Long-Term Results of Abrasion Arthroplasty for Full-Thickness Cartilage Lesions of the Medial Femoral Condyle

Valerio Sansone, M.D., Laura de Girolamo, Ph.D., Walter Pascale, M.D., Marco Melato, M.D., and Valerio Pascale, M.D.

Purpose: To evaluate the long-term functional results of arthroscopic abrasion arthroplasty for the treatment of full-thickness cartilage lesions of the medial femoral condyle. **Methods:** Between 1990 and 1996, 75 consecutive patients with isolated chondral lesions of the medial femoral condyle were treated with arthroscopic chondral abrasion. A retrospective analysis of the clinical results of this cohort was performed. The patients were evaluated according to the Knee Society Score questionnaire preoperatively, at 10 years postoperatively, and at final long-term follow-up at a mean of 20 years. At final follow-up, they were also assessed according to the Western Ontario and McMaster Universities Osteoarthritis Index. Patients were divided according to the lesion size and by age, and the Kaplan-Meier survivorship function (with second operation taken as an endpoint) for the various groups was calculated. **Results:** At a mean of final follow-up of 20 years (range, 16.94 to 23.94 years), a positive functional outcome (Knee Society Score $\geq$70 points or no reoperation) was recorded in 67.9% of the patients. Twenty-year survivorship in this cohort was 71.4% (95% confidence interval, 0.5690 to 0.8590). The survivorship was 89.5% for patients younger than 50 years and 55.7% for patients aged 50 years or older. The functional results for patients with lesions smaller than 4 cm^2 were significantly better than those for patients with lesions of 4 cm^2 or greater ($P = .031$). There were no statistical differences between patients with and without associated lesions at the time of surgery. **Conclusions:** Our hypothesis that there would be survivorship greater than 86% was disproved. However, arthroscopic abrasion arthroplasty can be a valid treatment for medial femoral condylar full-thickness defects of the knee, even in the long-term, particularly for younger patients and those with smaller lesions. **Level of Evidence:** Level IV, therapeutic case series.

Articular cartilage has very limited repair potential, and the treatment of symptomatic full-thickness chondral defects remains a major clinical challenge. Although a variety of surgical techniques are available, the choice of an evidence-based surgical treatment for chondral injuries remains a dilemma for the orthopaedic surgeon. Bone marrow stimulation, in particular microfracture, is still the first-line treatment for focal articular cartilage defects.[1] Because the natural history of articular cartilage lesions has not been defined, we can assess the success of surgical interventions only by comparing techniques.[2] However, there is a lack of prospective, randomized studies with adequate power to enable a valid comparison among the different surgical treatments.[3] Indeed, there are surprisingly few outcome studies with long-term follow-up to be found in the literature.[4-6]

In the late 1980s, in response to the theories of Lanny Johnson regarding arthroscopic cartilage restoration after abrasion,[7] we began to treat almost all the full-thickness cartilage lesions of the knee that we observed during arthroscopies using Johnson's technique. We were aware that the operation was probably palliative rather than curative, as Johnson[8] later concluded.

Given the lack of conclusive evidence either supporting or rebutting the procedure, we were curious to ascertain the fate of the patients we operated on more than 20 years ago. Therefore we performed a retrospective study aiming to evaluate the long-term functional results of arthroscopic abrasion arthroplasty for

From Università degli Studi di Milano (V.S., M.M., V.P.) and Istituto Ortopedico Galeazzi IRCCS (V.S., L.d.G., W.P., V.P.), Milan, Italy.

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Address correspondence to Valerio Sansone, M.D., Istituto Ortopedico Galeazzi IRCCS, Via R Galeazzi 4, Milan, Italy. E-mail: valerio.sansone@unimi.it

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the treatment of full-thickness cartilage lesions of the medial femoral condyle (MFC). In the absence of a value for the survivorship of an untreated lesion, a benchmark value against which to compare our survivorship results is necessarily arbitrary. However, we decided that the least arbitrary measure to choose would be the longest follow-up in the literature (86% at 5 years).[8] Therefore we hypothesized that there would be a success rate of greater than 86%, taking a second operation as an endpoint.

Methods

In a retrospective chart review of patients treated with chondral abrasion,[7,8] we identified 154 patients who had been operated on between January 1990 and April 1996. Among them, 75 satisfied the following inclusion criteria: isolated full-thickness lesion of the MFC (grade 4 on the Outerbridge scale[9]) and normal surrounding cartilage (maximum of 2 grade 2 lesions). The exclusion criteria were as follows: concomitant procedures such as ligament reconstruction or corrective osteotomy, previous surgery on the index knee, and significant malalignment on preoperative radiographs (>3° variation from the neutral axis) (Fig 1).

The indication for arthroscopic surgery was knee pain for longer than 6 months that had not responded to conservative treatment (oral anti-inflammatory medication, weight loss, activity limitation, and physiotherapy). Full-length, standing radiographs were obtained for all patients preoperatively, and the measurements were made during preoperative planning by the surgical team before the original procedure. All the operations were performed by the same surgeon (V.S.) in a single center, and all full-thickness lesions of the MFC found intraoperatively were treated with chondral abrasion in the reference period.

Operative Technique

After arthroscopic examination of the knee joint, the unstable margins of the full-thickness cartilage lesion were cautiously debrided with an arthroscopic full-radius blade, with the aim of obtaining a realistic measure of the lesion size and achieving stable edges. The area of the lesion was calculated in square centimeters after measuring the 2 main orthogonal diameters (length and width) with a calibrated meniscal probe.[10] Then the abrasion procedure of the eburnated bone was performed with a 4.5-mm spherical motorized burr.[7] The defect bed was lightly and uniformly abraded down to the subchondral plate to a depth of about 2 mm, which allowed for capillary bleeding. When required, a partial meniscectomy was performed. Bleeding was confirmed by arthroscopic visualization after reducing intra-articular pressure. No other marrow-stimulating techniques were performed.

All patients were treated with protected weight bearing using crutches or a walker for at least 6 weeks and then advanced according to patient tolerance. All the patients used continuous passive motion (CPM) that started on the first postoperative day and continued until they were discharged (4 to 7 days). Patients were instructed to continue the use of CPM at home for 6 to 8 hours per day for the following 6 weeks. Range of motion was encouraged as tolerated. Rehabilitation was started in the hospital and continued at home. It initially included stretching exercises, straight-leg raises, and passive motion and then progressed gradually to active closed-chain exercises such as stationary bicycling and, finally, to dynamic weight training.

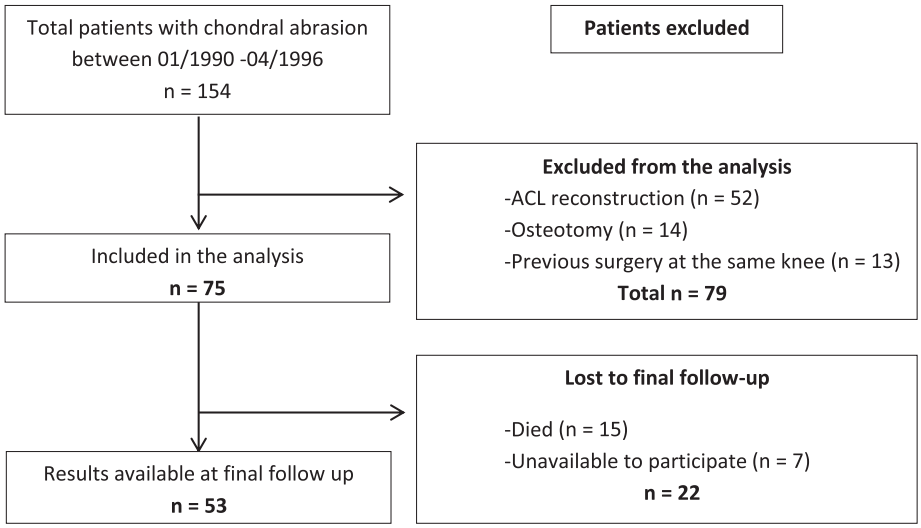

Fig 1. Details of patient cohort. (ACL, anterior cruciate ligament.)

Assessments

Preoperatively and at 10 years' follow up, patients were evaluated according to the Knee Society Score (KSS).[11] Although the 10-year follow-up data were not published, the study was continued by the senior author (V.S.) and a further KSS evaluation was performed at final follow-up. According to the accepted grading system, scores of 70 to 100 points were rated as positive results and scores lower than 70 points were deemed negative results.[11] At final follow-up, patients were also evaluated according to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).[12] The results were analyzed according to patient age at index surgery (≥50 years or <50 years)[13,14] and according to the size of the lesion (<4 cm^2 or ≥4 cm^2). All patients signed an informed consent form for the use of their data for research purposes.

The data were analyzed using the Yates χ^2 test, with significance set at $P < .05$. Kaplan-Meier survivorship curves were plotted (SPSS software; IBM, Armonk, NY).

Results

Among 154 patients treated with chondral abrasion in the reference period, 79 were excluded from this analysis because they did not meet the inclusion and exclusion criteria (Fig 1). Twenty-two patients (29%) were lost to final follow-up, of whom 15 (68%) had died. Therefore we were able to observe the results of 53 patients, of whom 24 (45.3%) were female patients and 29 (54.7%) were male patients. The mean follow-up period was 20.14 ± 1.91 years (minimum, 16.94 years; maximum, 23.94 years). At the time of surgery, the mean patient age was 45.93 ± 16.73 years (minimum, 17.1 years; maximum, 71.24 years). The mean age of female patients was 53.39 ± 15.3 years, whereas that of male patients was 39.82 ± 15.61 years. During the intraoperative evaluation of these 53 patients, 28 (52.8%) were found to have associated lesions (Table 1).

At final follow-up, 34 patients (64.2%) had been treated for medial femoral condylar lesions smaller than 4 cm^2; they had a mean age of 42.4 ± 16.5 years at the time of surgery. The other 19 patients (35.8%) had lesions of 4 cm^2 or greater, with a mean age of 53.4 ± 14.3 years when they underwent chondral abrasion. There were 28 patients (52.8%) who had been younger than 50 years at index surgery and 25 patients (47.2%) who had been aged 50 years or older (Table 2). There was a statistically significant relation between age and size of the lesion ($\chi^2 = 5.871$, $P = .022$).

In our study group, 17 patients (32.1%) reported a negative outcome (KSS <70 points and/or reoperation). Twelve of these patients had subsequently undergone total knee replacement, 1 had undergone unicompartmental knee replacement, and 1 had undergone a second arthroscopy. The mean time to operation of the 13 patients who underwent subsequent partial or total knee replacement was 13.3 ± 2.9 years (minimum, 10 years; maximum, 19 years). The remaining 36 patients (67.9%) reported positive results with good joint function and with either no pain at all or only very slight discomfort. The outcome results by age are given in Table 3. Of the 25 patients who were younger than 50 years at surgery, 84% had a positive outcome after chondral abrasion, whereas approximately half (53.6%) of the 28 patients who were aged 50 years or older had positive results. The relation between age and outcome was also statistically significant ($\chi^2 = 4.607$, $P = .046$).

The results of functional outcome by MFC lesion size are given in Table 4, and they showed a statistically significant correlation between these 2 variables ($\chi^2 = 5.962$, $P = .031$). The improvement in KSS was not statistically significant for larger lesions ($P = .31$). There was no correlation between functional outcome and the presence or absence of associated lesions ($\chi^2 = 1.576$, $P = .312$): Of the 28 patients who had associated lesions, 60.7% had a positive outcome; of the 25 patients without associated lesions, 76% had a successful outcome. There was no significant difference in KSS at final follow-up between patients with isolated MFC lesions and those with MFC lesions associated with a meniscal lesion in 1 or both menisci ($P = .061$).

Kaplan-Meier Survivorship Analysis

The data produced a 20-year survivorship for chondral abrasion of 71.4% (95% confidence interval [CI], 0.5690 to 0.8590) with a second operation as an endpoint (Fig 2). The survivorship function by age is given in Figure 3. For patients aged 50 years or older,

Table 1. Associated Lesions Found Intraoperatively in Patient Cohort at Final (20-Year) Follow-up

Associated Lesion	No. of Patients	% of Cohort
Isolated meniscus lesion	Medial: 12 Lateral: 3	Medial: 22.6 Lateral: 5.7
Lesions of both menisci	4	7.5
Medial meniscus and patellar chondropathy	3	5.7
Medial meniscus and trochlear chondropathy	3	5.7
Medial meniscus, trochlear, and patellar chondropathy	1	1.9
Trochlear chondropathy	2	3.8

NOTE. The final cohort comprised 53 patients.

Table 2. Lesion Size by Age Group in Cohort at Final Follow-up

	Chondral Lesion <4 cm^2	Chondral Lesion ≥4 cm^2
Age <50 yr	21 patients (39.6%)	4 patients (7.5%)
Age ≥50 yr	13 patients (24.5%)	15 patients (28.3%)

Table 3. KSS and Outcomes by Age Group at Final (20-Year) Follow-up

	KSS, Mean ± SD, Points		
	Preoperative	Final Follow-up	Positive Outcome* *v* Negative Outcome†
Age <50 yr (n = 25)	52 ± 10.3	86.3 ± 9.9	21 patients *v* 4 patients (84% *v* 16%) (negative outcomes comprised 1 unicompartmental replacement, 1 second arthroscopy, and 2 patients with KSS <70 points)
Age ≥50 yr (n = 28)	44.6 ± 10.7	67.2 ±11.6	15 patients *v* 13 patients (53.6% *v* 46.4%) (negative outcomes comprised 12 total knee replacements and 1 patient with KSS <70 points)

KSS, Knee Society Score.
*KSS of 70 points or greater.
†KSS of less than 70 points or patients who had undergone reoperation.

the survivorship of the procedure was 55.7% (95% CI, 0.3375 to 0.7765), whereas for patients younger than 50 years at the time of surgery, survivorship was 89.5% (95% CI, 0.7578 to 1.00). Analyzing the data for the presence or absence of associated lesions, we found a 20-year survivorship of 77.8% (95% CI, 0.5859 to 0.9700) for chondral abrasion if there was no associated lesion and of 66.1% (95% CI, 0.4513 to 0.8707) if there was an associated lesion (Fig 4). The survivorship according to lesion size was 53.6% (95% CI, 0.2518 to 0.8202) for lesions of 4 cm^2 or greater and 80.8% (95% CI, 0.6571 to 0.9589) for lesions smaller than 4 cm^2 (Fig 5). Five patients with lesions smaller than 4 cm^2 underwent a later operation, whereas 9 of the 14 patients (64.3%) with lesions of 4 cm^2 or greater underwent further surgery.

Clinical Scores

Preoperatively, the mean KSS was 48.2 ± 17.41 points. The mean KSS was 77.1 ± 22.95 points at 10 years' follow-up and 79.3 ± 11.66 points at final follow-up. When we compared the KSS at 10 years with that at 20 years' follow-up, the outcome remained positive (≥70 points) over time in 30 cases, remained negative (<70 points) in 1 case, improved from negative to positive in 6 cases, and deteriorated from positive to negative in 2 cases. We observed a statistically significant correlation between the scores at 10 and 20 years' follow-up ($P = .044$, $r = 0.371$), whereas there was no significant difference between the median KSS values of the 2 populations ($P = .073$). The mean WOMAC score at final follow-up in 2013 was 87.7 ± 10.4 points (minimum, 60.6 points; maximum, 96 points). There was a strong correlation between the KSS and WOMAC score at final follow-up ($r = 0.892$, $P < .001$).

Discussion

The main finding of this study is that chondral abrasion is a successful procedure for the treatment of isolated, full-thickness lesions of the MFC, even in the long-term. The natural course of untreated full-thickness chondral defects has not been precisely defined; however, it is believed that such defects lead to continued degeneration and unsatisfactory clinical scores.[15] Marrow-stimulation techniques are intended to promote cartilage repair by inducing bleeding from subchondral bone and by creating blood clots that contain mesenchymal cells. These marrow stem cells should differentiate into articular cartilage–like cells, ultimately leading to the development of a durable repair cartilage that fills the original defect and that opposes further degeneration. Among the bone marrow–stimulation techniques, microfracture is currently the preferred choice of many orthopaedic surgeons because it is technically simple, it is inexpensive, and it requires no preoperative planning. It has been used for the treatment of cartilage lesions since the 1990s and has been adopted worldwide. A recent systematic review of the durability and type of repair tissue produced after microfracture treatment reported that the technique can give good clinical outcomes at short-term follow-up in patients with small lesions (mean lesion size <3 cm^2) and that the technique gives better results in younger patients.[1] At longer-term follow-up, beyond 5 years postoperatively, treatment failure after microfracture may be expected regardless of lesion size. In particular, a study comparing microfracture and osteochondral autologous transplantation showed that 3 to 10 years after microfracture treatment, patients had lower functional outcomes, and that

Table 4. KSS and Outcomes at Final (20-Year) Follow-up According to Lesion Size

	KSS, Mean ± SD, Points		
	Preoperative	Final Follow-up	Positive Outcome* *v* Negative Outcome†
MFC lesion <4 cm^2 (n = 34)	51.4 ± 12.9	82.1 ± 10.6	28 patients *v* 6 patients (82.3% *v* 17.7%)
MFC lesion ≥4 cm^2 (n = 19)	42.7 ± 11.8	71.4 ± 17.2	8 patients *v* 11 patients (42.1% *v* 57.9%)

KSS, Knee Society Score; MFC, medial femoral condyle.
*KSS of 70 points or greater.
†KSS of less than 70 points or patients who had undergone reoperation.

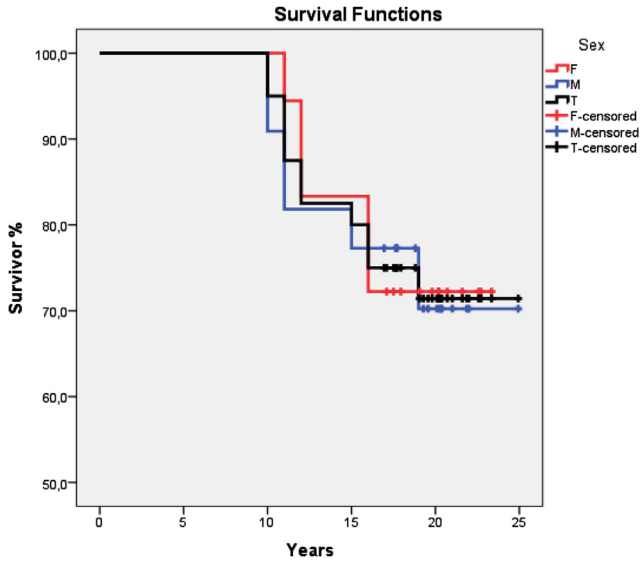

Fig 2. Twenty-year survivorship with second operation as endpoint. (F, female; F-censored, females withdrawing from study [death/reoperation]; M, male; M-censored, males withdrawing from study; T, total cohort; T-censored, total withdrawals from study.)

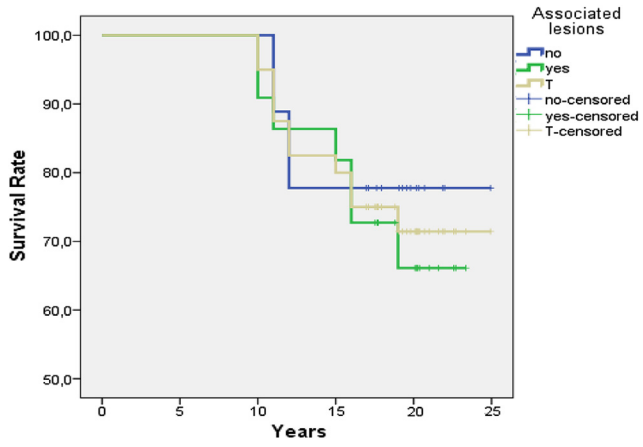

Fig 4. Twenty-year survivorship by absence or presence of associated lesions with second operation as endpoint. (no-censored, patients withdrawing from study [e.g., death/reoperation] who did not have associated lesions at time of surgery; T, total cohort; T-censored, total withdrawals; yes-censored, patients withdrawing from study who had associated lesions at time of surgery.)

at 10 years, only 37% of patients maintained the same preoperative physical activity levels.[4]

In abrasion arthroplasty the superficial layer of the eburnated bone cortex is removed with a motorized burr. In terms of clinical outcome, stabilizing the lesion edges and removing unstable chondral fragments—and thereby eliminating the mechanical symptoms—can achieve immediate relief. However, long-term follow-up is required to judge whether the pain relief will last over time and whether further degeneration of the lesion will occur. Unfortunately, in the literature very few data can be found regarding long-term results after most treatment options for articular cartilage lesions of the knee, and indeed, abrasion arthroplasty is no exception. To our knowledge, the longest follow-up period for abrasion without other associated procedures (e.g. osteotomy) is only 5 years.[8] Furthermore, most studies have included patients with multiple lesion sites without

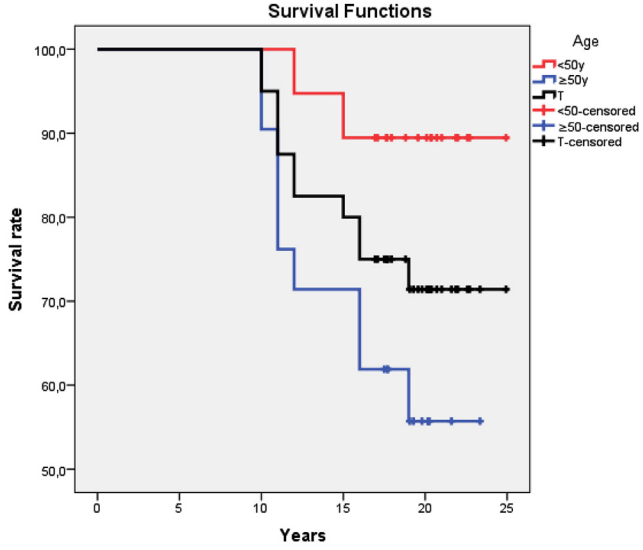

Fig 3. Twenty-year survivorship by age with second operation as endpoint. (<50-censored, patients aged <50 years at time of surgery withdrawing from study [death/reoperation]; ≥50-censored, patients aged ≥50 years at time of surgery withdrawing from study; T, total cohort; T-censored, total withdrawals.)

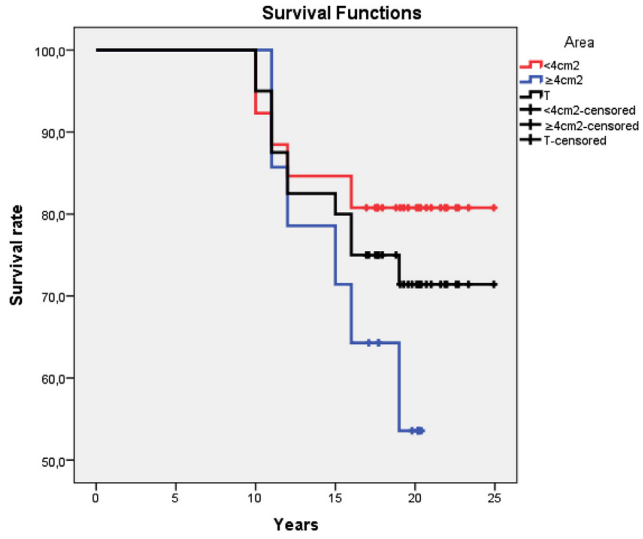

Fig 5. Twenty-year survivorship by size of lesion with second operation as endpoint. (<4cm^2-censored, patients with lesions <4 cm^2 withdrawing from study [e.g., death/reoperation]; ≥4cm^2-censored, patients with lesions ≥4 cm^2 at time of surgery withdrawing from study; T, total cohort; T-censored, total withdrawals.)

differentiating medial from lateral or patellofemoral compartments.[8,16,17] Finally, previous studies failed to exclude patients who have undergone prior procedures. Therefore in this study we have tried to minimize these variables and, hopefully, to offer a clearer understanding of the minimum 16-year follow-up results of abrasion arthroplasty.

In this series there was a 28.3% reoperation rate. The cases of an additional 3 patients (5.7%) who did not undergo reoperation were considered failures at final follow-up because of continued pain and limitation of activity. Reoperation was performed on average 13.3 years after the original procedure. The remaining patients all were pleased with their outcome and had minimal to no activity limitations and either no pain or mild pain with activity. Of the 12 patients who underwent total knee arthroplasty in the follow-up period, 9 initially had lesions of 4 cm^2 or greater. After observing high failure rates and no statistically significant improvement in KSS values for larger lesions in this series, we agree with the findings of other authors that marrow-stimulating techniques should not be performed in patients with lesions of 4 cm^2 or greater.[4,18-22] Indeed, over 80% of patients with lesions smaller than 4 cm^2 had a successful outcome, which is considerably higher than the success rate observed in the whole study cohort (67.9%). Patient age also had a significant effect on outcomes, with patients aged 50 years or older being more likely to have a negative outcome; however, a possible explanation for this finding may be the higher percentage of patients aged 50 years or older with large lesions rather than the patient age itself. Fifty years is the widely accepted cutoff age for regenerative cartilage treatments; indeed, a number of the most recent studies on this topic set 50 years as the age limit for inclusion.[23] Furthermore, several systematic reviews have confirmed that the outcome of regenerative cartilage restoration dramatically declines in patients aged 50 years or older.[1,24] For this reason, the results were analyzed for patients younger than 50 years and patients aged 50 years or older.

An important factor governing the success of the procedure has been shown to be the role of knee alignment. Patients with normal, or nearly normal, weight-bearing films fare better than those with more significant malalignment,[8,25-27] given that the healing potential of cartilage declines as the mechanical status of the joint worsens with deviation from the functional axis.[28,29] Therefore patients with axial deformity greater than 3° were not considered suitable candidates for this procedure. A second important factor is the postoperative rehabilitation protocol; the protocol was similar to protocols reported in the literature after marrow-stimulating surgical procedures. We instructed our patients to use CPM for 6 to 8 hours per day for 6 weeks, with protected weight bearing for 6 weeks. The beneficial effect of articular motion on cartilage nutrition and metabolism is well documented. Clinical studies have shown that CPM significantly increases the rate of macroscopic grading of the repair tissue.[18,30]

Abrasion arthroplasty with and without microfracture of the medial compartment of the knee has shown good short- to medium-term results in treating small lesions in patients without varus malalignment.[8,16] In a 5-year follow-up of 248 patients who had undergone abrasion arthroplasty, Johnson[8] reported an 86% success rate (14% reoperation rate) at 5 years. Although our hypothesis, which was based on this result, has been disproved (we observed a 71% success rate), the length of follow-up is barely comparable. Furthermore, Johnson did not separate patients with regard to chondral lesion location or size.

In comparison, our series of patients with long-term follow-up shows positive results in 82.4% of patients with lesions smaller than 4 cm^2. Our series confirms the finding of Johnson[8] that patients with more advanced degenerative changes fare poorly. Only 8 of the 19 patients (42%) with lesions of 4 cm^2 or greater had successful outcomes. However, it is important to note that although 13 patients in our study went on to undergo either partial or total knee replacement, at least 10 years had elapsed (mean, 13.3 years) before surgery was required. Without a control group, this study cannot show that abrasion arthroplasty may delay the requirement for joint replacement; however, our data seem to support the view that abrasion arthroplasty can be a palliative treatment to postpone more definitive surgery.[8]

Our series has far fewer patients than that of Johnson[8] because our survey was restricted to full-thickness chondral defects of the MFC without significant knee malalignment and without any other associated major surgery (e.g. knee ligament reconstruction or tibial or femoral osteotomy). However, by having strict inclusion and exclusion criteria, we believe that patient outcomes are more representative of the specific pathology in question—isolated MFC full-thickness chondral lesions. We attempted to minimize patient variables by limiting the inclusion criteria to patients who underwent MFC abrasion arthroplasty and by eliminating patients with multicompartmental or ligamentous pathology. This greatly decreased the number of patients in the study group; however, we have achieved a more homogeneous patient group from which relevant data may be gleaned.

Abrasion arthroplasty is a technically simple and low-cost procedure compared with other treatment options for full-thickness chondral injury. Our results suggest that patients with larger lesions are not appropriate candidates for abrasion arthroplasty and, therefore, other treatment options may be more

appropriate in these cases. In addition, it may be important for the surgeon to differentiate between traumatic chondral lesions and a generalized degenerative chondral surface regardless of the actual size of the full-thickness lesion.

Limitations

The limitations of this study include the retrospective, uncontrolled, nonrandomized nature of the study, as well as our hypothesis of 86% survivorship, which is arbitrary and unduly overly optimistic given that it is based on a midterm survivorship figure observed by Lanny Johnson, the author of the procedure. The number of patients is relatively small given the highly specific nature of the pathology we wished to study; furthermore, given the mean 20-year follow-up, there was inevitably a high rate of patients lost to final follow-up. However, given the lack of controlled prospective trials and the short- to medium-term follow-up of the few published studies, we believe that this survey, though with its evident limits, can represent a useful contribution to the understanding of the long-term efficacy of abrasion arthroplasty in the treatment of full-thickness cartilage lesions. These are the longest-term results reported in the literature for a marrow-stimulating technique performed on consecutive patients by a single surgeon for a single-site chondral lesion and, as such, may provide a benchmark with which to compare other techniques. It remains to be seen whether the newer, technically demanding, more invasive and economically expensive procedures may show clear superiority at long-term follow-up over this simple, minimally invasive and cost-effective option for the management of focal chondral defects of the knee.

Conclusions

Our hypothesis that there would be survivorship greater than 86% was disproved. However, arthroscopic abrasion arthroplasty can be a valid treatment for medial femoral condylar full-thickness defects of the knee, even in the long-term, particularly for younger patients and those with smaller lesions.

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