The Egyptian Journal of Hospital Medicine (October 2017) Vol. 69 (8), Page 3021-3028

Assisted Arthrscopic Microfracture Treatment of Osteochondral Lesions of The Knee

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ABSTRACT

Background: chondral injuries in the knee are a common source of pain and morbidity. Treatment of symptomatic chondral defects is challenging due to the limited healing capacity of articular cartilage. Microfracture is the most common surgical technique used to treat chondral defects in the knee and utilizes marrow stimulation to generate a fibrocartilage repair. Microfracture has demonstrated good short-term postoperative outcomes. Long-term outcomes following microfracture are variable, with loss of improvement attributed to the poor mechanical qualities of the fibrous repair tissue.

Aim of the work: this prospective study with a 12 months follow-up was conducted to determine the efficacy of microfracture in the postoperative follow-up. We prospectively followed up these patients preoperatively and postopertively, clinically and radiologically. The final diagnosis was confirmed during arthroscopy.

Patients and Methods: thirty symptomatic patients with articular cartilage defects of the knee were treated with the microfracture technique. Prospective evaluation of patient outcome was performed for a minimum follow-up of twelve months with a combination of validated outcome scores, subjective clinical rating and cartilage-sensitive magnetic resonance imaging.

Results: at the time of the latest follow-up, knee function was rated good to excellent for twenty patients (60%), fair for four patients (13%) and poor for eight (26%). A lower body-mass index correlated with higher scores for the activities of daily living, with the worst results for patients with a body-mass index of >30 kg/m2. Significant improvement in the activities of daily living score was more frequent with a preoperative duration of symptoms of less than twelve months ($p < 0.05$). Magnetic resonance imaging in 15 knees demonstrated good healing in tissue fill of eight patients (54%), moderate fill in four (29%) and poor fill in three patients (17%). The fill grade was correlated with the knee function scores. All knees with good fill demonstrated improved knee function, whereas poor fill grade was associated with limited improvement and decreasing functional scores after twelve months. **Conclusions**: microfracture healing of articular cartilage lesions in the knee results in significant functional improvement at a minimum follow-up of one year. The best short-term results were observed with good fill grade, low body-mass index and a short duration of preoperative symptoms. A high body-mass index adversely affects short-term outcome, and a poor fill grade was associated with limited short-term durability.

Keywords: microfracture (MF), oesteochondral defect (OCD), articular cartilage, knee, arthroscopic and athlete.

INTRODUCTION

An osteochondral defect (OD) is a lesion involving the articular cartilage and its subchondral bone. If only cartilage is involved in the pathology, the term chondral defect is used. Many synonyms are used, including osteochondritis dissecans, transchondral fracture, flake fracture, talar dome fracture, osteochondral fracture, osteochondral lesion and osteochondral defect [(1)].

Full-thickness articular cartilage defects only have limited regenerative potential. Thus, spontaneous healing is unlikely. Untreated full-thickness cartilage lesions are usually associated with significant pain and swelling. Moreover, patients have an increased risk of subsequent osteoarthritis which is a major cause of disability and represents a significant socioeconomic burden [(2)]. Various treatment options exist including nonoperative treatment, debridement with or without bone marrow stimulation, autologous chondrocyte implantation, allograft transplantation and osteochondral autograft transplantation or mosaicplasty. Despite advancements in some of these options, arthroscopic debridement combined with bone marrow stimulation is still the best currently available treatment [(3)]. The microfracture technique often is considered the golden standard therapy for the treatment of cartilage defects. The first results and the technique were published in 1994.The microfracture procedure was originally designed for patients with post traumatic lesions of the knee that have progressed to full thickness chondral defects. Unstable cartilage that overlies the subchondral bone also is an indication for microfracture as well as degenerative changes in the knee joint with proper

Received: 23/08/2017 DOI: 10.12816/0042850
Accepted: 2/09/2017

axial alignment. The technique has been developed by **Steadman** to enhance chondral resurfacing by providing an enriched environment for tissue regeneration and by taking advantage of the body's own healing abilities [(4)]. Microfracture technique, performed through arthroscopy as described by **Steadman *et al.*** [(5)]; it is a simple, cost-effective, popular treatment option for cartilage defects. The biological rationale of microfracture technique is to establish a super clot to provide a suitable environment for a viable population of mesenchymal stem cells from the marrow to differentiate into stable tissues within the lesion.

Unfortunately, fibrous tissue and fibrocartilage contain a high proportion of type I collagen, while the properties of the articular cartilage are determined by the matrix macromolecules. Type II collagen gives cartilage, tensile stiffness and strength. Type IX collagen helps to organize the meshwork of type II collagen fibrils [(6)].

Furthermore, microfracture was attractive because of the minimal iatrogenic damage associated with its use, so that once performed it did not preclude the use of other future procedures(Microfracture does not burn any bridges) [(7)]

PATIENTS and METHODS

From July 2014 to Septmber 2015, thirty patients underwent microfracture technique for full thickness osteochondral lesion of the knee in Deaprtment of Truma and Orthopedic Surgery in Menofia University Hospital.

Twenty six patients (86%) were male and four (13%) were female, with an average age and standard deviation of 32±8.9 years (range, 14 to 49), all of the patients were presented without prior surgery on the affected knee. The preoperative duration of symptoms averaged 28 ± 60 months (range, one to 375 months). Each patient was interviewed and asked to fill up a questionnaire regarding the type and level of sports participation according to the Tegner scale, previous knee problems and/or surgery, with special attention given to determine when the problem raised and the etiology of the lesions. Preoperative Lysholm score was determined, as well as the Tegner activity level prior to the onset of symptoms and prior to surgery. Intraoperatively, the location and the size of the lesions as well as the associated pathologies were recorded.

At final follow-up, the patients were asked to fill up another questionnaire to assess subjective function and symptoms. They were asked to score the operated knee, considering the contra lateral normal knee as 100%. Sport activity level prior to surgery, at one year postoperative, and at final follow-up were compared. Clinical examination was performed at final evaluation by an independent examiner to compare with the findings prior to surgery. Knee Lysholm were utilized for final assessment. Functional test (one leg hop) was also performed comparing the operated with the normal leg with a series of three jumps. A comprehensive literature search was compiled using Medline, Cinahl, and Google. Literature was reviewed and weighted towards relevance at answering the hypothesis. These results were then compiled and analyzed.

INCLUSION CRITERIA: the criteria for inclusion were full-thickness chondral defects grade II, III and IV, according to the International Cartilage Repair Society (ICRS)-classification system , with history of truma or not, also if the lesions associated with meniscal or ligamentous injury or not.The lesions were sized between 1 and 4 cm2 and had to be localized in only one of the three knee compartments (medial femoro-tibial joint, lateral femoro-tibial joint or patello-femoral joint). Furthermore the study population was limited to patients between 14 and 55 years of age.

EXCLUSION CRITERIA: excluded were patients with Rhumatoid arthritis, varus or valgus deformities with a malalignment over 5 degree, patella malalignment with medial or lateral shift of more than 0.5 cm, , infection or previous arthrscopic intrervention.

For this purpose the patients had to answer standardized questionnaires and were examined by an orthopaedic surgeon preoperatively and 6 and 12 months after surgery. Varus or valgus deformities were excluded by X-ray of the whole leg. The correct patella position was detected by a routine medio-lateral, patello-femoral and axial joints radiographs.

All surgery was performed by the same surgeon and all patients followed the same postoperative rehabilitation program. During preoperative clinical examination of the knee, the following were recorded: pain, crepitus, swelling and limitation of function.

Detailed information on surgical interventions was provided to all patients. An informed consent form concerning the operative technique to be performed was signed by all patients. The patients were enlightened about the rehabilitation program to be instituted.

Surgical technique: the operations were performed according to the technique described by **Steadman *et al.*** [5] except that we used only two portals for the arthroscope and the working instruments. We did not use a tourniquet routinely. An initial thorough diagnostic examination of the knee was done. After preparation of the bed, we used an arthroscopic awl with an angle that allowed the tip of the awl to be perpendicular to the subchondral bone surface.

We made multiple holes (Microfractures) in the exposed subchondral bone plate around the periphery of the bed immediately adjacent to the healthy cartilage rim then we made our way into the center of the defect. The awls were advanced with a mallet. The holes were made as close together as possible, but not so close that one hole was broken into another, thus damaging the subchondral plate between them. Usually the holes were about 3 to 4 mm apart. Once the holes were completed, the irrigation fluid pump pressure was lowered to visualize the release of fat droplets and blood from the microfracture holes into the knee.

All instruments were then removed. We did not routinely use an intra-articular drain. Typically, other necessary intra-articular procedures were done first before doing microfracture, with the exception of anterior cruciate ligament reconstruction. The postoperative rehabilitation program was carried out as suggested by Steadman. All patients were immediately placed on a continuous passive motion machine (CPM) and cold therapy was started. Patients with lesions in the weight bearing surfaces began CPM initially at a range of motion (ROM) of 10–70°.

The study was approved by the Ethics Board of Menofia University.

Statistical methodology

The data collected were tabulated and analyzed by SPSS (Statistical Package for the Social Science Software) statistical package version 22.0 on IBM compatible computer. Quantitative data were expressed as mean and standard deviation (X+SD) and they were analyzed by applying student t-test for comparison of two groups of normally distributed variables and Mannwhiteny U test for none normally distributed ones.

Qualitative data were expressed as number and percentage (No & %) and analyzed by applying chi-square test. Whenever the expected values in one or more of the cells in a 2x2 tables was less than 5, fisher exact test was used instead. All these tests were used as tests of significance at $P<0.05$.

RESULTS

In this study, 30 patients were examined arthroscopically in Department of Truma and Orthopedic Surgery at Menofia University Hospital. There were 26 males and 4 females with mean age of 32±8.9 years. There was evident history of trauma in 21 patients and no definite history of trauma in 9 patients (**Table 1**).

Table 1: demographic of the studied patients.

Variables		No	%
Sex	male	26	86.7
	femal	4	13.3
Age	≤35	17	56.7
	>35	13	43.3
mean±SD	32±8.9		
median	33		
range	14 - 49		

X ray was normal in 15 patients, OCD was detected only in one patient. MRI showed M.M injury in 15 patients , LM injury in 5 patients, bilateral meniscus injury in 5 patiens and torn ACL in 3 patients . MRI detected chondral lesion in 5 patients**.**

No intra- or post-operative complications were observed. None of the patients needed further operative treatment during the follow-up period. During the follow-up period, there were no clinical signs of knee joint infection or inflammation. There were no allergic reactions, no foreign body reactions, and no abnormal knee joint effusion or swelling. Chondral lesions grading according to ICRS classification was grade 2 in 10 patients, grade 3 in 16 patients and grade 4 in 4 patients (**Table 2).**

Table 2: showing grade of chondral lesion according to ICRS.

Grade of osteochondral lesion	No	%
2	10	33
3	16	53
4	4	13
Total	30	100

Scopic examination revealed isolated chondral lesion in 2 patients, chondral lesion associated with meniscal injury in 23 patients and chondral lesion was associated with torn ACL in 3 patients. chondral lesion affected medial femoral condyle in 22 patients, lateral femoral condyle in 6 patients and kissing lesion affect medial femoral condyle and medial tibial condyle in one patient (**Table 3).**

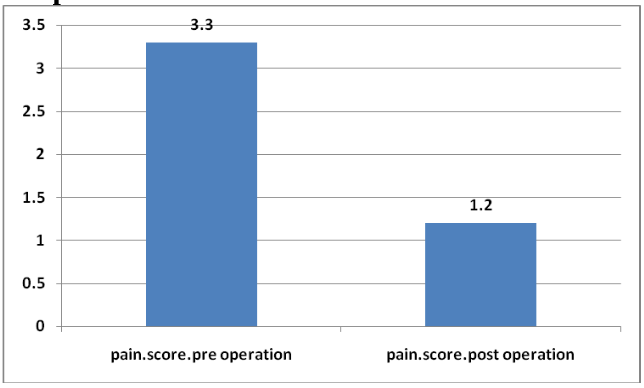
Table 3: showing OCD location.

Diagnosis	No	%
OCD	30	100
PATELLA	1	3.3
LFC	6	20
L.M.TEAR	4	13
MFC	22	73
MM.TEAR	15	50
ACL.TEAR	3	10
MULTIPLE.LOOSE.BODIES	1	3.3
OESTEOMALICIA	1	3.3
BILATERAL.MENISCUS.TEAR	4	13
LARGE.MEDIAL.PLICA	2	6.7
MFC.AND.MTC	1	3.3
LOOS.BODY	1	3.3
BACKERS.CYST	1	3.3

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).

Clinical data on patients without failure were collected until the postoperative year. The mean pain score improved significantly (p<0.001) from 3 to 1 postoperatively **(Table 4 & Graph 1), and** the mean Lysholm score increased from 61 before surgery to 90 after surgery (p<0.001) revealed 12 excellent, 6 good, 4 fair and 6 poor scores (**Table 5 and graph 2).**

Graph 1



Graph 2

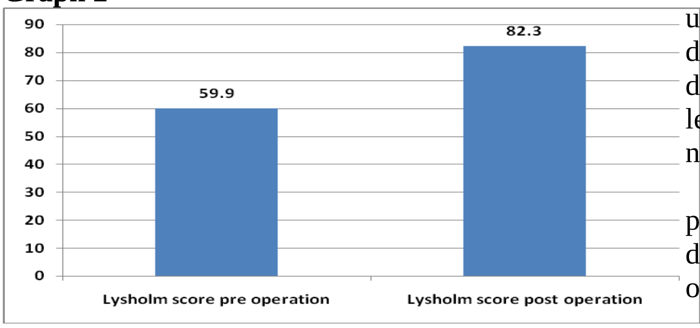


Table 4 : pain score pre op and post op

	outcomes.pain.score.pre.up	outcomes.pain.score.post.op	t.test	p.value
mean±SD	3.3±0.47	1.2±0.9	11.6	<0.001
median	3	1		
range	4-Mar	0-3		

Table 5: Lysholm score pre op and post op.

	ysholmscore preoperation	ysholmscore post operation	.test	.value
nean±SD	9.9±17.9	2.3±10.1	7.05	<0.001
nedian	1	0		
ange	5-82	9-99		

- ✓ OCD : OSETEOCHONDRAL DEFECT.
- ✓ M.M : MEDIAL MENISCUS.
- ✓ L.M : LATERAL MENISCUS .
- ✓ ACL : ANTERIOR CRUIATE LIG.
- ✓ MFC : MEDIAL FEMORAL CONDYLE.
- ✓ LFC : LATERAL FEMORAL CONDYLE.
- ✓ MTC : MEDIAL TIBIAL CONDYLE.
- ✓ ACI: AUTOLOGUS CHONDROCYTE IMPLANTATION.
- ✓ MF: MICROFRACTURE.
- ✓

DISCUSSION

The natural history of chondral lesions may be difficult to predict, as some authors think that many lesions are non-progressive and remain asymptomatic, while others believe that even small asymptomatic lesions may increase in size and eventually become painful if left untreated Furthermore, some people who sustain articular surface injury do not seek treatment [(8)].

Full-thickness chondral defects were encountered in a significant number of patients underwent knee arthroscopy. In a large, retrospective series, **Curl *et al*.** [(9)] found that 19% of patients underwent knee arthroscopy had grade IV chondral defects. An untreated, full-thickness chondral defect did not possess intrinsic healing potential and often leads to worsening symptoms and joint deterioration, notwithstanding the occasional study to the contrary

Cartilage defects left untreated for prolonged periods may lead to the development of early degenerative joint changes, particularly at the margin of the defects, perhaps explaining the inferior results that have been observed with late repair in our study and other investigations. Our findings, therefore, further emphasize the importance of early surgical treatment of articular cartilage lesions[10].

In the early 1990s, Steadman started his trial with microfractures and in **1994**, **Rodrigo *et al.*** [11] reported their results. Starting on July 1991, we decided to adopt their technique in athletes for the following reasons: minimally invasive, technically simple and low-cost procedure, preservation of the subchondral bone plateand most important, possibility for future treatments [12].

In this study 30 patients with knee problem were examined, investigated and scoped for their lesions. The aim of our work was to define grade and locate the chondral lesions in these patients. 2 patients had isolated chondral lesion (6.7%), 23 patients had chondral lesion with meniscal injury (77%), 3 patients had chondral lesion with ACL injury (10%). The chondral lesion affected young age below 35 years (56.7%) with 43.3% in older age. In this study, chondral lesion was graded according to ICRS and we found that 33% of patients had grade 2, 54% of patients had grade 3, while 13% of patients had grade 4. Management of any associated injuries in these patients was done as reconstruction of torn ACL or partial menisectomy for meniscal injury. **Travis *et al***. [13] stated that management of associated conditions such as malalignment, ligament insufficiency and or meniscal injury was essential for a successful outcome of chondral repair.

Development and implementation of the microfracture technique began in the early 1980s. The goal of the microfracture procedure was to create a combination of surgery and rehabilitation that would allow for cartilage repair**. Pridie** and others had written about methods of accessing bone marrow cells and their procedures showed moderate success. The microfracture surgical technique was developed by the senior author and coupled with a specifically designed rehabilitation program [14].

The microfracture technique was traditionally considered a superior to subchondral drilling as the use of an awl theoretically eliminated the risk of thermal necrosis of the subchondral bone that occurred with a hand-driven or motorized drill. A study challenged the validity of this claim [15] .

Bleeding occurring after the procedure leads to the formation of a hematoma, which fills the defective region. Hematoma forms a fibrin plug in the area of the defect. The development of the fibrovascular repair tissue (i.e., granulation tissue) ensues. Mesenchymal stem cells stemming from the subchondral bone proliferate and transform into chondrocytes under the influence of local growth and environmental factors [16]. At 6 to 8 weeks, fibro cartilaginous and hyaline-like tissue emerges. During these weeks, numerous chondrocytes in repair tissue were present. The cartilage tissue formed can fill the defect partially or completely. When the healing tissue was analyzed at 8 weeks, it was observed that it consisted of fibrous tissue (29%), fibro cartilaginous tissue (30%), granulation tissue (12%), bone tissue filling the defect (10%) and hyaline-like cartilage tissue (12%) [1].

The quality of the repaired tissue was still a matter of discussion. According to **Yoon**, significant amounts of type II collagen formation were verified after micro fracture in osteoarthritic knees [17].

Persistent gaps between the native and repair cartilage were observed in 92% of the micro fracture repairs. This finding is consistent with observations in previous clinical and laboratory studies, which have demonstrated failure of peripheral integration of the repair cartilage after micro fracture in as much as 53% of the repairs. This failure of peripheral integration is believed to increase the vertical shear stresses between repair and native cartilage, thereby promoting micro motion and degenerative changes [18]. The significance of MRI in the diagnosis of associating injury to chondral lesion as torn ACL or M.M injury was evident in this study , these results also were reported by **Scopp *et al.*** [8] they reported that MRI is important in diagnosis of chondral lesion because it fascilitates the diagnosis of concomitant injuries [19].

Steadman *et al*. [5] noted an improvement of pain in 75% of patients with full thickness articular cartilage lesions 3 years after treatment, with a 68% improvement in activities of daily living. The same authors observed postoperative Lysholm score of 83.1 and Tegner activity scale score of 4.5 in a group of patients with degenerative knee. In a study carried out by **Gill *et al.*** [20] they found that 86% of patients were able to go back to their previous level of sports after microfracture for traumatic cartilage defects despite the observed average score decrease, activity and functional outcome remained improved compared to preoperative function scores in most athletes. The reasons for the observed functional decline after microfracture were not completely understood. Deterioration of knee function occurred primarily in athletes with poor repair cartilage morphology and fill after microfracture [21]. However, decreasing knee function was also observed in some patients with good repaired tissue volume, and other factors must be considered. Limited peripheral integration of the repair cartilage tissue may contribute to the decreasing activity scores observed after micro-fracture because it increases vertical shear stresses between repair and native cartilage and promotes cartilage degeneration [22]. This study demonstrated that microfracture arthroplasty resulted in increased functional scores in patients treated for symptomatic cartilage lesions at a minimum follow-up of one years. The overall clinical results with microfracture in our study have shown improved knee function in 70% to 95% of patients. **Steadman *et al*.** [20] reported that their patients had substantial increase in the ability to perform the activities of daily living, strenuous work and sports after microfracture.

Similar to our findings**,** outcomes following microfracture surgery have been variable. Short-term results of microfracture have consistently demonstrated clinical improvement. In their study, **Mithoefer *et al*.**[23] found that microfracture demonstrated excellent short-term efficacy with functional outcomes improving in 75% to 100% of patients at 24 months. However, after 24 months, 47% to 80% of patients demonstrated a decline in function from their initial improvement. This was consistent with the decline in the long-term improvement rate to 67% to 85% at 6 to 7 years and an increased failure rate between 2 and 5 years postoperatively [23].

What are the factors that affect outcome?

The factors responsible for the development of osseous overgrowth had not been defined, but excessive removal of the subchondral bone plate during debridement or removal of the calcified cartilage layer may promote vascularization of the base of the repair tissue and provide a stimulus for endochondral ossification [24].

Our study demonstrated the clinical importance of body-mass index on functional outcome after micro-fracture repair of articular cartilage in the knee. In particular, a high body-mass index (>30 kg/m2) was associated with a significantly poor functional outcome after microfracture. Increased cartilage degradation was shown in osteoarthritic patients with a body-mass index in excess of 25kg/m2. This was thought to result from increased cartilage matrix catabolism in that patient population, and the same mechanism may be at work affecting the repair cartilage after microfracture [25]. Surface shearing, the creation of longitudinal disruptions in the subchondral plate, was associated with penetration angles deviating >20 degrees from the perpendicular, and with penetration depths >4mm [26]. Both infarction and surface shearing destabilized the subchondral bone plate; however, the clinical impact of the technical errors seen in this study was still unknown [23].

Does age or lesion location affect the outcome of microfracture ?

Located on the weight-bearing segment of the femoral condyle, a small lesion, which was well circumscribed, was protected during loading of the joint by the margins of the lesion that act as shoulders to maintain axial height of the tibiofemoral articulation. Presumably, in this instance, weight bearing would not deter the migration of undifferentiated mesenchymal cells into the clot filling the chondral defect or their subsequent proliferation and differentiation into fibrocartilage tissue at a minimum or hopefully, predominantly hyaline-like tissue [27].

Knowledge of the differences in survival in relation to specific variables provided surgeons with the appropriate indications for performing microfracture. Age >40 years and symptom duration >12 months were negative predictors. It was reasonable to believe that a lesion in a young individual will tend to heal better than a lesion in an old individual because the pool of chondrogenic cells is larger in the young [28].

Does lesion size influence outcome with microfracture ?

The size threshold in athletes at 2 cm2 was smaller than the threshold of 4 cm2 reported for the general population treated with micro-fracture, reflecting the increased demands on the cartilage repair in the demanding athletic population [29].

On the basis of experimental and clinical studies, the use of continuous passive motion (CPM) of the knee together with a period of non-weight bearing had been widely adopted for the management of chondral defects, especially after microfracture. **Salter *et al***. [30] stated that perhaps the most influential investigators to advocate the use of CPM in conjunction with biologic resurfacing procedures, were believing that the quality of chondral repair tissue was markedly improved by the “dynamic compression” that modulated the regenerative potential of chondrocytes [1].

Return to Sport

The ability of the athletes to return to sport at the pre-injury level was evaluated in each study. **Blevins *et al.*** [31] reported that 77% of athletes returned to sporting activity and 71% of those athletes felt that they returned to a pre-injury level with equal or superior results. **Namdari *et al***. [2] focused on NBA players and they reported that 58.3% of patients returned to play for >1 season after MF. This study failed to mention any interoperative data such as which MF technique was used, or lesion size repaired. **Gudas *et al*.** [32] reported that 52% of MF patients returned to sports at a pre-injury level, while others in the same study showed a decline in sports participation without any explanation for the decrease in activity. **Gobbi *et al.*** [18] reported initial return to sport, but then observed a decline in activity over time. This study had the longest follow up with an average of six years.

Some authors included among the disadvantages of microfracture the slow healing process, the long rehabilitation time and the fact that the repair tissue is fibrocartilage and not hyaline cartilage [33] .

We described an important drawback of the procedure with the microfracture technique loose bony particles were created, which easily become detached upon withdrawal of the awl. If the particles were not removed properly, they may act as loose bodies. These might subsequently give rise to locking and cartilage damage [34].

Overall, the success of microfracture in both groups of patients appeared equivalent to other reported studies using marrow-stimulating techniques [35] .

Finally, these results suggested that there was a subgroup of patients who do not form a sufficient repair cartilage volume after microfracture and experience only temporary functional improvement, while patients with a high fill volume had superior functional results and durability. Due to the limited number of serial magnetic resonance imaging scans in our investigation, additional studies are necessary to better describe the changes of repair cartilage fill over time [36] **.**

The limitations of our study were the absence of a control group and missing control arthroscopies with histologic samples. However, reliable statistical evaluation required a high number of cartilage biopsy procedures to be performed in the follow-up period, which was an ethical problem and thus these procedures are often not performed. For these reasons, we used control MRI studies to verify our clinical results.

CONCLUSION

According to the midterm results of this study, the microfracture technique was quite effective with regard to the improvement of daily activities with a favorable impact on pain relief and better functional results. Furthermore, we found that there was a correlation between functional results and age, size of defect, location of defect and BMI as prognostic parameters.

Micro-fracture is a readily available single-stage, arthroscopic technique. Technically easy and relatively low cost, it is ideal for smaller lesions with a stable shoulder of surrounding cartilage and can be used for incidental lesions discovered at the time of surgery. Micro-fracture results in tissue fill with fibrocartilage, which can be unpredictable. Even with complete filling of the lesion, the durability of the tissue is uncertain, with an estimated lifespan of 2-5 years in high-demand individuals.

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