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Minimum 2-Year Follow-Up

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Background: Recognition of the symbiotic relationship between the meniscus and articular cartilage is critical to the success of meniscal allograft transplantation. Simultaneous combined meniscal allograft transplantation and cartilage restoration procedures have been proposed for patients with a symptomatic postmeniscectomy knee with a focal chondral defect that would have traditionally been considered a contraindication to meniscal allograft transplantation.

Hypothesis: Combined meniscal allograft transplantation and cartilage restoration procedures can be used to neutralize traditional contraindications to meniscal allograft transplantation with results comparable to either procedure performed in isolation.

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

Methods: Thirty patients underwent 31 combined meniscal allograft transplantation and cartilage restoration procedures between 1997 and 2004. These patients were prospectively studied, and completed standardized outcome surveys (including Lysholm, International Knee Documentation Committee, and Short Form–12 scales) preoperatively and annually thereafter for a minimum of 2-year follow-up. Patients were grouped according to concomitant procedure: 16 (52%) underwent meniscal allograft transplantation combined with autologous chondrocyte implantation; 15 (48%) had meniscal allograft transplantation combined with an osteochondral allograft. Two patients were lost to follow-up, leaving 29 procedures for review.

Results: As a combined group, statistically significant improvements were observed in all standardized outcomes scores and satisfaction scales, except Short Form–12 mental, at a mean 3.1-year follow-up. Excluding the 2 lost to follow-up, 76% of all study participants (80% autologous chondrocyte implantation; 71% osteochondral allograft) reported that they were completely (31%) or mostly (45%) satisfied with their results. Overall, 48% of patients (60% autologous chondrocyte implantation; 36% osteochondral allograft) were classified as normal or nearly normal at their most recent follow-up using the International Knee Documentation Committee examination score. Ninety percent of patients would have the surgery again.

Conclusion: Combined meniscal allograft transplantation and cartilage restoration offers a safe alternative for patients with persistent symptoms after meniscectomy and focal cartilage injury. Results of combined procedures were comparable to published reports of these procedures performed in isolation. Long-term follow-up is needed to define the survivorship of these procedures in a young patient population.

Keywords: meniscus; meniscal allograft transplantation (MAT); osteochondral allograft (OA); autologous chondrocyte implantation (ACI); cartilage

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The consequences of meniscectomy are well documented in the literature with predictable cartilage degeneration over time,[9,39] sometimes rapidly.[4] Even partial meniscectomy can result in significantly increased tibiofemoral contact pressures.[19] Traditional indications for meniscal allograft transplantation (MAT) have been a symptomatic post-meniscectomy knee to alleviate symptoms and possibly prevent articular cartilage degeneration.[3,30,31,34]

Classic contraindications to MAT have been articular cartilage damage greater than Outerbridge grade II, axial malalignment, and ligament instability.[26,33] Recognition of the symbiotic relationship of the meniscus and the articular cartilage has been pivotal to the evolution of MAT, and the natural progression has been to broaden the indications to include situations that would have traditionally been contraindicated.

Farr et al[11] reported a series of 36 patients with combined MAT and autologous chondrocyte implantation (ACI) and showed statistically significant improvement in standardized outcome surveys and visual analog pain and satisfaction scores, with only 4 failures requiring revision surgery before their 2-year follow-up. They concluded that concomitant MAT and ACI resulted in improvement in symptoms and knee function but less so than previously reported outcomes for either MAT or ACI performed separately. Gersoff[13] published his non–peer-reviewed results in 2002, reporting improvement in Cincinnati knee scores without statistical analysis. Cole et al[8] published a series of MAT that included a single case with combined ACI, and Gillogly[14] discussed the need for additional procedures such as MAT being performed concomitantly, recommending that only 1 additional procedure be performed at the same time to minimize additional potential complications.

The purpose of this study is to report the early-term results after combined MAT and cartilage repair from a single institution performed by a single surgeon.

MATERIALS AND METHODS

Thirty consecutive patients (18 male, 12 female) with a mean age of 29.9 years (range, 13.9-47.9 years) underwent 31 simultaneous combined (MAT) and cartilage repair procedures, including ACI or fresh osteochondral allograft (OA) transplantation, in the same compartment, between 1997 and 2004. Patients were grouped according to their concomitant procedure; 16 (52%) underwent MAT combined with ACI and 15 (48%) MAT combined with OA. Of the procedures, 20 (65%) involved the medial compartment and 11 (35%) the lateral compartment (Table 1).

The mean size of all chondral lesions was 4.68 cm^2 (range, 1.80-9.50 cm^2). Chondral lesions averaged 3.93 cm^2 (range, 1.80-7.50 cm^2) for ACI and 5.48 cm^2 (range, 2.25-9.50 cm^2) for OA.

One female patient underwent bilateral combined procedures 2 years apart. Three OA patients underwent concomitant procedures (2 hardware removal from previous osteotomies and 1 proximal tibial osteotomy). Four of the 30 patients (13%) were workers' compensation cases. All 4 of these were in the OA group and underwent medial MAT combined with OA of the medial femoral condyle. Two patients were lost to follow-up, leaving 28 patients (29 procedures) for review.

Patient Evaluation

Patients were evaluated prospectively and followed after combined MAT and cartilage repair procedures (fresh OA or ACI) for continued symptoms after meniscectomy. All patients underwent an informed consent process that had been approved by the institutional review board and the human subjects committee of our hospital. Inclusion criteria were persistent symptoms after meniscectomy with combined articular cartilage injury, normal alignment or correction to normal alignment, and a stable ligamentous knee examination. Typical documented symptoms included activity-related swelling, crepitus, and joint-line pain.

Surgical Planning, Technique, and Rehabilitation

Before July 2005, all menisci in the medial compartment were transplanted using a double bone plug technique (n = 14) as described by Shelton and Dukes,[36] and all menisci in the lateral compartment were transplanted using the key-hole technique (n = 4) as described by Goble et al.[15] After July 2005, all MAT were performed using a bridge-in-slot technique (n = 13; 7 lateral and 6 medial).[10,27] The majority of the menisci were cryopreserved, with those placed after 2004 being fresh-frozen. Autologous chondrocyte transplantation was performed as described by Jones and Peterson.[17] Osteochondral allograft transplantation was performed according to established protocols.[12,20] The decision to proceed with ACI or OA was made by the senior surgeon based on patient age and the location, size, and depth of the lesion. A complete discussion of the complex treatment algorithm used has been previously published.[1,2] In general, ACI was chosen for relatively younger patients with superficial defects especially of the patellofemoral joint. Alternatively, fresh OA grafts were chosen for older patients with larger defects of the femoral condyle with associated bone loss.

Postoperatively, patients were placed in a hinged knee brace locked in full extension. Our rehabilitation protocol consisted of 6 weeks of nonweightbearing exercises, with the use of a continuous passive motion machine (0°-40°, increasing 5-10 deg/d to a maximum of 90°) in 2-hour increments for 6 to 8 hours per day. The brace was gradually opened at 4 to 6 weeks to allow progressive flexion as quadriceps control returned. The goal was for full range of motion by 8 to 12 weeks and release to all activities by 9 to 12 months.

Outcomes Assessment

Only patients with a minimum follow-up of 24 months were included for analysis. A single orthopaedic surgeon performed all surgeries and conducted the baseline and follow-up physical examinations. Questionnaires were administered preoperatively, 6 months postoperatively, 1 year postoperatively, and then annually using the International Knee Documentation Committee (IKDC), Noyes symptom

TABLE 1
Subject Demographics[a]

	Overall	ACI	OA
Procedures	31	16	15
Age, y	29.9 (13.9-47.9)	23.4 (13.9-38.6)	36.8 (19.6-47.9)
Gender, male/female	18/13	5/11	13/2
Cartilage defect size, cm^2	4.7 (1.8-9.5)	3.9 (1.8-7.5)	5.5 (2.3-9.5)
Location, medial/lateral	20/11	7/9	13/2
Follow-up, y	3.1 (1.9-5.6)	3.4 (1.9-5.6)	2.9 (1.9-5.0)
Workers' compensation	4	0	4
Previous procedures	Prior meniscectomy	1 OATS; 1 microfracture; 1 hardware removal; 3 ACL reconstructions	3 ACL reconstructions; 2 high tibial osteotomies
Concurrent procedures		None	1 high tibial osteotomy; 2 hardware removals

[a]Numbers in parentheses represent ranges. ACI, autologous chondrocyte implantation; OA, osteochondral allograft; OATS, osteochondral autograft transfer system.

rating and sports activity, Short Form–12 (SF-12), Knee Injury and Osteoarthritis Outcome Score (KOOS), Lysholm, and Tegner scoring systems. The criteria for failure were revision of either the MAT or cartilage repair procedure or arthroscopic confirmation of MAT or cartilage repair failure.

Physical examination consisted of assessment of range of motion, ligament stability, and amount of effusion. These results were noted preoperatively and at each follow-up in the physical examination component of the IKDC. Patients were also asked to use a visual analog scale scoring system for (1) their level of pain (0, no pain; 10, worst pain imaginable), (2) overall condition of the knee (0, cannot perform activities of daily living [ADLs]; 10, normal), and (3) satisfaction with the surgical outcome (0, completely satisfied; 10, completely unsatisfied). Statistical analysis was performed using SPSS for Windows, version 11.5 (SPSS Inc, Chicago, Ill). The Wilcoxon signed rank test was used to compare baseline and the most recent follow-up scores. The Mann-Whitney test was used to compare scores between subgroups. Statistical significance was set at $P < .05$.

RESULTS

As a combined group, statistically significant improvements were observed in all standardized outcomes scores and visual analog pain and satisfaction scales, except SF-12 mental, at a mean of 3.1-year follow-up (range, 1.9-5.6 years; SD, 1.2) (Table 2 and Figure 1). Excluding the 2 patients lost to follow-up (1 OA and 1 ACI), 22 of 29 (76%) study participants (12/15 [80%] ACI and 10/14 [71%] OA) reported that they were completely (31%) or mostly (45%) satisfied with their results. Overall, 14 of 29 (48%) patients (9/15 [60%] ACI and 5/14 [36%] OA) were classified as normal or nearly normal at their most recent follow-up using the IKDC knee examination score. Excluding the 2 patients lost to follow-up, 26 of 29 (90%) patients reported that they would have the surgery again.

Autologous Chondrocyte Implantation Versus OA

The ACI and OA groups (Table 1) were significantly different in age ($P < .001$) and size of chondral defect ($P = .030$) but were similar in time to follow-up ($P = .317$). Preoperative scores for ACI were significantly higher than for OA in Lysholm ($P = .037$), Noyes symptom ($P = .011$), IKDC ($P = .002$), KOOS pain ($P = .007$), KOOS symptom ($P = .019$), KOOS ADL ($P = .003$), and KOOS quality of life (QOL, $P = .001$) scores. The absolute outcome scores for ACI were significantly better than were those for OA in the following scoring systems: IKDC ($P = .0024$), KOOS pain ($P = .011$), KOOS symptom ($P = .025$), KOOS ADL ($P = .002$), KOOS sport ($P = .001$), and KOOS QOL ($P < .001$). Preoperative scores for the OA group were significantly lower than were those of the ACI group for several outcome scoring systems (Table 3). However, the percentage increase was significantly higher for OA compared with ACI for the SF-12 mental (+5.9% vs –6.0%, respectively; $P = .038$) but not significantly different for the remainder of the scoring systems (Table 3 and Figure 2).

There were no infections, neurovascular complications, or other complications associated with the procedures. All OA patients had radiographic documentation of complete integration of their grafts. All OA involved the medial compartment. The ACI group was split with half involving the medial compartment and half involving the lateral compartment. There was no significant difference between outcomes for medial versus lateral compartment involvement (Table 4).

Subsequent Procedures

Five patients underwent subsequent procedures on the same knee. Four patients underwent limited debridement; 3 patients had mild hypertrophy of their ACI patches (2 with complete fill and normal appearance, 1 with mild softening), and 1 had mild trochlear chondral changes unrelated to his

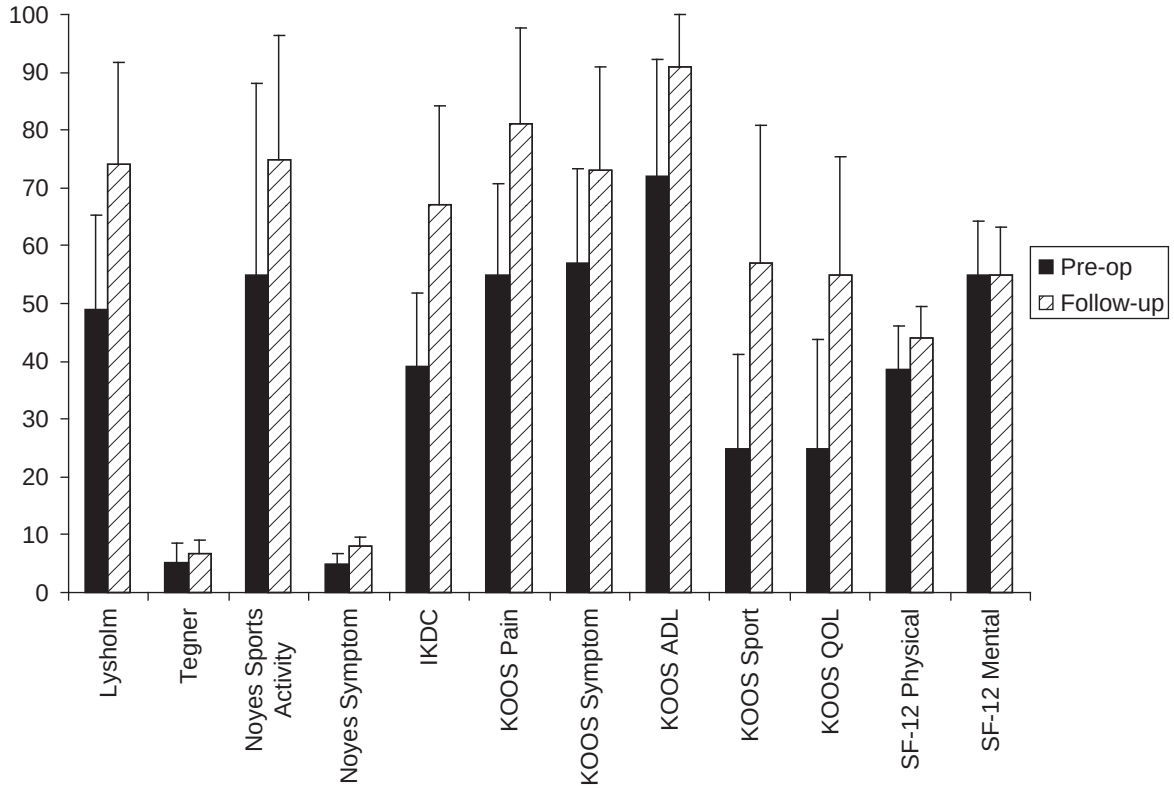

Figure 1. Overall outcome scores. ADL, activity of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; Pre-op, preoperative; QOL, quality of life; SF, Short Form.

TABLE 2
Overall Outcome Scores[a]

Knee Scoring System	Preoperative ± SD	Follow-up ± SD	P^b
Lysholm	48.7 ± 16.4	74.0 ± 17.7	<.001
Tegner	5.0 ± 3.3	6.7 ± 2.3	.001
Noyes			
Sports activity	54.8 ± 33.1	74.6 ± 21.3	.001
Symptom	5.4 ± 1.8	7.9 ± 1.6	<.001
IKDC	38.7 ± 12.7	66.9 ± 17.2	<.001
KOOS			
Pain	55.4 ± 15.7	81.3 ± 16.7	<.001
Symptom	56.6 ± 16.3	73.0 ± 18.0	<.001
ADL	72.1 ± 20.1	91.1 ± 11.6	<.001
Sports	25.4 ± 16.2	57.0 ± 23.9	<.001
QOL	25.2 ± 18.9	55.1 ± 20.4	<.001
SF-12			
Physical	38.9 ± 7.3	44.0 ± 5.5	.001
Mental	55.5 ± 9.4	55.2 ± 8.2	.34

[a] ADL, activity of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; QOL, quality of life; SF, Short Form.
[b] All *P* values are statistically significant, except for SF-12 mental.

OA graft that was 100% intact. In all 4 of these patients, the MAT was documented to be entirely intact with complete incorporation. The final patient had a granuloma removed from the ipsilateral knee 18 months after her ACI/MAT. At reoperation, the meniscal allograft was noted to be normal in appearance, and the ACI site had good fill and integration.

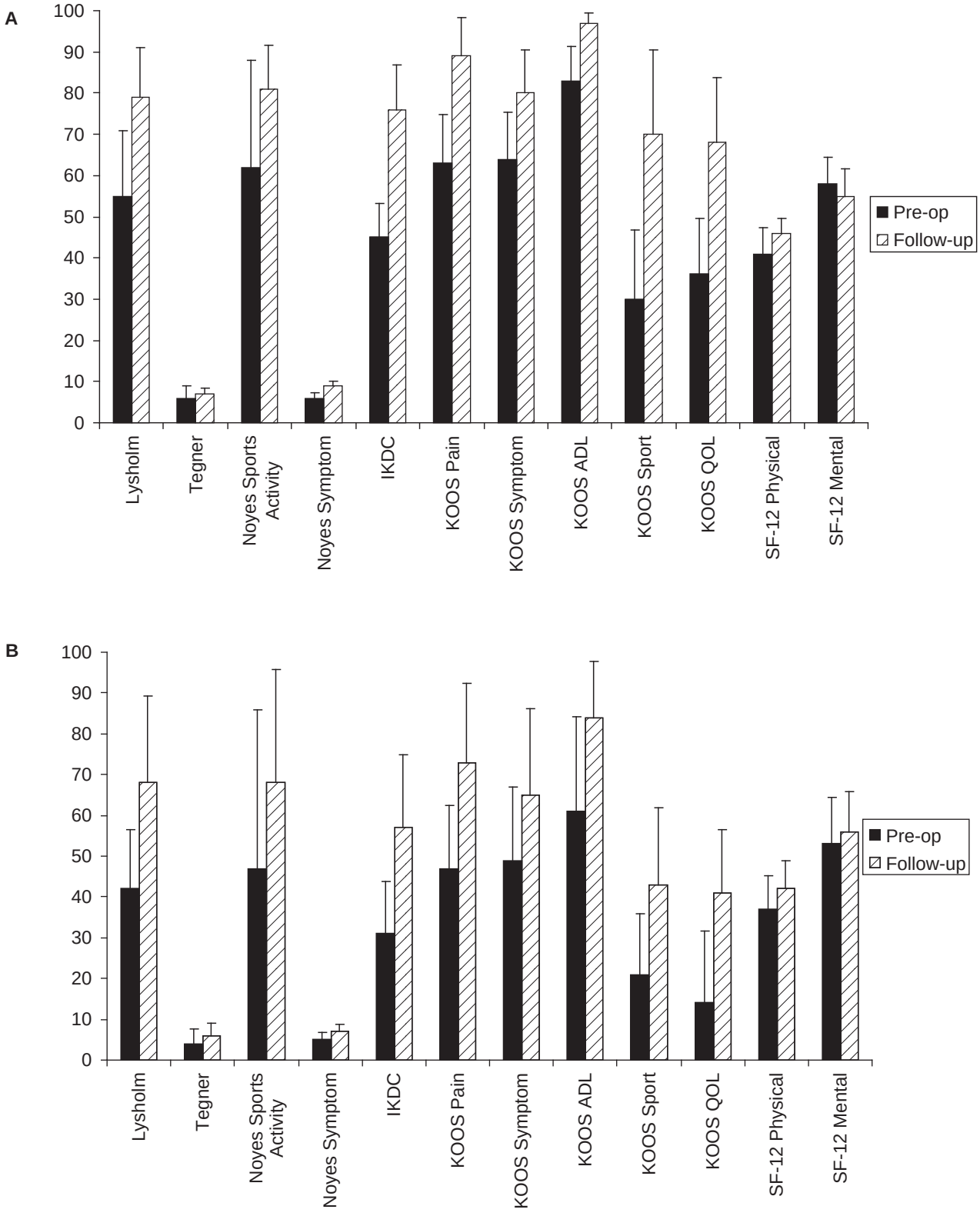

Figure 2. A, MAT/ACI outcome scores. B, MAT/OA outcome scores. ACI, autologous chondrocyte implantation; ADL, activity of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; MAT, meniscal allograft transplantation; OA, osteochondral allograft; Pre-op, preoperative; QOL, quality of life; SF, Short Form.

TABLE 3
ACI Versus OA Outcome Scores (±SD)[a]

Score	ACI + MAT	OA + MAT	OA vs ACI: *P*
Lysholm			
Preoperative	55.0 ± 16.0	42.0 ± 14.5	.037[b]
Follow-up	79.4 ± 11.9	68.2 ± 21.3	.104
P	<.001	.001	
Tegner			
Preoperative	5.5 ± 2.9	4.4 ± 3.7	.391
Follow-up	7.3 ± 1.5	6.2 ± 2.9	.217
P	.026	.030	
Noyes			
Sports activity			
Preoperative	61.8 ± 26.0	47.3 ± 39.0	.264
Follow-up	81.1 ± 10.6	67.7 ± 27.7	.105
P	.018	.036	
Symptom			
Preoperative	6.2 ± 1.4	4.5 ± 1.8	.011[b]
Follow-up	8.6 ± 1.2	7.1 ± 1.8	.013[b]
P	<.001	<.001	
IKDC			
Preoperative	45.5 ± 8.2	31.4 ± 12.8	.002[b]
Follow-up	76.0 ± 10.8	57.1 ± 17.8	.002[b]
P	<.001	<.001	
KOOS			
Pain			
Preoperative	62.9 ± 11.9	47.3 ± 15.5	.007[b]
Follow-up	88.9 ± 9.4	73.1 ± 19.3	.011[b]
P	<.001	<.001	
Symptom			
Preoperative	63.5 ± 11.3	49.2 ± 17.9	.019[b]
Follow-up	80.4 ± 10.6	65.1 ± 21.1	.025[b]
P	<.001	.012	
ADL			
Preoperative	82.6 ± 8.3	60.9 ± 23.3	.003[b]
Follow-up	97.4 ± 2.5	84.3 ± 13.7	.002[b]
P	<.001	.003	
Sports			
Preoperative	29.6 ± 16.8	20.8 ± 14.8	.160
Follow-up	70.4 ± 20.5	42.7 ± 18.8	.001[b]
P	<.001	.001	
QOL			
Preoperative	35.7 ± 13.5	13.9 ± 17.5	.001[b]
Follow-up	67.9 ± 15.7	41.3 ± 15.4	<.001[b]
P	<.001	<.001	
SF-12			
Physical			
Preoperative	40.6 ± 6.3	37.0 ± 8.2	.204
Follow-up	45.6 ± 3.5	42.2 ± 6.9	.120
P	.009	.081	
Mental			
Preoperative	58.2 ± 6.4	52.6 ± 11.3	.118
Follow-up	54.7 ± 6.5	55.7 ± 9.9	.773
P	.159	.135	

[a] ACI, autologous chondrocyte implantation; ADL, activity of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; MAT, meniscal allograft transplantation; OA, osteochondral allograft; QOL, quality of life; SF, Short Form.
[b] Statistically significant.

TABLE 4
ACI Medial Versus Lateral Follow-up Outcome Score (±SD)[a]

Knee Scoring System	Medial	Lateral	*P*
Lysholm	83.8 ± 9.5	76.0 ± 13.1	.239
Tegner	6.8 ± 1.2	7.6 ± 1.8	.362
Noyes			
Sports activity	79.2 ± 5.8	82.5 ± 13.4	.581
Symptom	8.9 ± 1.2	8.5 ± 1.2	.528
IKDC	79.7 ± 11.2	73.3 ± 10.3	.289
KOOS			
Pain	87.5 ± 12.0	89.9 ± 7.6	.650
Symptom	85.1 ± 10.5	76.8 ± 9.9	.154
ADL	97.3 ± 2.9	97.4 ± 2.5	.933
Sports	81.7 ± 13.3	61.9 ± 21.5	.072
QOL	69.8 ± 16.5	66.4 ± 16.0	.706
SF-12			
Physical	44.8 ± 4.2	46.1 ± 3.0	.510
Mental	52.6 ± 6.7	56.3 ± 6.3	.311

[a] ACI, autologous chondrocyte implantation; ADL, activity of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; QOL, quality of life; SF, Short Form.

Failures

Two patients were considered to have failed results. One patient had returned to all activities without significant complaints and had a new twisting injury 3 years after a lateral MAT combined with OA graft for a 4 cm^2 grade IV postmeniscectomy focal chondral defect of the lateral femoral condyle. He was found to have a bucket-handle tear of the allograft meniscus. At the time of his revision lateral MAT, the OA graft of the lateral femoral condyle was intact with complete incorporation with no signs of degeneration of the allograft meniscus. The other patient underwent complete meniscectomy 2.4 years after MAT/OA and was found to have tricompartmental degenerative changes. The follow-up scores for these patients were based on the last survey before the revision procedure (2.2 and 2.1 years, respectively).

DISCUSSION

Commonly, patients with a postmeniscectomized knee have articular cartilage defects possibly due to a compromised load-bearing state. Understanding of the meniscus and its function continues to grow, and improved knowledge of the biomechanical consequences of the postmeniscectomized knee has led to an emphasis on meniscal preservation. It is well established that cartilage degeneration follows a predictable pattern after meniscal resection.[32] Recent evidence has supported this contention, reinforcing that even smaller meniscal resections may effectively result in a biomechanical equivalent to a meniscectomized knee.[19]

Traditional doctrine has been to avoid MAT in the setting of chondral defects because of the less predictable results. Unfortunately, many of these patients are young, and the predictable long-term consequences of progressive articular cartilage degeneration lead to poor results.[2]

With the promising results of MAT,[8,29,37,38,40] the indications have expanded to include those patients with previous contraindications such as axial malalignment and ligament instability, provided that the abnormalities are corrected at the time of MAT.[35] Based in part on a similar premise, simultaneous MAT and cartilage repair procedures have been proposed to deal with those patients who have a symptomatic meniscectomized knee with focal chondral defects. These articular defects would have traditionally been considered to be contraindications to MAT; however, based on previous successes with combined procedures,[16,35] MAT combined with cartilage repair procedures have been undertaken.

Cartilage restoration options include ACI and OA transplantation.[1,2] Performed in isolation, each of these cartilage repair procedures has been demonstrated to be a viable option for focal chondral defects with predictable results.[6,17,18,22,28]

When faced with a meniscus-deficient patient with a localized articular cartilage defect, the surgeon must consider the risks and benefits of performing simultaneous, combined procedures. The optimal situation is to be able to effectively resolve both the meniscus and articular cartilage issues at the same time, without compromising the results from either procedure or subjecting the patient to any increased risk of complications.

One of the concerns regarding performing combined procedures such as MAT and cartilage repair has been the possibility of increased complication rates. In our series, there was no increase in complications associated with performing combined MAT and cartilage repair procedures.

We had no infections, neurovascular complications, or other complications. In a recent report, Noyes et al[26] reported their 2- to 5.7-year results for 40 consecutive patients who underwent MAT. Sixteen of these patients also underwent simultaneous osteochondral autograft transfer without an increase in the rate of complications.

With recent improvements in storage and transplantation techniques, reported outcomes for MAT have documented up to 90% return to normal or near normal IKDC scores.[8] Historical MAT outcome scores have shown wide variations,[23,24] possibly due to the degree of chondral damage. Commonly reported results for ACI have shown varied success, although Cole et al recently reported the results of the Study of Treatment of Articular Repair group (unpublished data, 2007). They reported on 126 patients with 4-year follow-up after ACI and concluded that ACI provided "sustained (minimum 4 year) and clinically meaningful improvement in symptoms and function." Autologous chondrocyte implantation has been shown to be superior to mosaicplasty both in subjective outcome measures and with second-look arthroscopy healing rates.[5]

Similar positive results have been shown for OA. McCulloch et al[20] reported an 84% satisfaction rate after OA, with 88% of grafts demonstrating full incorporation. Chu et al[7] reported an 86% success rate in 123 patients followed for a mean of 7.5 years.

Overall, the only outcome measure that did not show significant improvement was SF-12 mental. One potential explanation for this may be in patient expectation. This is demonstrated in the comparison of ACI versus OA. Although there was no difference in absolute scores for SF-12 mental, the percentage change was significantly higher for OA than for ACI, perhaps suggesting that patients undergoing a 2-stage procedure such as ACI had higher expectations for their outcomes, potentially leading to worse SF-12 mental scores.

Although it is difficult to compare the outcomes of selected groups between studies, our results for combined MAT and cartilage repair are comparable with expected outcomes reported in the literature. A report by Cole et al[8] on isolated MAT demonstrated similar follow-up scores on the Lysholm (71.6), Tegner (6.5), Noyes (sport, 70.9; symptom, 7.4), and IKDC (64.1) scales at a minimum 2-year follow-up. Comparable Lysholm scores have been reported in several other studies for meniscus transplantation in isolation or combined with ACL reconstruction or ACI.[11,35,40] Farr et al[11] identified a mean follow-up Lysholm score of 77.7 in 29 patients undergoing concurrent MAT and ACI. Cartilage procedures in isolation—both ACI and OA—have similar outcomes via Noyes, IKDC, and KOOS scores to those of these patients with combined cartilage and MAT surgeries.[21,28]

This highlights the difficulty in extracting anticipated outcome measures from previous studies, as many reports include outcomes from combined procedures in their results for isolated procedures. It has previously been difficult to characterize this group of patients because of the combined nature of their articular disease. Although our numbers are low and the mean follow-up only 3.1 years, we present a population of patients treated with a simultaneous, combined MAT and articular cartilage repair procedure performed by a single surgeon, evaluated with the same outcome measures. Our results are promising and are commensurate with expected outcomes after the cartilage repair procedures in isolation.

A limitation of the study is potential bias. Although the patients were followed prospectively, they were not randomized into treatment groups. The comparison between ACI and OA groups highlights the potential selection bias for determining which cartilage repair procedure a patient received. In addition, there was no set protocol for repeat MRI evaluation of MAT. It has been the practice of the senior author to obtain postoperative MRI if indicated[25]; however, this was not evaluated in the present study.

CONCLUSION

Combined MAT and cartilage repair procedures offer a safe intermediate procedure for patients with persistent symptoms after meniscectomy with combined articular cartilage injury. Results of combined procedures were comparable with published reports of these procedures performed in isolation. Long-term follow-up is needed to define the survivorship of these procedures as many of the patients were young.

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