, including condylar defect size, as well as the preoperative and postoperative International Knee Documentation Committee (IKDC) score, Short Form 12 score, Knee Injury and Osteoarthritis Outcome Score (KOOS), and Lysholm score, were recorded. Paired tests and regression analysis were used, and an α value of .05 was set as significant with Bonferroni correction used in the case of multiple comparisons. **Results:** The mean follow-up period was 4.2 years (range, 2 to 11 years). The mean condylar defect size was 4.7 ± 2.0 cm^2 at the time of the index procedure. Lysholm scores, IKDC scores, and all KOOS subdomains showed significant improvement from preoperatively to postoperatively ($P < .001$). Patients with condylar defects of less than 4 cm^2 had a significantly greater increase in the preoperative versus postoperative IKDC score ($P = .010$), Lysholm score ($P = .018$), and KOOS ($P = .016$) than those with condylar defects greater than 4 cm^2. Femoral condyle defect size was also significantly inversely correlated with the postoperative IKDC score ($P = .015$), KOOS ($P = .003$), and Lysholm score ($P = .010$). The rate of patient satisfaction with the procedure was 82%. **Conclusions:** Patients undergoing combined meniscus allograft and femoral osteochondral allograft transplantation showed improved functional scores after surgery. The postoperative scores, however, indicated residual knee dysfunction, and the reoperation rate was high. There was an inverse association between postoperative functional scores and the size of the condylar defect. **Level of Evidence:** Level IV, therapeutic case series.

The long-term detrimental effects after a significant meniscectomy in the knee are well known.[1] This has led clinicians to preserve meniscus tissue when possible. In young and active patients, knee pain with meniscus deficiency can be a challenging problem, particularly when concomitant cartilage damage exists, often developing after the index meniscectomy. Meniscus allograft transplantation (MAT) has emerged as a treatment option in this patient population, with good clinical outcomes reported.[2-5] Although human investigations have not shown MAT to be chondroprotective, the procedure has been shown to decrease cartilage degeneration in an animal model.[6] MAT has also been shown to reduce contact pressures in cadaveric knees compared with the meniscus-deficient state.[7]

In the past, significant concomitant articular cartilage damage in the same knee compartment was a contraindication to MAT because clinical results showed inferior outcomes in this subpopulation.[8,9] Typically, surgical treatment for focal articular defects measuring no more than 1 to 2 cm^2 is amenable to microfracture, but unfortunately, this technique does not restore native hyaline cartilage.[10] Another option for smaller-sized defects is osteochondral autograft used as a

From the Department of Orthopedic Surgery, Rush University Medical Center, Chicago, Illinois, U.S.A.

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Address correspondence to Geoffrey D. Abrams, M.D., 1611 W Harrison St, Ste 300, Chicago, IL 60612, U.S.A. E-mail: gabrams@gmail.com

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single plug or in a mosaicplasty pattern.[11] For larger defects, autologous chondrocyte implantation (ACI) or osteochondral allografts (OCAs) may be used.[12,13]

With the development and refinement of these articular cartilage restoration techniques, full-thickness cartilage damage is no longer an absolute contraindication to MAT. Investigations have previously reported results for MAT with combined microfracture,[14] ACI,[14-18] or OCA.[14,19] A smaller series of combined MAT and OCA outcomes has also been previously published, with good clinical outcomes reported.[18] Another investigation reported on clinical results for 7 patients after combined MAT, OCA, and osteotomy procedures.[14]

The purpose of this investigation was to determine clinical results after combined femoral OCA and meniscus transplantation at a minimum of 2 years' follow-up. We hypothesized that pain and functional scores would significantly improve after the procedure.

Methods

All patients provided informed consent, and the study was approved by the hospital's institutional review board. The inclusion criteria were persistent symptoms after meniscectomy, an isolated International Cartilage Repair Society grade 3 or 4 defect of the femoral condyle, normal alignment or correction to normal alignment, ligamentous stability, and minimum 2-year clinical follow-up. The exclusion criteria included a lack of any of the previously mentioned factors, treatment for concomitant patellofemoral cartilage defects, and a tibial plateau lesion of International Cartilage Repair Society grade 2 or greater in the involved compartment.

All surgeries were performed by the senior author (B.J.C.), with clinical evaluations performed by an unblinded observer preoperatively and postoperatively. When possible, these evaluations were performed at the patients' regular follow-up visit, but some data were collected by mail and telephone. In the case of telephone or mail follow-up, all subjective data were collected for each scoring tool, as were any potential complications and/or reoperations performed at outside institutions. Outcomes tools included the subjective International Knee Documentation Committee (IKDC) score,[20] Short Form 12 (SF-12) score,[21] Knee Injury and Osteoarthritis Outcome Score (KOOS),[22] and Lysholm scoring system.[23] Failure was defined by patients' symptoms of such a degree that they chose to undergo additional arthroscopic surgery. Standard procedure by the senior author is to allow 12 to 18 months of recovery after this procedure. If the patient is still symptomatic at that time, diagnostic arthroscopy with interventions as needed may be offered. All final functional assessment scores were collected after any revision surgery that may have been performed.

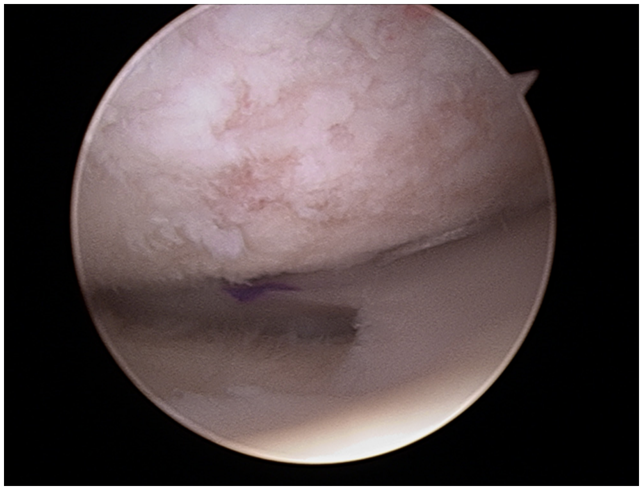

Fig 1. Arthroscopic image of the medial compartment of a right knee showing a newly transplanted allograft meniscus, along with grade 3 to 4 cartilage damage to the femoral condyle, before OCA.

Surgical Procedure

Meniscal transplantation was performed differently depending on the year in which the procedure was performed. Before 2005, MAT in the medial compartment was performed by the double-bone plug technique[24] whereas transplantations in the lateral compartment used the keyhole technique (Fig 1).[25] From 2005 to present, both medial MAT and lateral MAT were performed by the bridge-in-slot technique.[26] OCA transplantation was performed through a mini-arthrotomy by use of previously published techniques.[27] In general, once the mini-arthrotomy had been created, a cylindrical sizing tool was used to gauge the size of the graft needed. A guide pin was placed in the center of the defect, and a reamer was used over the guide pin to remove the damaged tissue. The graft was then prepared on the back table such that it matched the diameter and depth of the prepared recipient site (Fig 2). Every effort was made to obtain

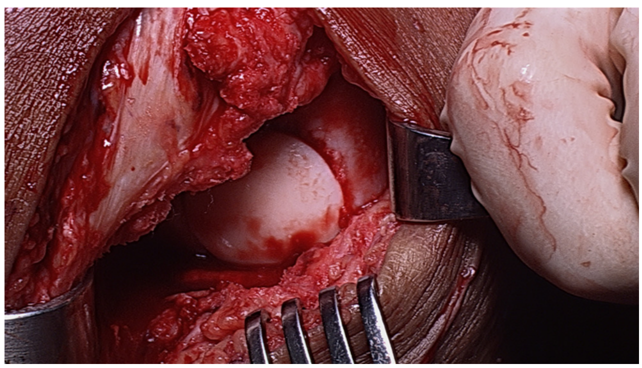

Fig 2. Intraoperative view of the same knee in Fig 1 showing a mini—medial parapatellar arthrotomy with implantation of an OCA in the medial femoral condyle.

the ipsilateral condyle as well as an appropriately sized graft from the tissue bank. Graft tissue implanted before 2004 was typically cryopreserved, whereas grafts placed after this time were fresh frozen for menisci and fresh in the case of osteoarticular allografts (AlloSource, Centennial, CO).

Postoperatively, all patients were placed in a hinged knee immobilizer that was locked in full extension. Heel-touch weight bearing was instituted for 6 weeks. During this time, a continuous passive motion machine was used for 6 to 8 hours per day with initial range of motion from 0° to 40° of flexion, increasing 5° to 10° per day up to a maximum of 90° of flexion. The hinged knee brace was gradually opened at 4 to 6 weeks to allow for increasing flexion as quadriceps function returned. Full range of motion was expected by 8 to 12 weeks and return to unrestricted activities by 9 to 12 months postoperatively.

Statistical Analysis

A Shapiro-Wilk test indicated our data were normally distributed. Paired *t* tests were used to compare baseline and follow-up clinical and functional assessment scores (SPSS software, version 18; IBM, Armonk, NY). The associations between gender, age, medial/lateral procedures, and condylar defect size with functional scores were determined with regression analysis. An α value of .05 was set as statistically significant with Bonferroni correction used when performing multiple comparisons.

Results

Between 2003 and 2009, 32 patients (mean age, 35.0 ± 10.0 years; 17 men and 15 women) underwent combined OCA and MAT and met the inclusion criteria, including a minimum follow-up period of 2 years. The mean follow-up period was 4.4 years (range, 2 to 11 years). There were 7 lateral compartment procedures (22%), 24 medial compartment procedures (75%), and 1 combined lateral and medial OCA with lateral MAT. The mean condylar defect size was 4.7 ± 2.0 cm^2, and patients underwent a mean of 2.2 surgical procedures (range, 1 to 5) before their allograft procedure (Tables 1 and 2 and Appendix Table 1, available at www.arthroscopyjournal.org). There were no intraoperative or postoperative complications in any patient.

For all patients, both the mean Lysholm score (41.9 ± 16.1 preoperatively *v* 63.6 ± 24.1 postoperatively, $P < .001$) and mean IKDC score (32.9 ± 11.4 preoperatively *v* 55.3 ± 23.6 postoperatively, $P < .001$) significantly increased from baseline. The overall KOOS significantly increased from 42.5 ± 11.7 to 62.7 ± 21.0 ($P < .001$) (Fig 3), with significant differences also being seen in each of the KOOS subdomains (Fig 4). By use of the paired *t* test, there was also a significant difference in overall SF-12 scores (43.5 ± 5.6 preoperatively *v* 46.6 ± 5.9 postoperatively, $P = .041$); however, mixed findings were seen in the SF-12 physical subdomain ($P = .017$) and SF-12 mental subdomain ($P = .466$) (Fig 3).

Patients with condylar defects of less than 4 cm^2 had a significantly greater increase in the preoperative versus postoperative IKDC score ($P = .010$), Lysholm score ($P = .018$), and KOOS ($P = .016$) versus those with condylar defects greater than 4 cm^2. Femoral condyle defect size was also significantly inversely correlated with the postoperative IKDC score ($P = .015$), KOOS ($P = .003$), and Lysholm score ($P = .010$). There was no association between condylar defect size and the preoperative IKDC score ($P = .757$), preoperative overall KOOS ($P = .920$), or preoperative Lysholm score ($P = .833$). Neither age, gender, nor medial versus lateral compartment was significantly associated with the postoperative Lysholm score, KOOS, or IKDC score. The mean patient satisfaction rating was 6.9 ± 2.8 (on a scale from 1 to 10, with 10 representing complete satisfaction). Of the 28 patients who responded to the question, 23 (82%) stated that they were satisfied with the outcome and would undergo the procedure again.

Eight patients (25%) underwent subsequent surgical procedures for continued knee pain after their index procedure (Table 1 and Appendix Table 1, available at www.arthroscopyjournal.org). No patient required additional MAT or OCA procedures for tearing or failure of incorporation. The operations performed after the index procedure were almost exclusively for chondroplasty

Table 1. Demographic and Surgical Data for Patients at Time of Combined OCA and MAT

Factor	Data
Age (yr)	35.0 ± 10.0
Gender	15 women and 17 men
Compartment	24 medial, 7 lateral, and 1 combined
Mean cartilage defect size (cm^2)	4.7 ± 2.0
Reoperations	8 (25%)
Meniscus transplant debridement	7
Chondroplasty	6
Loose body removal	2
Lateral release	1
Synovectomy	1

Table 2. Number and Type of Previous Procedure Before Combined OCA and MAT (Excluding Prior Meniscectomy With or Without Chondroplasty)

	No. of Patients
ACL reconstruction	9
Microfracture	5
Meniscus repair	3
High tibial osteotomy	3
ACI	1 (same compartment)
Loose body removal	1
Hardware removal	1

ACL, anterior cruciate ligament.

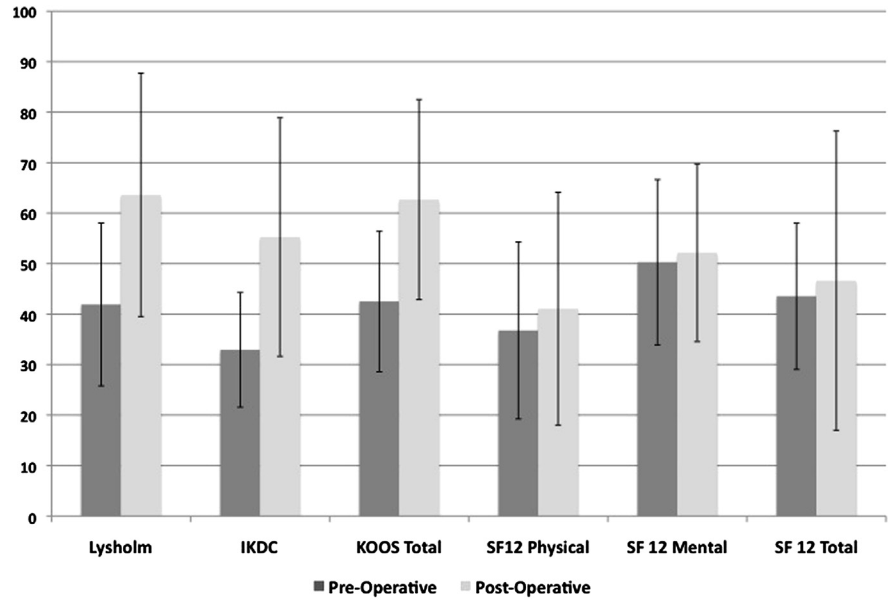

Fig 3. Mean preoperative and postoperative Lysholm, IKDC, KOOS, and SF-12 functional scores for all 32 patients undergoing combined MAT and OCA.

and/or meniscus debridement (Table 1 and Appendix Table 1, available at www.arthroscopyjournal.org). Of the 8 patients who underwent repeat arthroscopy, 6 (75%) had initial condylar defects greater than 4 cm^2. There was no association between revision surgery and the number of previous procedures before the index operation.

Discussion

This study reports on the results of patients undergoing combined meniscus transplant and OCA transplant. We found that functional scores improved from preoperatively through a mean follow-up period of 4 years. In addition, a smaller chondral cartilage defect size was correlated with increased postoperative functional scores, as well as a larger improvement from preoperative to postoperative scores. Most of the patients were satisfied with their results and would undergo the same procedure again.

Articular cartilage damage to the femoral condyles is common in the post-meniscectomy state.[28] This is because of the altered load-bearing characteristics on the cartilage surface, which increases contact loading on the chondrocytes.[29] The recognition of this relation has

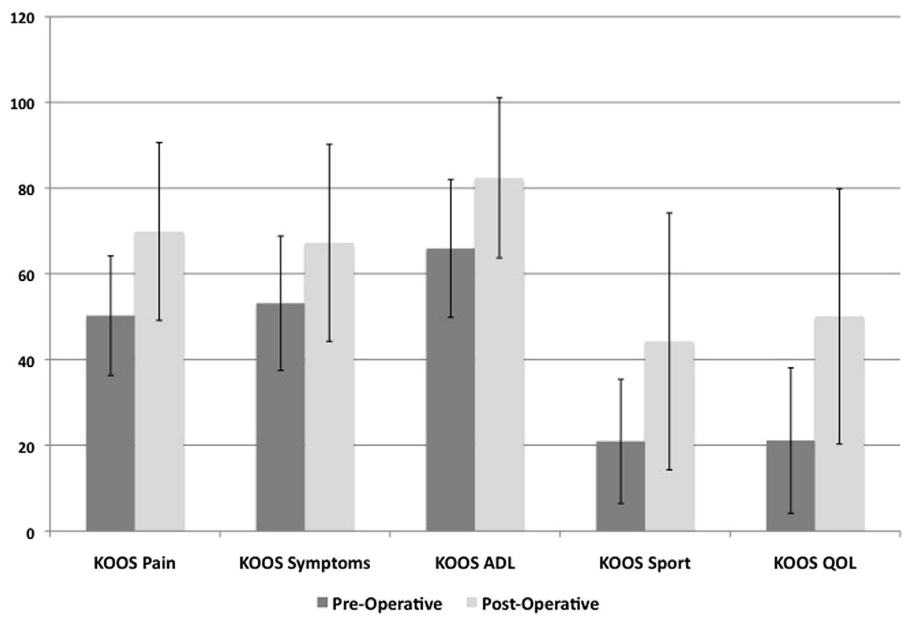

Fig 4. Mean preoperative and postoperative KOOS subdomain scores for all 32 patients undergoing combined MAT and OCA. (ADL, activities of daily living; QOL, quality of life.)

led to an increased focus and emphasis on meniscus preservation, particularly in the young patient. In some instances, however, meniscus repair cannot be performed because of the tear pattern, and meniscectomy must be carried out. In patients who undergo meniscectomy and continue to have concordant knee pain, MAT is a treatment option.[2] Initially, MAT was contraindicated in the setting of significant articular cartilage damage because of the predictable progression of the cartilage irregularity, leading to poor clinical results.[30] However, studies began to emerge on combined procedures to also address previous contraindications to MAT such as ligamentous instability,[31,32] malalignment,[14,33] and articular cartilage defects.[14-19]

OCA transplantation for larger, isolated cartilage defects in the knee for which nonoperative or other surgical treatments have failed remains a valid option. Williams et al.[34] reported outcomes at a mean of 4 years' follow-up for 19 patients who underwent fresh-frozen OCA transplantation for symptomatic cartilage defects in the knee. They found that functional outcome scores significantly improved and that normal articular cartilage thickness was maintained in 18 of the implanted grafts, as measured on postoperative magnetic resonance imaging. Another recent investigation examined the results of OCA transplantation in a young, active military population.[12] In this population, 42% of patients were unable to return to active military duty because of their knee and only 5% were able to return to their prior level of sports participation after a mean of 4 years postoperatively.

We found significant improvement in the Lysholm score, IKDC score, and KOOS from preoperatively to postoperatively. These differences were clinically significant. The minimum clinically important difference for the IKDC score is 6.3 at 6 months and 16.7 at 12 months, which our difference surpassed, thus being indicative of a clinically relevant change.[35] The minimum detectable change for the KOOS subscores is 6 to 6.1 (pain), 5 to 8.5 (symptoms), 7 to 8 (activities of daily living), 5.8 to 12 (sports and recreation), and 7 to 7.2 (quality of life), whereas the minimum detectable change for the overall Lysholm score is 8.9 to 10.1.[36] The differences reported in function for this investigation indicate change that is detectable to the patient. Although there was no difference in the SF-12 mental score, the SF-12 physical subdomain did show a significant change.

Our findings are consistent with the other 2 published investigations that have specifically examined clinical results after combined OCA and MAT.[14,18] Rue et al.[18] reported 2-year results on a cohort of patients undergoing either combined MAT and ACI or combined MAT and OCA from our institution. In the latter group, which consisted of 14 patients, they reported significantly improved functional scores in terms of the Lysholm score, IKDC score, and KOOS, with the SF-12 score showing no significant change from preoperatively to postoperatively. We also found significant improvements in the Lysholm, IKDC, and KOOS functional outcome scores, with similar postoperative values for these 3 measures to those of Rue et al. Similarly, we also found no difference in outcomes between patients undergoing medial procedures and those undergoing lateral procedures. Interestingly, we did find significant differences in the preoperative and postoperative overall SF-12 score, as well as the SF-12 physical subdomain. This was not the case in the investigation of Rue et al., which did not find differences in these measures. Because there was no difference in the patient age between our study and that of Rue et al. (37.0 years *v* 36.8 years), this finding may be related to the slightly smaller condylar defect size in our study (4.6 cm^2 *v* 5.5 cm^2) or the lack of sensitivity of the SF-12 for detecting outcomes in combined OCA-MAT patients. Gomoll et al.[14] reported on 7 patients also from our institution with a combination of MAT, a cartilage procedure, and osteotomy, with 5 of these patients undergoing OCA/MAT as well as osteotomy. There were significant improvements in the Lysholm score, IKDC score, and KOOS as compared with before the procedure at a mean follow-up of 24 months.

Although this investigation did report significantly improved functional outcomes after surgery, it should be noted that functional scores at final follow-up were typically significantly below those reported in the literature. For example, our postoperative IKDC score was 55.2 versus 74.1 for patients undergoing treatment for focal articular cartilage defects.[35] After isolated MAT and MAT combined with an additional procedure (but not OCA transplantation), Yoon et al.[37] reported mean Lysholm scores of 80.5 and 74.2, respectively, and mean IKDC scores of 69.8 and 66.3, respectively. In contrast, the mean postoperative Lysholm score in this investigation was 63.6. The lower scores in our cohort reflect the fact that the procedure is a salvage procedure. These patients have typically undergone numerous procedures before the combined MAT and OCA transplant and have significant knee pathology and lifestyle limitations. The goal of this procedure is not to return patients to high-level athletic activity but, rather, to improve their pain with activities of daily living. The lower function scores are a reflection of this.

A secondary goal was to determine the association between functional outcome scores and cartilage defect size. We found that an increased defect size was negatively correlated with postoperative outcomes. This has not previously been reported for patients undergoing combined MAT and cartilage procedures. In a study of 454 patients undergoing microfracture for symptomatic condylar defects in the knee, however, Salzmann et al.[38] reported that the condylar defect size was larger in those patients with clinical failure during the follow-up period. In contrast, Peterson et al.[39] studied 224 patients at a mean of 10 years after ACI for knee cartilage defects; they found that the size of the lesion did not correlate with Lysholm, Tegner-Wallgren, Brittberg-Peterson, Noyes, or KOOS functional outcome scores. The latter finding is also consistent with a recent systematic review that specifically investigated all patient-, knee-, and defect-specific variables with regard to ACI clinical outcomes. One reason for these differences may be related to the involvement of the subchondral bone. Proper execution of ACI requires maintenance of the calcified cartilage layer and intact subchondral bone. Microfracture and OCA transplantation, however, violate both of these layers and may lead to increased stimulation of nociceptors in larger lesions.

The lack of consistency in the correlation between condylar defect size and clinical outcome after cartilage restoration procedures may be related to the variability in procedures and techniques included in these investigations. For example, treatment of lesions in the patellofemoral joint have demonstrated lower functional outcome scores as compared to treatment of lesions on the femoral condyles.[40] Many of the investigations have included patients with defects throughout the knee, in addition to patients who have undergone concomitant procedures such as ligament reconstruction and/or osteotomies. In addition, larger high-grade defects tend to be associated with more overall degeneration in the knee. Despite having a macroscopically intact articular surface either surrounding or opposing the defect, the overall compromised physiology of the joint makes it more challenging to reliably reduce symptoms and improve function. Nonetheless, this patient group remained generally satisfied with their outcomes.

Limitations

There are several limitations to this investigation. First, there is no control or comparative group with which we can compare our results, and therefore we cannot detect the benefit that may have been gained through further nonoperative measures such as rehabilitation, anti-inflammatory medications, and/or injections. However, these measures were considered to have failed in all of the patients, and because of this, the patients desired to proceed with biologic restoration. Furthermore, a small percentage of our cohort underwent concomitant procedures in addition to the OCA/MAT procedures. This heterogeneity makes it difficult to reliably separate the treatment effects of cartilage restoration versus concomitant procedures. We continue to believe, however, that correction of alignment is especially critical to improve patient outcomes in the setting of biologic restoration. In addition, the group of patients included in this investigation were nonconsecutive in nature and represent only a portion of the total OCA/MAT procedures performed during the study period. This may have caused selection bias because patients with poorer outcomes after surgery may have preferentially elected not to undergo requested follow-up or sought care from another physician. In addition, the technique for MAT changed during the course of the study based on the practice pattern of the senior author, and this may have led to a slight confounding effect among patients. Lastly, we did not perform an a priori power analysis because our goal was to include the maximum number of patients at our institution who underwent combined MAT and OCA. Given that we had statically significant improvement in nearly all of the outcome measures, the chance of an isolated type I error is small.

Conclusions

Patients undergoing combined MAT and femoral OCA showed improved functional scores after surgery. The postoperative scores, however, indicated residual knee dysfunction, and the reoperation rate was high. There was an inverse association between postoperative functional scores and the size of the condylar defect.

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Appendix Table 1. Detailed Demographic and Surgical Data for Patients at Time of Combined OCA and MAT

	Age (yr)	Gender	Compartment	Defect (cm^2)	Subsequent Procedure
Patient 1	18	F	Medial/lateral	2.75	—
Patient 2	46	F	Medial	2.25	—
Patient 3	48	F	Medial	6.25	Chondroplasty of medial femoral condyle, patella, and trochlea
Patient 4	40	F	Medial	1.0	—
Patient 5	19	F	Lateral	3.3	—
Patient 6	44	M	Medial	3.24	—
Patient 7	42	F	Medial	4.0	—
Patient 8	37	M	Medial	6.25	—
Patient 9	44	F	Medial	7.2	—
Patient 10	41	F	Medial	6.25	Medial meniscectomy and chondral debridement
Patient 11	39	M	Lateral	3.24	Debridement of meniscus transplant and OCA
Patient 12	43	F	Medial	1.6	—
Patient 13	47	M	Lateral	6.25	—
Patient 14	26	M	Medial	6.25	Debridement of meniscus transplant and OCA
Patient 15	33	M	Medial	4.8	Debridement of meniscus transplant and OCA, synovectomy, and lateral release
Patient 16	41	F	Medial	4.0	—
Patient 17	27	F	Lateral	4.0	—
Patient 18	33	M	Lateral	6.25	—
Patient 19	23	F	Medial	4.0	—
Patient 20	18	F	Lateral	2.25	—
Patient 21	40	M	Medial	4.0	Debridement of meniscus transplant and loose body removal
Patient 22	45	M	Medial	9.5	—
Patient 23	43	M	Medial	2.25	—
Patient 24	20	M	Medial	6.25	Debridement of meniscus transplant and OCA and loose body removal
Patient 25	33	F	Medial	6.25	—
Patient 26	21	F	Lateral	3.24	Lateral meniscectomy
Patient 27	18	M	Medial	4.84	—
Patient 28	36	M	Medial	4.0	—
Patient 29	40	M	Medial	4.0	—
Patient 30	25	M	Medial	7.5	—
Patient 31	47	M	Medial	5.6	—
Patient 32	32	M	Medial	8.0	—

F, female; M, male.