Outcomes of Microfracture for Traumatic Chondral Defects of the Knee: Average 11-Year Follow-up

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Purpose: In this study, we measured functional outcomes of patients treated arthroscopically with microfracture for full-thickness traumatic defects of the knee. **Type of Study:** A case series of patients with 7 to 17 years' follow-up. **Methods:** Between 1981 and 1991, a total of 72 patients (75 knees) met the following inclusion criteria: (1) traumatic full-thickness chondral defect, (2) no meniscus or ligament injury, and (3) age 45 years and younger (range, 13 to 45 years). Seventy-one knees (95%) were available for final follow-up (range, 7 to 17 years). All patients completed self-administered questionnaires preoperatively and postoperatively. **Results:** The following results were significant at the $P < .05$ level. Significant improvement was recorded for both Lysholm (scale 1 to 100; preoperative, 59; final follow-up, 89) and Tegner (1 to 10; preoperative, 3; final follow-up, 6) scores. At final follow-up, the SF-36 and WOMAC scores showed good to excellent results. At 7 years after surgery, 80% of the patients rated themselves as "improved." Multivariate analysis revealed that age was a predictor of functional improvement. **Conclusions:** Over the 7- to 17-year follow-up period (average, 11.3 years), patients 45 years and younger who underwent the microfracture procedure for full-thickness chondral defects, without associated meniscus or ligament pathology, showed statistically significant improvement in function and indicated that they had less pain. **Key Words:** Outcomes—Chondral defects of the knee—Cartilage.

Our preliminary functional outcome studies[1,2] suggest improvement over preoperative status, but neither of these studies focused on the effect of microfracture on knee injuries limited to isolated traumatic articular cartilage defects without meniscus and ligament pathology. Most chondral defects are associated with damage to other tissues in the knee.[1,2] Therefore, the functional outcome is based on healing of the other tissues as well as the chondral defect. We detailed this combined healing in another study.[3]

Our hypothesis in the present study is that patients with isolated full-thickness defects in the knee will have better function and less pain postoperatively compared with the preoperative status, if the defect is treated by the microfracture procedure described in this paper. The objective of the present study was to determine the nature and extent of functional outcomes due to microfracture for cartilage defects in knee alone without ligament or meniscus pathology.

METHODS

The present study was long term (average, 11.3 years; range, 7 to 17 years). The study population was limited to patients with only traumatic chondral defects. No patient had ligament or meniscus pathology. The cohort was further limited to patients 45 years of age and under. All the defects were treated with arthroscopic debridement and microfracture.[4,5]

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0749-8063/03/1905-3216$30.00/0
doi:10.1053/jars.2003.50112

TABLE 1. *Traumatic Full-Thickness Chondral Defects Study Group 45 Years of Age and Younger Treated by Microfracture 1981–1991 (68 Patients, 71 Knees)*

Average age	30.4 yr (range, 13-45)
Males	45 (2 bilaterals)
Females	23 (1 bilateral)
Average time from injury to surgery	166.9 wk (range, 0.9-839)
Acute (<12 wk)	15 knees
Chronic (≥12 wk)	56 knees
Average time to final follow-up	11.3 years (range, 7-17)
Average size of lesion	277.4 mm^2 (range, 20-1,000 mm^2)
Defect location	
Medial femoral condyle (MFC)	19
Lateral femoral condyle (LFC)	5
Trochlear groove (TG)	20
Patella (PT)	8
Medial tibial plateau (MTP)	0
Lateral tibial plateau (LTP)	2
Patella and trochlear groove	5
Trochlear groove and lateral femoral condyle	3
Lateral femoral condyle and lateral tibial plateau	4
Patella and lateral femoral condyle	2
Medial femoral condyle and lateral tibial plateau	1
Medial tibial plateau and lateral tibial plateau	1
Medial femoral condyle and trochlea groove	1

Between 1981 and 1991, a total of 302 consecutive patients with either traumatic or degenerative full-thickness chondral defects underwent the microfracture procedure.[4,5] Of these 302 patients, 25% met the inclusion criteria for this study. Exclusion criteria were knees with any anterior cruciate ligament or meniscus tears that required treatment, joint space narrowing indicating malalignment (determined by anteroposterior weight-bearing roentgenograms), chronic degenerative arthritis, and age over 45 years. Seventy-two patients (75 knees) met these criteria. All patients were treated by arthroscopic microfracture and evaluated annually. Two patients were lost to follow-up. Two knees were considered treatment failures. Sixty-eight patients (71 knees) who met our inclusion criteria were available for the final functional outcome evaluation. The details of the study group appear in Table 1.

Surgical Technique and Rehabilitation

The technique of microfracture has evolved. With our technique, 3 portals are made for use of the inflow cannula, the arthroscope, and the working instruments. When the full-thickness isolated articular cartilage lesion is identified, the exposed bone is debrided of all remaining cartilage tags using a curette and a full-radius resector (Smith & Nephew, Andover, MA). All loose or marginally attached cartilage around the defect is also debrided to create a perpendicular edge of healthy well-attached viable cartilage around the defect. To avoid excessive damage to the subchondral bone, care is taken not to debride through the subchondral plate. The calcified cartilage layer that remains is gently removed using a curette.

After preparation of the bed, we use an arthroscopic awl with an angle that allows the tip of the awl to be perpendicular to the subchondral bone surface. We make multiple holes ("microfractures") in the exposed subchondral bone plate around the periphery of the bed immediately adjacent to the healthy cartilage rim. We then make our way into the center of the defect. The awls are advanced with a mallet. The holes are made as close together as possible, but not so close that one hole breaks into another, thus damaging the subchondral plate between them. Usually the holes are about 3 to 4 mm apart. The depth of the holes are about 3 to 4 mm. The arthroscopic irrigation pump pressure is reduced, all instruments are removed from the knee, and the joint fluid is evacuated. No drains are placed intra-articularly. A more extensive discussion of the rationale and technique of microfracture has been published previously.[4,5]

Lesions on the weight-bearing surfaces on the condyles are treated immediately postoperatively, beginning in the recovery room, with a continuous passive motions (CPM) machine.[1,2,4] The initial range of motion is 30° to 70° and this is increased as tolerated by 10° to 20° until full range of motion is obtained. The rate of the machine is usually one cycle per minute, but the rate varies based on patient performance and comfort. Most patients tolerate the use of the machine at night, but some patients use the CPM machine intermittently during the day. In either case, the patients use the CPM machine for 6 to 8 hours per 24 hours. If patients are unable to use the CPM machine, then they receive instructions for passive flexion and extension of the knee with 500 repetitions 3 times a day. Patients are encouraged to gain full passive range of motion of the injured knee as soon as possible after the surgical procedure. Cold therapy is used for all patients for 1 to 7 days postoperatively. Exercises have been described in detail by Hagerman et al.[6] We briefly present the essentials of the rehabilitation program here.

For lesions of the femorotibial joint, patients use crutch-assisted touchdown weight-bearing for 6 to 8 weeks after the surgical procedure. Limited strength training is initiated immediately. Patients perform double-leg one-third knee bends the day after the microfracture procedure. Because they are limited to touchdown weight-bearing, patients place most of their body weight (75% to 80%) on the uninjured leg to perform the exercises. Stationary bike and deep water programs are begun at 1 to 2 weeks after the microfracture surgery. After 8 weeks, patients progress to full weight-bearing and begin a more vigorous program of active motion of the knee. Stationary bike with increasing resistance is the most important exercise. Elastic resistance cord exercises begin approximately 8 weeks after microfracture. Free or machine weights are permitted when the patient achieves the early goals of the rehabilitation program, but not before 16 weeks after microfracture. Depending on the clinical examination, we determine when a patient can return to sports that involve pivoting, cutting, and jumping, usually 4 to 6 months postoperatively.

The rehabilitation protocol for patients with patellofemoral lesions differs from the protocol for patients with femorotibial lesions. Patients with patellofemoral lesions are placed in a CPM machine immediately postoperatively and cold therapy is used. Patients have partial weight-bearing for 1 to 2 weeks. They use a brace locked at 0° to 20° for at least 8 weeks. The brace prevents excessive shear force on the maturing marrow clot. Passive motion is allowed with the brace removed, but otherwise, the brace is worn at all times. The brace is opened gradually before it is discontinued. During these weeks, the patients are allowed weight-bearing as tolerated, but within limits of knee flexion controlled by the locked brace. When the brace is discontinued, strength training is advanced progressively.

Functional Outcome Analysis

At the time of first examination, patients were asked to complete a self-administered questionnaire. These patients were sent the questionnaire annually for evaluation of symptoms, function, return to sports, activities of daily living, and satisfaction. Symptoms were evaluated on a 4-point scale; activity levels, function, and satisfaction were graded on a 10-point ordinal scale. The questionnaire was developed by the authors before validated outcome questionnaires were available. Our original questionnaire is shown in Fig 1. The Lysholm scores[7] and the Tegner scale[8] were calculated preoperatively and at final follow-up. Also at final follow-up, all patients completed the questionnaires, including the Western Ontario and McMaster University Osteoarthritis Index (WOMAC)[9] and the modified SF-36.[10] The modified SF-36 questionnaire includes 4 concepts: physical function, role function, bodily pain, and general health.

Demographic data and results of the self-administered questionnaires and the Lysholm and Tegner scores are maintained in our database. The results of the WOMAC and modified SF-36 were included before final analyses were made.

Statistical Analysis

Descriptive statistics at final follow-up (arithmetic mean, standard deviation, range) were calculated using standard formulas. Other statistical tests appropriate for this study were selected and performed by skilled statisticians. General improvement in symptoms (pain, swelling, activities of daily living, strenuous work, and sports) from preoperative status over the minimum 7-year study period was assessed using repeated measures analysis of variance with the Greenhouse-Geisser test[11] of within-subjects effects. Specific comparisons between years were performed using post hoc paired t tests. Comparison of proportions of patients with regard to pain status (improved, same, worsened) at years 3, 5, and 7 was performed using the Z-approximation.[12] Factor analysis was performed in different ways. The effects of patient age, chronicity of lesion, and size of lesion were assessed using Pearson correlation with post hoc independent samples t tests. The effect of lesion location was assessed using 1-way analysis of variance.

To assess changes in function and activity levels, the Lysholm and Tegner scores (final follow-up minus preoperative scores) were analyzed. To determine independent predictors of improvement in Lysholm score (final follow-up minus preoperative scores), multivariate analysis[13] was performed using a linear regression model with backward selection. Statistical analyses were performed with SPSS (version 9.0; SPSS, Chicago, IL), SAS (version 6.12; SAS Institute, Cary, NC), and nQuery Advisor (version 3.0; Statistical Solutions, Boston, MA) software packages. All statistics were reviewed by an independent statistician.

RESULTS

Two patients were lost to follow-up. Treatment was considered a failure in 2 patients. One patient (who

1. Please grade each symptom that you experience currently during your **highest level of activity**.

SYMPTOM (*Please fill out both knees*)

	Right Knee				Left Knee			
	NONE	MILD	MODERATE	SEVERE	NONE	MILD	MODERATE	SEVERE
1) Pain	○ 1	○ 2	○ 3	○ 4	○ 1	○ 2	○ 3	○ 4
2) Swelling	○ 1	○ 2	○ 3	○ 4	○ 1	○ 2	○ 3	○ 4
3) Partial Giving Way	○ 1	○ 2	○ 3	○ 4	○ 1	○ 2	○ 3	○ 4
4) Full Giving Way	○ 1	○ 2	○ 3	○ 4	○ 1	○ 2	○ 3	○ 4
5) Locking	○ 1	○ 2	○ 3	○ 4	○ 1	○ 2	○ 3	○ 4
6) Noise Sensations (popping, grinding, cracking)	○ 1	○ 2	○ 3	○ 4	○ 1	○ 2	○ 3	○ 4
7) Joint Stiffness	○ 1	○ 2	○ 3	○ 4	○ 1	○ 2	○ 3	○ 4

2. Please indicate whether you walk with a limp. ○ None ○ Mild ○ Moderate ○ Severe

3. At your **highest level of activity**, do you experience any difficulties while performing the following tasks:

	NONE	MILD	MODERATE	SEVERE
1) Walking	○ 1	○ 2	○ 3	○ 4
2) Squatting	○ 1	○ 2	○ 3	○ 4
3) Ascending Stairs	○ 1	○ 2	○ 3	○ 4
4) Descending Stairs	○ 1	○ 2	○ 3	○ 4
5) Running	○ 1	○ 2	○ 3	○ 4

Rate the following on a scale from 10 to 1.	BEST									WORST
4. Your **current** activity level in **Sports**.	○ 10	○ 9	○ 8	○ 7	○ 6	○ 5	○ 4	○ 3	○ 2	○ 1
5. Rate your **current** activity level in **Activities of Daily Living**.	○ 10	○ 9	○ 8	○ 7	○ 6	○ 5	○ 4	○ 3	○ 2	○ 1
6. Rate your **current** ability to do **Strenuous Work** (vigorous activities).	○ 10	○ 9	○ 8	○ 7	○ 6	○ 5	○ 4	○ 3	○ 2	○ 1
7. Rate your **current** ability to do **Sedentary Work** (sitting activities).	○ 10	○ 9	○ 8	○ 7	○ 6	○ 5	○ 4	○ 3	○ 2	○ 1

Rate the following on a scale from 10 to 1.	Very Satisfied				Neutral					Very Unsatisfied
How satisfied are you with your current OUTCOME?	○ 10	○ 9	○ 8	○ 7	○ 6	○ 5	○ 4	○ 3	○ 2	○ 1

FIGURE 1. A subjective questionnaire was administered before surgery and at yearly intervals postoperatively.

had a previous chronic 1 × 1 cm patella and 1 × 1 cm trochlear lesion) fell 2 years after surgery and experienced patellofemoral pain requiring a Fulkerson osteotomy. The other patient, who had persistent pain at 3 years, required a repeat microfracture of the medial femoral condyle. The data from these 4 patients were deleted from our analyses.

Of the 72 patients (75 knees) meeting the inclusion criteria, 71 knees were available at final follow-up. Our follow-up rate was 95% (71 of 75 knees). The scores at final follow-up for various symptoms and functional activities are shown in Table 2. There was improvement of all parameters comparing the preoperative scores with the postoperative scores. Pain and swelling decreased over the study period ($P < .001$). Pain decreased from preoperative scores to scores at 1 year ($P < .001$) and from year 1 to year 2 ($P < .022$); however, little change was seen from years 2 to 7 (Fig 2A). The WOMAC pain scores showed 23 knees to be pain free at final follow-up; 38 knees had mild pain and 10 had moderate pain. Swelling also decreased from preoperative scores up to year 3 ($P < .017$). Swelling did not change from years 3 through 7 ($P < .810$) (Fig 2A). Patients' ability to do activities of daily living, strenuous work, and sports improved from preoperative scores to scores obtained at year 1 and year 2 ($P < .01$). Little change was seen from year 2 to year 7 ($P > .20$) (Fig 2B).

Although the average pain scores showed improvement after surgery, not all knees improved (Fig. 3). Postoperative pain levels improved over preoperative levels at year 3 ($P < .001$), year 5 ($P < .001$), and at year 7 ($P < .001$). At 3 years after microfracture, the pain scores in 11 of 71 knees were unchanged. However, of the 11 knees with unchanged pain scores at 3, 5, and 7 years, 5 knees had none or mild pain scores preoperatively but required surgery for persistent swelling and discomfort. Three of the 71 knees had increased pain postoperatively.

A similar trend was seen when evaluating the pa-

TABLE 2. *Descriptive Statistics of Study Population at Final Follow-up (71 Knees)*

Variable*	Mean	SD	Range
Follow-up (yr)	11.3	1.8	7.0-17.0
WOMAC: pain	2.3	2.5	0-8
WOMAC: stiffness	1.9	1.4	0-6
WOMAC: function	7.2	7.6	0-27
SF-36: general health	92.6	11.4	60-100
SF-36: physical function	89.9	17.8	33-100
SF-36: bodily pain	84.7	16.0	35-100
SF-36: role limitation	92.5	22.7	0-100
Lysholm	88.9	7.3	66-100
Lysholm change†	30.1	12.3	4-61
Tegner	5.8	1.5	2-9
Tegner change†	2.7	1.7	−1-6
Patient satisfaction	8.3	1.6	4-10
Pain	1.9	0.5	1-3
Pain change†	−1.5	0.9	−3-1
Swelling	1.5	0.6	1-3
Swelling change†	−1.5	1.0	−3-1
ADL	8.1	1.5	4-10
ADL change†	2.8	2.6	−3-8
Strenuous work	7.6	2.0	1-10
Strenuous work change†	2.7	3.0	−4-9
Sports	7.1	1.8	1-10
Sport change†	2.9	3.4	−4-8

*Five scoring systems were used to evaluate the patients and their knees. WOMAC score (best = 0): pain on a scale of 0 to 20; stiffness, 0 to 8; function, 0 to 68. SF-36 score, on a scale of 1 to 100 (100 = best). Lysholm, a knee-specific score, on a scale of 1 to 100 (best = 100). Tegner, an activity score, on a scale of 1 to 10 (best = 10). Satisfaction and items listed through sport change are results of our questionnaire. It was self-administered preoperatively and annually postoperatively for the 7 years.

†At $P < .05$, these changes between preoperative and final follow-up scores were significant.

TABLE 3. *Multivariate Analysis:* Linear Regression Model With Backwards Selection Using Lysholm Scoring System*

Variable	Standardized Regression Coeffient (B)	*P* Value
Age	−0.299	.011
Chronicity	−0.084	.466
Location	−0.226	.066
Size of lesions	−0.146	.225

*Model $R^2 = 0.193$. Statistical analysis was performed with SPSS (version 9.0; SPSS, Chicago, IL) and SAS (version 6.12; SAS Institute, Cary, NC) software packages.

tients' ability to do strenuous work. By year 7, 4 of 71 knees had limitations that eliminated the patients' ability to do strenuous work. All patients' Lysholm scores improved at final follow-up compared with their scores preoperatively. Activity level, as measured by the Tegner scale, improved or remained unchanged in all but 1 patient, whose activity level decreased by one grade.

The results of factor analysis showed that increased age was associated with less improvement in Lysholm scores at final follow-up ($P < .018$; $r = -.28$). Patients younger than 35 years had greater improvement in Lysholm scores than patients 35 to 45 years old ($P < .048$). There was little association between chronicity and improvement in Lysholm scores at final follow-up ($P < .404$; $r = -.101$). Larger lesion size was associated with improvement in Lysholm scores at final follow-up ($P < .048$; $r = .232$). However, the preoperative Lysholm score (55) for knees with large lesions (> 400 mm^2) was lower than the score (60) for smaller lesions (< 400 mm^2). Both groups had similar scores at final follow-up. There was no association between location of lesion and improvement in Lysholm scores at final follow-up ($P < .104$; power, 45%).

Multivariate analysis showed one independent predictor of improvement on Lysholm scores. That predictor was age (Table 3). The analysis showed only a trend toward location of lesion being a predictor ($P <$

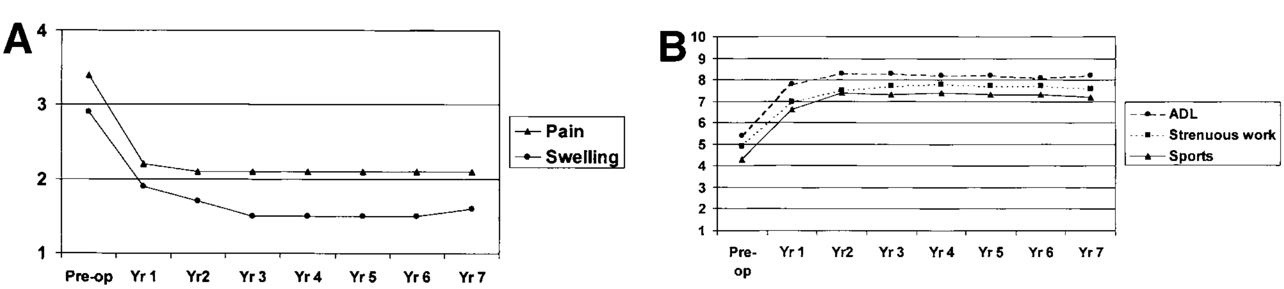

FIGURE 2. (A) Graph of pain and swelling scores from preoperative to year 7 postoperative. 1, no pain or swelling; 4, severe pain and swelling. (B) Graph of function scores from preoperative to year 7 postoperative. 1, unable to perform activities; 10, no limitation in performing activities or strenuous work.

.066) in this study population. No perioperative complications were related to the surgical procedure.

DISCUSSION

The microfracture technique[3,4,14] accompanied by the prescribed rehabilitation[6] decreased symptoms (pain) and improved function in 95% of the study population at up to 17 years' follow-up (a minimum of 7 years' follow-up). The results support our hypothesis.

Our surgical treatment is a combination of techniques that differentiate debridement and microfracture from previous attempts at chondral repair. The microfracture procedure was developed by the senior author (J.R.S.) to enhance chondral resurfacing. The rationale for the microfracture procedure is based on basic science[14,15] and modifications of other procedures recorded in the literature.[16-24] Our practices are supported by Rand,[20] who stated that the healing of articular cartilage requires a source of cells, provision of matrix, removal of stress concentration, and intact subchondral bone plate with some mechanical stimulation. However, the exact nature of the healing tissue is not thoroughly understood at this time. As a result of our extensive basic science and clinical experience with the microfracture technique, we believe that that the high rate of pain relief over a long period is a result of the formation of a durable repair cartilage cap. Our animal studies have shown that this repair tissue is a combination, or hybrid, of fibrocartilage and hyaline cartilage, and it contains about 70% type II collagen at one year.[15] We believe that this regenerate remodels over time and becomes stable repair tissue. Our second-look data suggest that only when persistent grade IV defects remain in the microfracture or if new grade IV lesions in the joint develop, the knees deteriorate.

Previous attempts have been reported for the treatment of cartilage defects. Pridie[21] pioneered the drilling procedure, but the results in approximately 50% of his patients were hampered by postoperative stiffness due to the arthrotomy. Other reports[22,23] of abrasion plus drilling versus abrasion alone revealed no difference in the subsets, but the abrasion plus drilling group's defects were more severe preoperatively than the defects of the group treated by abrasion alone. Childers and Ellwood[24] noted a significant difference in failure rates in patients over 30 years of age undergoing abrasion and drilling. Our data also show that age over 35 (compared with under 35 years old) is a negative predictor. None of these earlier studies[21-24] used an extensive reporting system, such as ours, with standardized reporting instruments. Therefore, comparisons are not possible. With standardized scores for function and scales for activity levels, we will be able to compare results with other authors.

Recently, the technique of treating femoral condyle lesions with periosteal resurfacing plus cell autografting (autologous chondrocyte implantation) has been described.[25] Early results are promising; however, this technique requires 2 surgical procedures rather than one, as well as cell culture procedures. Other open biological resurfacing procedures, such as perichondral autografts,[26] mosaicplasty,[27-28] and shell allografts[29-30] have been attempted with varying success rates. In our opinion, an open procedure should seldom be used as the initial procedure. Furthermore, we cannot compare our results to these results because the methods of analyses differ.

In our study, the indication for surgery in each patient was a painful knee, finding of a chondral defect on magnetic resonance imaging (MRI), or the suspicion of a chondral defect based on history and physical examination, such as point tenderness, catching, intermittent locking, or persistent swelling. All patients who exhibited these indications had 3 months or more of nonsurgical therapy if they presented several months after injury. If the condition did not improve, they were advanced to surgery. Some patients were operated on acutely (less than 3 months after injury) because of a high suspicion of a severe internal derangement of the knee. The diagnosis was confirmed by arthroscopy in each case.

Most improvement occurred in the first year; however, maximum improvement was not seen until 2 to 3 years postoperatively. Patients may complain of ongoing symptoms during the early postoperative period. They need to be counseled preoperatively as well as reassured postoperatively that full recovery takes several years.

The recovery is long because of the physiologic remodeling of the regenerate. Most of our information has come from second-look arthroscopies, with varying degrees of defect filling observed at 3, 6, and 12 months. The speed of this process varies among patients. The length of time for maximum improvement was not expected initially, but similar observations have been noted in other cartilage healing procedures.[25,28-29] Our future work will focus on improving the time to healing and enhancing the quality of the regenerate, perhaps with cytokines, cell therapy, gene therapy, and other newly developed techniques.

The patients who had persistent pain at 3, 5, and 7 years (Fig 3) did not elect to undergo further surgery.

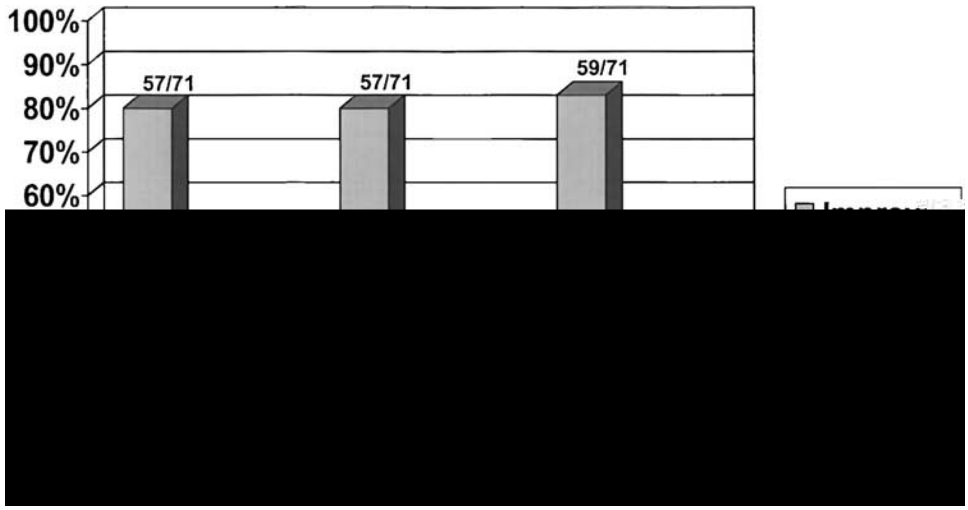

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FIGURE 3. Not all patients had less pain postoperatively. By year 7, some patients considered the pain in their knees unchanged as compared with the preoperative status and a few considered the pain worse postoperatively. More than 80% of the patients rated their knees "improved."

This suggests that many of the unimproved patients chose to live with their disability as opposed to undergoing more extensive procedures. Because the microfracture procedure has low morbidity and minimal risk (no complications in this series of patients) and because patients frequently do not elect to undergo further extensive procedures, one can argue that microfracture is a good initial procedure for the treatment of chondral defects.

The results of factor analysis showed age to be an independent predictor of Lysholm score. Patients under 35 years of age improved an average of 32 points and patients over 35 to 45 years of age improved an average of 26 points. The improvement in function, as indicated by the Lysholm score, supports the use of microfracture in all patients in our study population (ages 13 to 45 years).

We recognize the limitations of our present study, which is not meant to be a randomized controlled study or a study of serial objective observations or MRI observations. It is a functional outcome case series of patients with chondral lesions of the knee who underwent the microfracture procedure, without a concurrent control group. Second-look data without functional outcomes were the subject of another article[2] and are not included in this study. Many more questions need to be answered, such as is the tissue formed after the microfracture procedure fibrocartilage or a combination of hyaline cartilage and fibrocartilage? For example, in an equine model, the microfracture repair cartilage was 48% fibrocartilage and 20% hyaline cartilage.[15] Can further improvement be assured if a higher percent of hyaline cartilage is achieved? Can improvement be detected using serial MRI studies? Is the regenerate durable or does it start to deteriorate after a decade or more? Does the surgically induced marrow clot filling the defect contain natural healing factors?

In summary, we found that arthroscopically performed debridement and microfracture for isolated full-thickness chondral defects in patients under 45 years of age led to significant improvement as measured by the Lysholm scoring system. Scores indicating improvement in pain and function as measured by sequential questionnaires were maintained a minimum of 7 years and up to final follow-up. The majority of patients indicated good to excellent results on SF-36 and WOMAC scoring systems at final follow-up. Given the pain relief ($P < .001$), improvement in function ($P < .01$), and no perioperative complications, we recommend the arthroscopically performed debridement and microfracture procedure as the initial treatment for traumatic full-thickness chondral defects of the knee.

Acknowledgment: The authors thank David Zurakowski, Ph.D., for his review of the statistics.

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