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Autologous Chondrocyte Implantation Improves Patellofemoral Cartilage Treatment Outcomes

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Many patients with patellofemoral pain have multiple knee disorders, such as chondral defects, malalignment, and ligament insufficiency. I reviewed a treatment approach that included autologous chondrocyte implantation and biomechanical altering procedures to reduce impairment and symptoms in patients with patellofemoral lesions and biomechanical disorders. Thirty-eight patients (39 knees; mean age, 31.2 years) had large isolated (trochlear, 4.3 cm^2; patellar, 5.4 cm^2) or bipolar (mean total surface area, 8.8 cm^2) patellofemoral lesions. The minimum followup was 0.5 years (median, 3.1 years; range, 0.5–5.1 years). I observed a median improvement for the following patient and physician scores: modified Cincinnati Knee Rating System scores (3 points each), Lysholm score (31 points), and visual analog scale scores for resting (2 points) and maximum pain (3 points). At a mean followup of 1.2 years in the 22 patients (23 knees) undergoing second-look arthroscopy, autologous chondrocyte implantation repair tissue scored a median of 11 of 12 points using the International Cartilage Repair Society cartilage repair assessment. Twenty-five patients had 32 subsequent surgeries, including 14 to remove hardware from a prior osteotomy. Autologous chondrocyte implantation failed in three patients. Despite the high rate of reoperation, the data suggest combined treatment of autologous chondrocyte implantation and biomechanical altering procedures may be a reasonable option for selected patients with coexisting patellofemoral lesions and mechanical disorders.

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Patellofemoral pain is common and affects athletes and nonathletes.[12] Patients who present with patellofemoral pain are challenging to treat because the etiology of the pain is often multifactorial and, at times, unclear. Patellofemoral pain often is associated with trauma, repetitive overuse, and patellar alignment and tracking outside the mean of asymptomatic patients (alternative terminology to malalignment).[5,12] Many patients with patellofemoral pain have multiple knee disorders (eg, chondral defects, patellar malalignment, patellar tilt, or ligament insufficiency), all of which may contribute to symptoms and may be unresponsive to nonsurgical measures.

After nonoperative treatment has failed, past surgical treatment for some subsets of patients with patellofemoral pain has focused on the treatment of either biomechanical disorders or cartilage lesions. These discrete treatment approaches have had variable success. In a study that examined the efficacy of anteromedialization (anteromedial tibial tuberosity transfer, which includes lateral release) to treat symptomatic patients with patellar excessive lateral tracking (subluxation), patellar tilt, and chondral lesions, Pidoriano et al[18] reported 46% of patients had good to excellent results as measured by the modified Lysholm scale. However, patients with medial, proximal, or diffuse patellar lesions were less likely to have good or excellent results compared with those who had distal or lateral patellar lesions.[18]

Poor outcomes also were reported by Brittberg et al[2] in patients whose chondral lesions were treated with autologous chondrocyte implantation (ACI) without addressing the concomitant biomechanical knee disorder (lateral patellar subluxation). In that study, the majority of patients (five of seven) with patellar lesions reported fair or poor results at a mean followup of 36 months after ACI.[2] In subsequent studies, better results were obtained when

combining ACI with a concurrent biomechanical corrective procedure to treat patients with patellofemoral lesions and concomitant biomechanical disorder.[10,15,17] This improvement suggested an incremental, synergistic benefit with a comprehensive treatment approach.

I therefore hypothesized symptomatic patients with patellofemoral chondral lesions and biomechanical disorders would report improvement in the patient-reported modified overall condition score after receiving a combined treatment of ACI and other mechanical corrective procedures. The secondary hypothesis was patients would report improvements in Lysholm scale and pain visual analog scale (VAS) scores after receiving a combined treatment (ACI plus a corrective mechanical procedure). A tertiary hypothesis was the repair tissue generated would adequately fill the defect, have good integration with surrounding cartilage, and have a smooth intact surface as measured by the International Cartilage Repair Society (ICRS) cartilage repair assessment scale. Finally, the type and number of subsequent operations after ACI were evaluated.

MATERIALS AND METHODS

The outcomes of patients treated with ACI since September 1998 were prospectively tracked. At baseline (before implantation), patient outcome scores, patient demographics, prior surgeries, and data from a physical examination were collected. Defect characteristics and information regarding concomitant surgeries were collected during implantation. At periodic followup visits, clinical outcomes were prospectively assessed using the modified scales of the Cincinnati Knee Rating System (patient-reported [primary outcome] and physician-rated [JF, LD, BM, CD]) (0–10 scale, with higher score indicating better outcome),[3] the patient-reported Lysholm scale (0–100 scale, higher score indicating better outcome),[13] and patient-reported VAS (0–10, higher score indicating worse outcome) for maximum pain and pain at rest. The ACI repair tissue in some patients undergoing surgery after ACI was assessed (JF) using the ICRS cartilage repair assessment scale.[22] In this assessment tool, the repair tissue is graded from 0 to 4, with higher score indicating better outcome, in three categories, degree of defect repair, integration to border zone, and macroscopic appearance; these scores are added to get the overall repair assessment score (maximum, 12).[22] Information regarding surgeries performed after ACI also was collected at periodic followups. The protocol had prior approval of the Institutional Review Board of St Francis Hospital and Health Center in Indianapolis, IN,

Data were prospectively collected from a subset (38 patients, 39 knees) of patients (201 patients, 207 knees) treated between September 1998 and November 2005 (the month the study was initiated). Per a priori criteria, patients were included if they (1) had full-thickness patellar and/or trochlear cartilage lesions (ICRS Grade 3 or 4) treated with ACI and (2) had their ACI performed 2 or more years from the time of study initiation. Patients were excluded if they had a nonACI cartilage repair procedure performed concurrently with ACI or ACI-treated lesions that were located in areas other than the patella and/or trochlea. Of 201 patients (207 knees) treated during this observation period, 72 patients (74 knees) had ACI-treated patellar and/or trochlear lesions and were at least 2 years past their implantation date. Of these, 34 patients (35 knees) were excluded using the previously noted criteria. The minimum followup from ACI to the most recent postoperative followup for the 38 patients was 0.5 years (median, 3.1 years; range, 0.5–5.1 years; 34 of the 38 patients (89.5%) had followup of 2 or more years for the overall condition score. For 22 patients (23 knees), the mean ± standard deviation time between ACI and second-look arthroscopy was 1.2 ± 0.8 years.

Fifty-five percent of patients were male with a mean age of 31.2 years (range, 14.9–50.5 years) at the time of the ACI (Table 1). Fourteen patients (14 knees) had one patellar lesion (mean size, 5.4 ± 1.9 cm^2), 18 patients (18 knees) had one trochlear lesion (mean size, 4.3 ± 1.9 cm^2), and six patients (seven knees) had one lesion in the patella and the trochlea (mean total surface area, 8.8 ± 3.5 cm^2) (Table 1). All treated patellar lesions were Type III (14%) or IV diffuse panpatellar or central (86%); of the trochlear lesions, 56% were central (Table 1). The patients had a mean of 1.9 surgeries before im-

TABLE 1. Patient and Lesion Characteristics

Characteristics	Value
Patients (38 patients)	
Age (years)*	
Mean ± SD	31.2 ± 11.3
Range	14.9–50.5
Gender (number)	
Male	21 (55%)
Female	17 (45%)
Lesions (39 knees, 46 lesions)	
Lesion size by location (cm^2)	
Patellar, 14 knees (36%)	
Mean ± SD	5.4 ± 1.9
Median (range)	5.2 (3.0–8.4)
Trochlear, 18 knees (46%)	
Mean ± SD	4.3 ± 1.9
Median (range)	4 (2.3–9.0)
Bipolar,† 7 knees (18%)	
Mean ± SD	8.8 ± 3.5
Median (range)	8.6 (4.8–14.5)
Lesion type (number of lesions)	
Patellar	21
Type IV proximal pole, diffuse or central	18 (86%)
Type III medial facet only	3 (14%)
Trochlear	25
Central	14 (56%)
Lateral	6 (24%)
Medial	3 (12%)
Medial/central/lateral	2 (8%)

*Age for one patient (two knees) was counted twice because implants on the right and left knees were performed at different times; †one patient had bilateral autologous chondrocyte implants; seven bipolar knees correspond to six patients; SD = standard deviation

plantation (Table 2). Ninety-five percent (36 of 38) of patients had a procedure, staged before or concurrently with ACI, to correct at least one coexisting biomechanical disorder to optimize joint environment for ACI. Eighty-seven percent (33 of 38) of patients had a surgical procedure concomitantly with the ACI (Table 2). The most common concomitant procedure was anteromedialization (74%). Of the patients who had a concomitant anteromedialization, 13 had patellar lesions, 10 had trochlear lesions, and five (six knees) had bipolar lesions.

Autologous chondrocyte implantation (Carticel® [autologous cultured chondrocytes]; Genzyme Biosurgery, Cambridge, MA) of the patellar and trochlear defects was performed as previously reported.[2,15,17] The suturing technique ensured the periosteal flap maintained the concave and convex contours of the trochlea and patella, respectively (Fig 1).[8,15] For patellar and trochlear lesions, the periosteal patch was oversized 2 to 4 mm in the medial to lateral direction. Suturing started at the four corners of the periosteal patch and then at the apex (highest aspect of the patella or deepest aspect of the trochlear groove). These individual sutures were alternated medially/laterally and proximally/distally to restore the native topography (Fig 2).

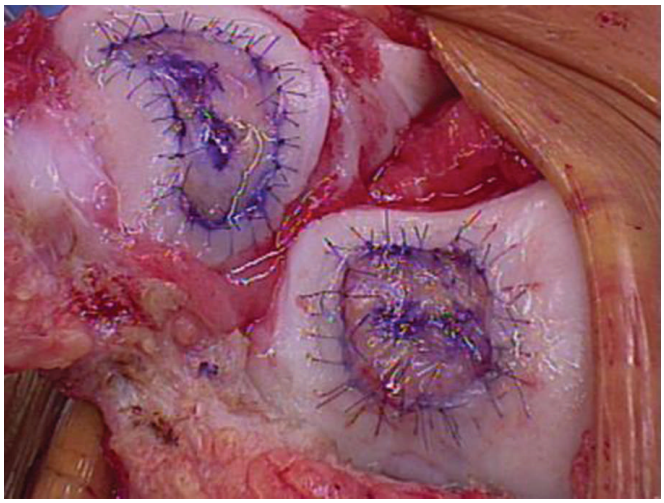

Fig 1. The convex shape of the patella (above) and concave shape of the trochlea (below) are maintained after suturing the periosteal patch over the articular cartilage defect.

TABLE 2. Number and Percentage of Patients (n = 38) with Prior and Concomitant Surgical Procedures

Procedure	Number of Patients
Prior procedures	
Chondroplasty with scope	35 (92.0%)
Removal of loose bodies	11 (28.9%)
Lateral release	9 (23.7%)
Partial synovectomy	6 (15.8%)
Marrow stimulation	3 (7.9%)
Anterior cruciate ligament revision	3 (7.9%)
Partial lateral meniscectomy	2 (5.3%)
Anteromedialization	2 (5.3%)
Hardware removal	2 (5.3%)
Medial release	1 (2.6%)
Partial medial meniscectomy	1 (2.6%)
Patellar tendon avulsion	1 (2.6%)
Retinacular release	1 (2.6%)
Scar revision	1 (2.6%)
Tibial tubercle medialization	1 (2.6%)
Other	5 (13.2%)
Unknown*	10 (26.3%)
Concomitant procedures†	
Anteromedialization‡	28 (73.7%)§
Lateral meniscal allograft transplantation	2 (5.1%)
Lateral release	2 (5.1%)
Anterior cruciate ligament revision	1 (2.6%)
Medial patellofemoral ligament reconstruction	1 (2.6%)
Medial release	1 (2.6%)
Scar debridement	1 (2.6%)

*Unknown surgical procedures were those of patients referred to my practice who could not recall the exact previous procedure; †one patient had an anteromedialization, lateral release, medial release, and scar débridement; ‡included a titrated (limited) lateral release; §these 28 patients include one patient with bilateral implants, or 29 knees

Anteromedialization was performed if the patient presented with lateral patellar tilt, lateral subluxation of the patella, or chondral lesions located on the distal lateral region of the patella. Anteromedialization also was performed to decrease stress on the implanted area through force reduction with the anteriorization portion and improve contact area by the medialization portion of anteromedialization osteotomy (stress = force per unit area). Patellar tilt, height, and position relative to the trochlea were determined by clinical examination (tilt per the Sage test[7]), lateral view (calculation of Caton-Deschamps ratio[21]) radiographs, and Merchant shallow angle axial view radiographs, respectively.

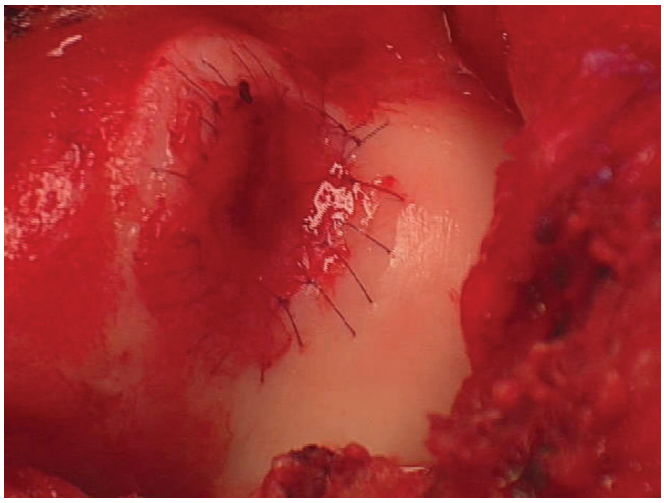

Fig 2. The concave shape of the trochlea is maintained after the periosteal patch is sutured over the articular cartilage defect.

Lateral release and anteromedialization was performed according to the Fulkerson algorithm.[6] To decrease loading, the tibial tuberosity was elevated anteriorly 10 to 15 mm. In patients with frank lateral patellar subluxation, the patella was centralized; in those with patellar tilt and no frank subluxation, the patella was elevated anteriorly 10 to 15 mm but only medially by approximately 6 to 8 mm (to decrease lateral loading but not overload medially by using the steepest slope[1]). Isolated lateral release was performed only if the patient presented with excessive lateral patellar tilt (patellar medial displacement was limited between 0 and ½ quadrants [of total trochlear width] medially and there was positive clinical tilt) and had a lateral patellar or trochlear chondral lesion. Tilt was reversed with a lateral release extended only proximally enough to allow one to two quadrants of medial displacement. Because the degree of release varies by patient, the release was gradually extended (titrated) to achieve this goal.

A standard rehabilitation protocol[20] was individualized for each patient. Immediately after surgery, cooling therapy, elevation, and compression were applied. Six hours after surgery, the knee was placed in a continuous passive motion machine at 0° to 30° for a minimum of 8 hours per day for 6 weeks. If tolerated, range of motion was increased (5°–10° per day) with the goal of achieving full range of motion by Week 6. Isometric quadriceps exercises and core proximal exercises (eg, hip extensor, hip abductors, and pelvic stabilizers) were performed throughout the day. Patellar mobilization (four to six times per day), hamstring stretching, and calf stretching also were encouraged during the first 6 weeks. Patients who did not have concomitant bony surgery began partial weightbearing immediately with crutches (approximately 25% body weight) and wore a knee brace locked in full extension during ambulation. Starting Week 6, patients were encouraged to increase partial weightbearing to full weightbearing by Week 8. Patients who underwent concurrent anteromedialization began with minimal weightbearing (approximately the weight of the limb, foot-flat weightbearing). They progressed to full weightbearing if, at 6 weeks, radiographs confirmed there was no evidence of osteotomy healing failure. Strengthening was initiated as mentioned previously with use of electrical stimulation and/or biofeedback if quadriceps function was poor. After 6 weeks, minisquats (0°–30°) were incorporated as the patient's weightbearing status increased. Bicycle riding with low resistance was encouraged beginning Weeks 4 to 6, and weight machines and closed kinetic chain exercises were incorporated by Weeks 8 to 10; open kinetic chain knee, pelvis, and lower extremity exercises were used throughout with the exception that knee extension with weight was avoided (at all times). After 6 months, activities were advanced on a case-by-case basis, slowly allowing inclines and stairs. For some patients I recommended slow advancement of activities during a 24-month period.

Autologous chondrocyte implantation was defined as a failed treatment when patients had an operation after implantation that (1) necessitated removal of the graft, (2) confirmed partial or full delamination of the graft, (3) confirmed a loss of defect fill, or (4) violated the subchondral bone (eg, abrasion arthroplasty, microfracture, drilling, unicompartmental knee replacement, TKA). Patients whose ACI failed were included in the overall analyses. Followup data for the patients who met the study definition of treatment failure were imputed as follows: for the patient and physician Cincinnati and Lysholm scores, the lowest (worst) observed scores were used; VAS pain and VAS maximum pain scores were imputed with the maximum (worst) observed scores. A patient was considered to have a good to excellent result if the modified Cincinnati overall condition scale score was 6 or better. Good to excellent results using the modified Lysholm scale score was determined according to Pidoriano et al[18]; a good to excellent result was based on a modified Lysholm scale score of 80 or better.

For each end point, the median change in score from baseline to the most recent postoperative evaluation was calculated. The difference in score was compared with zero using the sign test with SAS (UNIVARIATE procedure; SAS Institute, Cary, NC). I determined a minimum sample size of 38 patients would provide greater than 99% power to detect a reported change in overall condition score of 1 point. For one patient with missing data and three patients with data collected at earlier times (6 months, 11 months, and 12 months), 2-year followup scores were imputed using their last observation carried forward (LOCF). To ensure the LOCF method of imputation did not overestimate the effect size of the primary analysis, the data were reanalyzed using a more conservative method of imputation; 2-year followup scores were assigned the second worst (lowest) score observed. International Cartilage Repair Society scores of treatment failures were not imputed; two treatment failures had ICRS scores. The effects of age, gender, lesion location, lesion size, having bipolar lesions, and having a concurrent anteromedialization with ACI on the primary clinical outcome were evaluated individually (GLIMMIX procedure; SAS Institute). For all analyses, p values less than 0.05 were considered significant.

RESULTS

The patient-reported modified Cincinnati overall condition score improved ($p < 0.01$) by a median 3 points from a median score of 4 at baseline to a median score of 6 at latest followup (Table 3). Factors known to potentially affect treatment outcomes, such as age, gender, lesion location, and lesion size, did not affect this primary result. Subanalysis also showed improvement in overall condition occurred after ACI regardless of having a bipolar patellofemoral lesion or having a concurrent anteromedialization with ACI. The median improvements of patients with bipolar versus monopolar lesions were similar as were those of patients with a concurrent anteromedialization versus those without. The LOCF method to impute missing data did not overestimate the observed improvement in the modified Cincinnati overall condition score. The majority of patients (80%, or 31 of 39 patients) rated their overall condition (modified Cincinnati) as good (11 of 39 patients had scores of 6), very good (11 of 39 patients had scores of 7 or 8), or excellent (nine of 39 patients had scores of 9 or 10).

TABLE 3. Scores and Score Changes for All Variables

Variable	Number*	Preoperative	Postoperative	Change	p Value†
Patient Cincinnati[3]	38	4 (1, 8)	6 (3, 10)	3 (–5, 8)	< 0.0001
Physician Cincinnati[3]	38	4 (1, 8)	6 (3, 9)	3 (–5, 7)	< 0.0001
Lysholm[13]	39	56 (20, 96)	86 (52, 100)	31 (–31, 79)	< 0.0001
VAS resting pain	38	2 (0, 9)	0 (0, 7)	–2 (–9, 7)‡	0.0070
VAS maximum pain	38	8 (3, 10)	4 (0, 10)	–3 (–10, 3)‡	< 0.0001

Data are presented as median (minimum, maximum) points; *numbers are the number of knees with preoperative and most recent scores for each variable; †changes in scores from preoperative to most recent followup were analyzed using the sign test and last observation carried forward; ‡negative change represents an improvement in outcome; VAS = visual analog scale

Improvements ($p < 0.001$) were observed for the physician-rated modified Cincinnati score, Lysholm score, and VAS scores for resting and maximum pain. Median improvements in score were 3 points for the physician-rated Cincinnati scale, 31 points for the Lysholm scale, 2 points for the VAS resting pain, and 3 points for the VAS maximum pain (Table 3).

In 22 patients (23 knees) who had subsequent surgery, ICRS scores indicated repair of patellar and trochlear cartilage defects. Except for one bipolar patellar lesion, all monopolar and bipolar patellar lesions had an ICRS score of 3 or 4 for cartilage fill, integration, and appearance. This is reflected in the median scores for each ICRS parameter by lesion (Table 4). International Cartilage Repair Society scores indicating degree of repair tissue integration with border zone generally were better ($p < 0.05$) for patellar lesions compared with trochlear lesions. Additionally, total composite ICRS scores ranged from 10 to 12: monopolar patellar lesions (100%, 10–11), bipolar patellar lesions (80%, 10–12) (Fig 3), monopolar trochlear lesions (88%, 10–12), and bipolar trochlear lesions (100%, 10–12) (Fig 4).

Twenty-five patients (26 knees) had 32 subsequent operations after ACI. In 14 patients, subsequent operations were performed because of pain resulting from osteotomy hardware. These patients also reported minor patellofemoral symptoms, such as crepitus, mild pain, or catching, which otherwise would not warrant arthroscopic intervention. Seven patients underwent a subsequent operation because they had major mechanical symptoms, such as marked catching or clunking, presumably the result of periosteal patch overgrowth, periosteal patch delamination, or focal scar tissue; two of these patients were treated with microfracture (treatment failures). None of the patients with graft or periosteal patch hypertrophy ($n = 12$) experienced ossification of the graft. Five patients had a subsequent operation because of limited range of motion resulting from postoperative scar impingement or the presence of some degree of arthrofibrosis (none had patellar infera). Three patients had a subsequent operation because of substantial patellofemoral pain; a cartilage lesion (ICRS Grade 1B–2) was the only finding at these arthroscopies. One patient had acute knee sepsis develop and the implants were removed (treatment failure). One patient had a subsequent operation to remove hardware for an unrelated femur fracture treated before implantation. Another patient underwent arthroscopy after ACI for treatment of a medial meniscal tear with partial meniscectomy.

TABLE 4. ICRS Cartilage Repair Assessment System Scores[22] for Patients with Postoperative Procedures after Autologous Chondrocyte Implantation

Lesion Location	Number of Lesions*	Degree of Defect Repair	Integration to Border Zone	Macroscopic Appearance	Total
Patellar lesions					
Monopolar	10	4 (3, 4)	4 (4, 4)†	3 (3, 4)	11 (10, 11)
Bipolar	5	4 (2, 4)	4 (3, 4)	3 (3, 3)	11 (8, 12)
Trochlear lesions					
Monopolar	8	4 (2, 4)	4 (1, 4)†	3 (1, 4)	10.5 (3, 12)
Bipolar	5	4 (3, 4)	4 (4, 4)	3 (3, 3)	11 (10, 12)
Total	28	4 (2, 4)	4 (1, 4)	3 (1, 4)	11 (3, 12)

Data are presented as median (minimum, maximum) points; *lesions found in 22 patients or 23 knees; †scores for integration to border zone were significantly different for patellar versus trochlear lesions by Wilcoxon's rank sum test ($p < 0.05$); ICRS = International Cartilage Repair Society

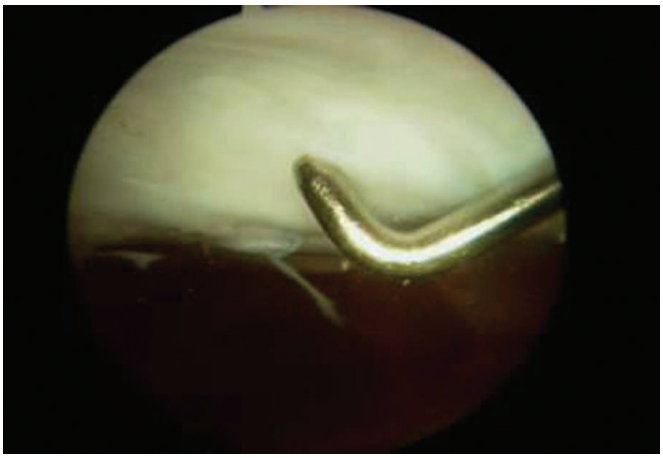

Fig 3. Cartilage repair can be seen in this patellar lesion 1 year after ACI.

DISCUSSION

There is a subset of patients with chondral defect(s) and some type of mechanical problem(s) who have had extensive nonoperative treatment fail. Some studies suggest successful treatment of patients with mechanical and chondral patellofemoral problems requires comprehensive treatment of both abnormalities[10,15,17] The current study was done to determine if a comprehensive treatment approach combining ACI and a concurrent mechanically corrective procedure improves function, reduces symptoms, and yields good-quality repair tissue in patients with combined patellofemoral chondral lesions and biomechanical knee disorders.

This study has multiple limitations. Although not exclusive, the limitations include the lack of a comparative control group, the inability to generalize results, nonblinded assessment of treatment, unknown interrater reliability, and short-term followup. Without a comparative group, I was not able to control the potential effects of known or immeasurable sources of bias. However, additional analyses confirmed the primary result was not affected by lesion size, lesion location, having bipolar lesions, having a concurrent anteromedialization with ACI, age, or gender. Patients and evaluators were not blind to treatment; as a result, the treatment effect observed may be overestimated. Also, separate scoring exercises were not done to test interrater or intrarater reliability. However, the potential bias associated with this limitation may be mitigated by the fact that the primary outcome instrument (modified Cincinnati overall condition scale) had clear definitions associated with scores. Another limitation is the inability to generalize results. This study is based on the experience of one surgeon and may not reflect results obtained in routine clinical practice. Furthermore, the results are preliminary and longer-term followup is needed. However, the study did use a priori inclusion and exclusion criteria to select patients. The minimum 2-year followup rate was 89.5%. I also ensured all patients complied with rehabilitation, a factor known to affect treatment outcomes and not always documented in outcome studies. Furthermore, patient-reported outcome data are supplemented by repair tissue assessments performed in a subset of 22 patients.

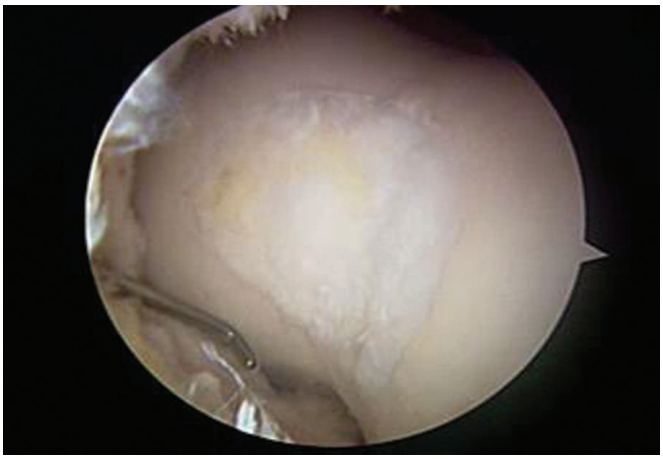

Fig 4. A trochlear lesion 1 year after ACI shows cartilage repair.

The Fulkerson tibial tuberosity anteromedialization osteotomy is commonly used to treat symptomatic patients with specific patellofemoral disorders, including those with patellofemoral compartment chondral lesions. Pidoriano et al[18] correlated the region of the patellar articular cartilage lesion with patient outcomes in a series of patients who had Fulkerson's anteromedial tibial tuberosity transfer without cartilage restoration. In that series, results were measured using the modified Lysholm scale. Using these categorical values, they reported good and excellent results in 56% of patients with medial facet patellar lesions (Type III) and in 20% of patients with proximal pole or panpatellar lesions (Type IV). In addition, patients with central trochlear lesions had largely poor results with anteromedial tibial tubercle transfer. In the current study, 74% (28 of 38) of patients had a concomitant anteromedialization with ACI. All treated patellar lesions were Type III or IV, and 56% of trochlear lesions were located in the central region of the trochlea. According to the modified Lysholm scale, 75% (21 of 28) of patients who were treated with ACI and anteromedialization had a good to excellent result. Applying the chondrosis patterns of Pidoriano et al[18] to the current ACI plus anteromedialization series, good to excellent results were reported by 80% (12 of 15) of patients (81% [13 of 16] of knees) with a

Type IV patellar lesion and 75% (six of eight) of patients (78% [seven of nine] of knees) with a central trochlear lesion. This is an improvement from the outcomes reported by Pidoriano et al for these types of chondral lesions treated with anteromedialization alone. Only three patients in the current series had Type III patellar lesions and were treated with ACI and anteromedialization: one reported an excellent result (modified Lysholm of 90), another reported a fair result (modified Lysholm of 79), and the third reported a poor result (modified Lysholm of 58).

The current data appear consistent with those reported by Henderson and Lavigne[10] and Minas and Bryant.[15] Across these studies, the magnitude of improvement in the modified Cincinnati overall condition score from baseline to followup was comparable: in the current study, median improvement was 3 points; in the study by Henderson and Lavigne,[10] mean improvement was 3.1 points; and in the study by Minas and Bryant,[15] mean improvement was 1.92 points. Also, in the series of Henderson and Lavigne,[10] additional analyses showed 86% of patients treated with ACI and anteromedialization and 54.5% of patients treated with ACI alone reported good to excellent results according to the modified Cincinnati scale.

In the current series, 66% (25 of 38) of patients had 32 operations after ACI. Of the 32 operations, 44% (37% [14 of 38] of patients) were performed because of pain related to the hardware used in the anteromedialization procedure. Forty-seven percent (39% [15 of 38] of patients) were performed because of symptoms (eg, catching, clunking, pain) that the primary investigator considered related to ACI, including 22% (18% [seven of 38] of patients) of subsequent surgeries that were performed because of complications related to the periosteal patch. It is challenging to directly compare subsequent operation rates across studies because of differences in patient variables (severity of knee disorder), the length of followup, and methods by which subsequent operations are grouped and reported; comparisons should be interpreted cautiously. The rate of subsequent operations reported here is higher (66%) than that (45%) of a subgroup of patients who had ACI with concomitant extensor realignment. Fewer patients (18%) in this study had subsequent operations resulting from periosteal patch complications compared with patients (75%) reported by Henderson and Lavigne.[10] In addition, the overall subsequent operation rate is higher (66%) for treatment of patellofemoral lesions than for treatment of condylar lesions as reported by Browne et al[3] (37%), Micheli et al[14] (16%), and Knutsen et al[11] (25%). This finding is not surprising given the extent of subsequent surgeries (44%, or 14 of 32) that were performed to remove hardware from a prior osteotomy. In addition, most patients who had a subsequent surgery did not meet the study definition of having treatment failure. Excluding three patients with treatment failure and one patient with missing followup data, 95% (20 of 21) patients who had an operation after ACI subsequently reported improvement in their overall condition score from baseline to latest followup.

Failure of ACI as a result of noncompliance with rehabilitation has been reported as ranging from 7% to 15% of failures.[3,4,16] The critical role of rehabilitation on outcome with ACI also has been stressed.[9,15,19] In the current study, all patients completed their prescribed rehabilitation. Although the effect of rehabilitation on outcome was not analyzed, complete rehabilitation of all study patients may have contributed to the 80% of patients who rated their function as good, very good, or excellent at their latest followup and the 7.8% of patients who met the study definition of having treatment failure.

Collectively, the results from this study and those from earlier studies lend support for the strategy of combining ACI and corrective procedures to treat knees with symptomatic patellofemoral compartment chondral lesions in which there is a suboptimal biomechanical environment. Data also suggest ACI may yield cartilage repair tissue that will adequately fill the defect, have good integration with surrounding cartilage, and have a near-normal surface appearance. Additional patient followup of this series is warranted to confirm these early results.

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