ORIGINAL ARTICLE

Arthroscopic hip surgery with a microfracture procedure of the hip: clinical outcomes with two-year follow-up

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Background: *Outcome studies assessing a cohort of patients receiving microfracture in the hip have focused on second look arthroscopy and return to sport, which have shown favourable results in the absence of osteoarthritis. Few studies exist focusing on clinical outcomes after microfracture in the hip using patient reported outcome (PRO) scores. The purpose of this study is to evaluate two-year clinical outcomes of a series of patients treated with microfracture during arthroscopic hip surgery using PRO scores.*
Methods: *During the study period, all workers' compensation (WC) and non-WC patients treated with microfracture during arthroscopic hip surgery were included. Four PRO scores, pain scores and satisfaction were used to assess clinical outcomes. Any revision surgeries or conversions to total hip arthroplasty (THA) were noted. Location of microfracture procedure, lesion size and additional variables assessed survivorship.*
Results: *Thirty-seven cases met the inclusion/exclusion criteria, of which 30 patients (30/37, 81%) were available for minimum two-year follow-up. Twenty-six patients were classified as survivors. Preoperative scores for patients with WC status were lower than non-WC patients and statistically significant ($p<0.5$) for three of the PROs. However, changes in all four PRO measurements demonstrated statistically significant improvements from preoperative to two-year follow-up for both compensation groups ($p<0.05$). The amount of change in PRO scores for both compensation groups was similar and not statistically significant. Two patients required THA and two patients required revision arthroscopy.*
Conclusion: *Our study demonstrates statistically significant clinical improvement in PRO's after receiving microfracture during arthroscopic hip surgery at minimum two-year follow-up.*

Keywords: *Hip, Arthroscopy, Microfracture, Cartilage*

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INTRODUCTION

Articular cartilage damage is challenging for orthopedists to address because of its limited healing capacity (1). Advances in the field of hip arthroscopy, such as the use of microfracture in the hip, have broadened the spectrum of surgical interventions available for management of intra-articular pathology. The objective of microfracture is to bring marrow cells and growth factors from the underlying bone marrow into the affected chondral defect. By penetrating the subchondral bone, pluripotent marrow cells can emerge to form new fibrocartilage to fill the chondral defect.

Microfracture is a surgical procedure often described to treat chondral defects of the knee, with promising results (2-4). Research addressing the efficacy of microfracture in the hip joint is limited and indications for microfracture use in the hip is extrapolated from literature on the knee (2-6). The advantages of microfracture include the ability to access a large surface area of the acetabulum and femoral head, cost-effectiveness, minimal morbidity and is straightforward to perform. Clinical outcomes of microfracture in the hip have been favourable in the absence of osteoarthritis (OA), with no significant complications reported (5-9). Additional outcome studies in a cohort of patients receiving microfracture in the hip have focused on second look arthroscopy in revision surgeries and return to sport, which have shown favourable results in the absence of OA (5, 10). There are few previous studies focusing on clinical outcomes for patients receiving microfracture during arthroscopic hip surgery, and use of several patient reported outcome (PRO) scores.

The purpose of the study is to evaluate the clinical outcomes of a series of workers' compensation (WC) and non-WC patients treated with microfracture during arthroscopic hip surgery using PRO scores, with a minimum of two-year follow-up. We hypothesise patients receiving microfracture to treat chondral defects will demonstrate significant improvements with a minimum of two-year follow-up.

METHODS

At our centre, clinical and outcomes data is prospectively collected on all patients undergoing arthroscopic surgery of the hip. The study period was between August 2008 and January 2011. PRO scores used included the modified Harris Hip Score (mHHS), the Non-Arthritic Hip Score (NAHS), the Hip Outcome Score – Activities of Daily Living (HOS-ADL), and the Hip Outcome Score – Sport Specific Subscale (HOS-SSS). PRO scores were collected preoperatively and at three months, 12 months, and 24 months follow-up. All four questionnaires were used, as it has been reported that there is no conclusive evidence for the use of a single PRO questionnaire for patients undergoing hip arthroscopy (11, 12). Visual analogue scale (VAS) pain scores and patient satisfaction rating were also collected. Any revision surgeries, complications, additional surgery or conversions to THA were noted. Location of microfracture procedure, lesion size, acetabular labrum articular disruption (ALAD) (13) and Outerbridge (14) classification systems were also recorded to help assess survivorship. Our institutional review board approved this study.

The inclusion criteria for this study were WC and non-WC patients treated with microfracture for full thickness cartilage defects performed during arthroscopic hip surgery. The indications for surgery were predominantly labral tears with mechanical symptoms and failure of conservative treatment. Exclusion criteria were previous hip conditions such as Legg-Calves-Perthes disease, avascular necrosis (AVN), and Tönnis grade ≥2.

Surgical technique

The hip arthroscopies were performed by the senior author (BGD) in a practice dedicated to hip preservation. All surgeries were performed in the modified supine position using a minimum of two portals (standard anterolateral and mid-anterior) (15-16). After establishment of portals and capsulotomy, a diagnostic arthroscopy was performed and intraoperative data was documented, including defects of the ligamentum teres, labrum, synovium and articular cartilage. The ALAD classification was used to classify articular cartilage damage (13). Femoral and acetabular Outerbridge grade were also recorded (14).

Bony pathology was corrected under fluoroscopic guidance. Acetabuloplasty was performed for pincer impingement, and femoral neck osteoplasty was performed for cam impingement. Labral tears were repaired when indicated or selectively debrided until a stable labrum was achieved while preserving as much labrum as possible. The full-thickness cartilage damage was then treated with microfracture, performed according to Steadman's technique (17, 18). Using a shaver, loose cartilage was removed and portions of delaminated cartilage were removed with a ring curette to create stable borders. The calcified layer was also removed with the curette.

Rehabilitation protocol

For the first two weeks, the patients were kept in a hip brace locked at 0–90° of flexion at all times. The patient was restricted to non weight-bearing status for the first eight weeks following surgery. Patients started physical therapy on the first postoperative day to initiate range of motion. This was accomplished by four hours per day using a continuous passive motion (CPM) machine or on a stationary bicycle for two hours a day. Two weeks postoperatively, the brace was discontinued with continued emphasis on range of motion. At eight weeks postoperatively, patients started weight-bearing with gradual advancement to full weight-bearing.

Statistical methods

For preoperative and postoperative mean comparisons, scores were modeled using repeated measures analysis of variance (ANOVA) as a function of group (worker's compensation yes or no) and time (preoperative, postoperative) as the fixed main effects. Group x time was the fixed interaction effect and person as the random effect, thus taking into account that observations are not independent across time (2 x 2 ANOVA). The normality assumption was evaluated using the quantile-quantile plots of the residuals. The constant variance assumption was evaluated by constructing plots of the residuals versus the predicted values under the above ANOVA model. We confirmed that there were no major violations of the normality and the constant variance assumptions.

Comparisons of variables between groups without failure versus with failure used the Wilcoxon rank sum test with continuous/ordinal variables. Categorical variables were compared between groups using the Fisher's test. Formal survivor analysis was performed using the Kaplan-Meier method.

RESULTS

Patient population

A CONSORT flow diagram is presented in Figure 1. A total of 37 cases met the inclusion/exclusion criteria and 30 patients (30/37, 81%) were available for two-year follow-up (mean 35 months ± 24-50). The study group consisted of 12 females (12/30, 40%) and 18 males (18/30, 60%). The mean age was 45 years (range 29.5–60). Twenty-eight patients (28/30, 93%) had acetabular microfracture and the remaining two (2/30, 7%) had femoral microfracture. Concomitant surgical procedures are presented in Table I. The majority of patients (29/30, 97%) had a capsular release with one patient receiving capsular plication. Postoperative diagnoses are presented in Table II. No kissing lesions were reported. Table III provides information per patient detailing if femoroplasty or acetabuloplasy was performed, ALAD classification and acetabular and femoral Outerbridge grades.

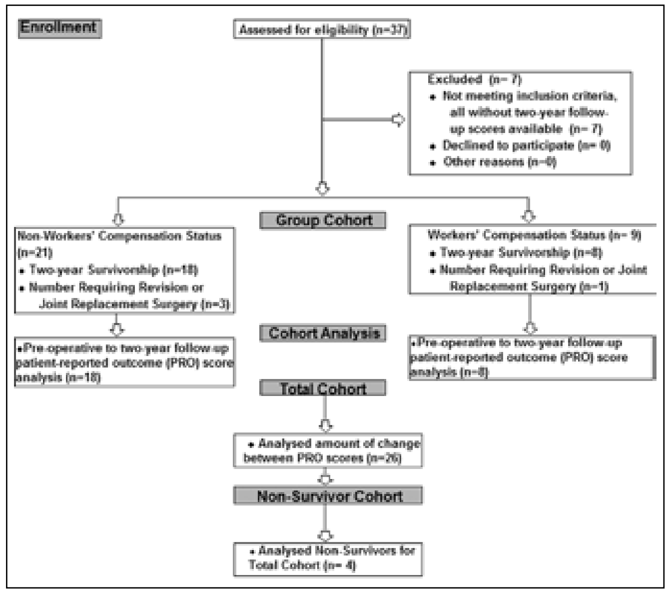

Fig. 1 - *Microfracture case series CONSORT flow diagram.*

TABLE I - CONCOMITANT SURGICAL PROCEDURES

Procedure Type	Number with Procedure (n = 30)	Percentage with Procedure
Osteoplasty	20	67%
Ligamentum Teres Debridement	18	60%
Acetabuloplasty	17	57%
Labral Debridement	15	50%
Labral Repair	12	40%
Synovectomy	10	33%
Capsular Release	29	97%
Chondroplasty	7	23%
Removal of Loose Body	6	20%
Capsular Plication	1	3%
Femoroplasty	2	6%
Iliopsoas Release	2	6%
Trochanteric Bursectomy	2	6%
Debridement of Acetabular Fossa	1	3%
Debridement of Trochanteric Bursitis	1	3%
Labral Reconstruction with Capsular Augmentation	1	3%
Removal of Os Acetabulum	1	3%

TABLE II - POSTOPERATIVE DIAGNOSES

Diagnosis	Number (N = 30)	Percentage
Chondral Defect	30	100%
Labral Tear	27	90%
CAM Lesion	22	73%
Ligamentum Teres Tear	16	53%
Pincer Lesion	16	53%
Synovitis	7	23%
Loose Body	6	20%
Trochanteric Bursitis	3	10%
Os Acetabulum	1	3%
Acetabular Notch	1	3%
Adhesive Capsulitis	1	3%
Capsular Stiffness	1	3%
Hip Flexor Tendonitis	1	3%
Snapping Hip	1	3%

Total cohort non-survivorship was four out of 30 (4/30). A total of two patients (2/30) in the study group, who had acetabular microfracture, required revision surgery. Out of the 28 patients who had acetabular microfracture, two required subsequent THA (2/28). No patients required a THA after femoral microfracture, for a two out of two survivorship.

At two-year follow-up, 26 patients (26/30, 87%) were defined as survivors, meaning they did not require THA or revision surgery after initial arthroscopy with a microfracture procedure performed. All four PRO measurements and pain scores demonstrated statistically significant improvements for both groups from preoperative to two-year follow-up ($p<0.05$). Preoperative scores for patients with worker's compensation (WC) status were lower than non-WC patients and statistically significant ($p<0.5$) for three of the PROs, mHHS, NAHS and HOS-ADL. Preoperative pain and HOS-SSS scores were not statistically different between groups, but trending lower for patient with WC status ($p = .08$). PRO outcome means for both Non-WC and WC are presented in Figure 2. When compared, the amount of change in PRO scores for both groups was similar and not statistically significant. For two-year survivors (26/30, 87%) mean pain scores combined from both compensation groups decreased significantly from 6.3 to 3.7 ($p<0.001$), and satisfaction had a mean of 7.25 for both compensation groups on a 1–10 scale, and were not statistically different.

Based on our data, the standard deviation for the mHHS paired mean difference from baseline to two years is 16.9. We hypothesised that a mean change of ten points would be considered clinically important. We determined 25 patients would be needed to detect this mean difference with 80% power at the usual $p<0.05$ level of significance. Therefore, our sample size of 30 was adequate to confirm the mean difference.

Two patients required conversion to THA after acetabular microfracture. The first was a 55-year-old male who was found during the initial procedure to have a grade 4 full thickness defect on the acetabulum and two grade 3 lesions on the femoral head measuring 1 cm^2 and .25 cm^2. The second patient was a 61-year-old, obese female who was found to have a grade 4 full-thickness, large chondral flap off the acetabulum measuring 4.75 cm^2, as well as grade 2 damage on the femoral head. THA was required because of increasing pain and interference with activities of daily living along with failure of additional conservative therapies.

Two patients required revision surgery. One patient, a 46-year-old female, required revision arthroscopy 11 months subsequently because of persistent pain and recurrence of mechanical symptoms. The original injury was a high impact car to pedestrian motor vehicle accident. The revision arthroscopy involved lysis of scar tissue in the capsular labral recess and debridement of hypertrophic fibrocartilage in the area where microfracture was previously performed. Upon last follow-up, the patient reported notable improvement. The second patient required revision surgery 18 months after the initial arthroscopic procedure with acetabular microfracture due to recurrence of pain, which was confirmed with relief from intrarticular injection. MRA identified a re-tear of the labrum. Intraoperative findings during the revision procedure also identified a high-grade ligamentum teres tear, small pincer lesion and adhesive capsulitis.

The following variables were compared in the four patients requiring revision surgery or THA and compared to the 26 survivors: lesion size, ALAD class, acetabular cartilage damage and femoral cartilage damage with the Outerbridge classification system. Results from each patient are presented in Table III with corresponding classification legends. None of these variables significantly varied between survivors and non-survivors. When assessing surgical procedures, the only proportion that was significantly different ($p = 0.018$) between the groups was removal of loose body. A total of three out of four non-survivors who required revision or subsequent THA had removal of a loose body, compared to three

TABLE III - DIAGNOSTIC AND OPERATIVE DATA BY INDIVIDUAL PATIENTS

Patient	WC	ALAD Classification*	Femoral Osteoplasty-Arthroscopic	Acetabuloplasty-Arthroscopic	Acetabular cartilage damage (Outerbridge grade)§	Femoral cartilage damage (Outerbridge grade)§
1	No	2	No	No	2	2
2	No	2	No	Yes	2	3
3	No	0	No	Yes	4	0
4	No	0	Yes	Yes	3	3
5	No	4	Yes	No	4	0
6	No	0	Yes	Yes	4	4
7	No	0	Yes	Yes	4	0
8	No	0	Yes	Yes	4	3
9	No	0	Yes	Yes	4	2
10	No	0	No	No	4	2
11	No	0	No	Yes	4	2
12	No	4	Yes	No	4	3
13	No	4	Yes	No	4	0
14	No	0	Yes	No	4	0
15	No	4	Yes	No	4	0
16	No	3	Yes	No	0	4
17	No	4	Yes	Yes	4	2
18	No	4	Yes	Yes	4	0
19	No	0	Yes	Yes	3	4
20	No	3	No	No	3	2
21	No	3	Yes	Yes	3	0
22	Yes	4	Yes	Yes	4	0
23	Yes	4	Yes	Yes	4	0
24	Yes	4	Yes	No	4	0
25	Yes	2	No	Yes	2	0
26	Yes	4	Yes	Yes	4	0
27	Yes	4	Yes	No	4	0
28	Yes	4	Yes	No	4	0
29	Yes	3	Yes	No	3	0
30	Yes	3	Yes	Yes	4	0

* ALAD Classification System15: 0 = None, 1 = Softening of the adjacent cartilage, 2 = Early peal of the cartilage (carpet delamination), 3 = Large flap of the cartilage, 4 = Loss of cartilage.
§ Outerbridge Classification System16: 0 = Normal cartilage, 1 = Cartilage with softening and swelling, 2 = A partial- thickness defect that doesn't reach subchondral bone, 3 = Fissuring to the level of subchondral bone with area greater than 1.5 cm, 4 = Exposed subchondral bone.

out of 26 for the survivors. We computed failure free probabilities over time using the Kaplan-Meier method. The failure free probabilities were 100% at 12 months, 93.3% at 18 months (95% CI: 84.4%–100%), and 89.9% at 24 months (95% CI: 79.9%–100%), which are shown in Figure 3.

DISCUSSION

The results of this study demonstrate statistically significant improvement in PRO scores after receiving microfracture during arthroscopic hip surgery at minimum two-year

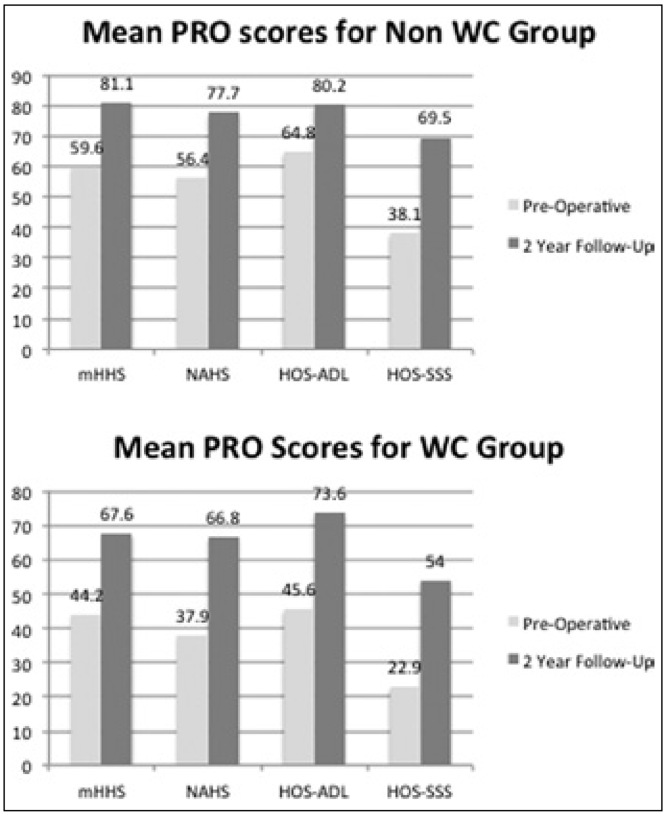

Fig. 2 - *PRO scores pre-operatively and at two-year minimum follow-up by compensation status.*

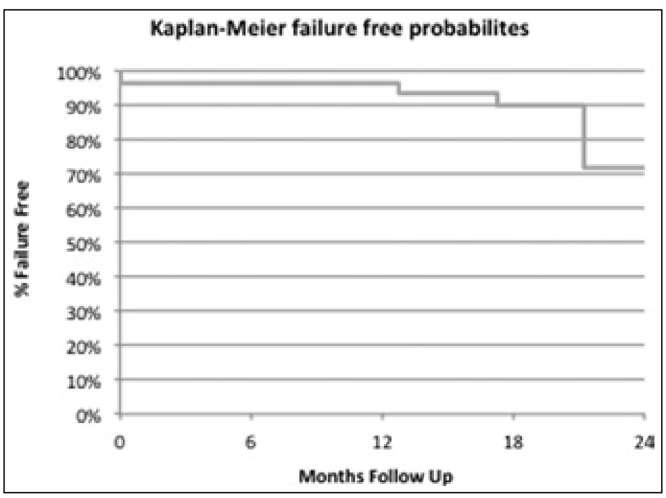

Fig. 3 - *Kaplan-Meier failure free probabilities.*

follow-up. To our knowledge this is the largest prospective case series specifically evaluating patient reported outcomes with minimum two-year follow-up after receiving microfracture during arthroscopic hip surgery. Additionally, we were able to use four different PRO scores, providing a wider array of instruments than previous studies. Out of 30 patients who met established inclusion criteria, 26 were categorised as survivors. Two patients required revision surgery and two needed subsequent THAs, for a survivorship of 26/30 (87%). Out of the two patients who required subsequent THAs, both had diffuse degenerative changes beyond the focal area of microfracture seen at time of arthroscopy. However, both patients presented with more significant chondral defects and intra-articular pathology during the first arthroscopic procedure than was revealed through clinical or radiographic findings. Acetabular microfracture had a 4/28 non-survivorship and femoral microfracture had a 2/2 survivorship. Overall, the data presented represents favorable results for patients receiving microfracture during arthroscopic hip surgery for focal chondral defects in the hip.

Steadman et al (18) contend advantages of microfracture include cost-effectiveness, technologically feasible, and minimal risks, while leaving additional treatment options available to the patient. Microfracture does not rely on replacing damaged tissue, but creating a “marrow-based strategy” for tissue repair (18). Indications include full-thickness cartilage defects and unstable cartilage flaps overlying subchondral bone. Contraindications include patient unwillingness or inability to adhere to demanding rehabilitation protocol, specifically weight bearing restrictions, and degenerative OA or systemic immune-mediated disease. Age and size of lesion are not specific contraindications, but microfracture is generally preferred for smaller lesions <4 cm^2. Additional joint pathologies should also be addressed when performing microfracture. Full benefits of microfracture are usually not seen in knees for a minimum of six to 12 months, with continued improvement lasting for up to two years and then leveling off.

Knutsen et al conducted a randomised trial comparing autologous chondrocyte implantation with microfracture in the knee (4). In contrast to Steadman et al, this study excluded acute injuries and included chronic and larger lesions. Forty patients were randomised to receive autologous chondrocyte implantation and 40 received microfracture. Findings at five years showed both groups demonstrated statistically significant improvement in PRO scores, but there was no difference between the two treatment types. Similar to the Steadman study, younger patients had clinically better outcomes as compared to older patients. Both groups reported a 23% failure rate. Additionally, five years post-treatment, 34% of patients had radiographic evidence of early OA despite this being an excluding factor at the beginning of the study. However, the authors attribute this finding to their patient cohort and corresponding demographics and confounding variables. The authors recommend microfracture as first-line procedure for cartilage defects in the knee while autologous chondrocyte implantation may be most beneficial as a second-line treatment for larger chondral defects.

Phillipon et al advocated that microfracture principles can also be applied to the hip (5). The authors reported on a series of nine patients who previously underwent microfracture for acetabular chondral defects and underwent second look hip arthroscopy for a variety of reasons (5). The mean percent fill of the defects was 91%, with good quality cartilage at a mean of 20 months. The authors concluded microfracture is an effective treatment strategy for chondral lesions in appropriately selected patients such as patients without diffuse OA and those able to adhere to the strict rehabilitation protocol.

Many additional authors support the use of microfracture in the hip as an option to promote cartilage healing without adding significant risk or morbidity. Byrd et al (9) reported on the arthroscopic management of cam-type FAI in 207 hips. Microfracture was performed in 58 hips based on surgeon assessment, which included grade 4 chondral defects, intact subchondral plate and healthy surrounding cartilage. For patients who received microfracture, their mHHS score improved a mean of 20 points, from 65 preoperatively to 85 postoperatively. Karthikeyan et al published a series of 20 patients who underwent hip arthroscopy for FAI and underwent microfracture for acetabular chondral defects (19). These patients subsequently underwent a second look arthroscopy for various reasons. The mean time interval between the primary and revision surgeries was 17 ± 11 months. The mean percent fill was 93% ± 17%, with macroscopically good quality cartilage. The Non-Arthritic Hip Score (NAHS) mean was 54.5 points before both primary and revision surgeries. The score improved to an average 78 points at a mean follow-up of 21 months.

Byrd et al published their series of nine patients who were found to have an inverted labrum as a possible cause of hip OA (8). All nine patients concomitantly presented with grade 4 acetabular chondral lesions. Out of the nine patients, only four demonstrated mHHS score improvement of at least 10 points, however of those four, three were patients who received microfracture and had a mean mHHS score improvement of 36 points. Additionally, the three microfracture patients were the only patients to return to greater than simple activities of daily living such as martial arts and horseback riding. The authors report these patients continue to demonstrate satisfactory function five years postoperatively.

Haviv et al assessed outcomes related to femoral osteochondroplasty to treat cam lesions and acetabular chondral lesions (20). Patients with additional intra-articular hip pathology were excluded. Out of 170 hips, 29 (17%) patients received microfracture, for which criteria included grade 2 or 3 lesions <300 mm^2. The authors reported a significantly better NAHS in this patient group. The authors theorise the improved NAHS scores reflect improvement in the ability to perform higher demand activities.

Microfracture has been more specifically studied as an independent variable in the athletic population. McDonald et al conducted a study in elite athletes assessing return to play between those who did and did not receive microfracture (10). Sports played included football, soccer, hockey, baseball, tennis, and golf. Thirty nine patients (39 hips) received microfracture, compared to 81 patients (94 hips) in the control group. No significant differences were found between the two groups for rate of return to play, however the microfracture group did have a 1.6 times higher risk of not returning. Additionally, there was no statistical difference between the number of seasons played postoperatively between the two groups. The authors concluded microfracture can be used in an athletic population to help increase levels of return to play.

In contrast to other studies, Philippon et al (21) conducted a study reporting two-year outcomes after hip arthroscopy for the treatment of femoroacetabular impingement (FAI) and related labral and chondral pathology where patients receiving microfracture showed no significant difference in postoperative mHHS score when compared to patients not receiving microfracture. Of the 122 patients who met the inclusion criteria, 47 (38.5%) received microfracture, eight on the femoral head, 30 on the acetabular surface and nine on both. The authors reported patients who received both types of microfracture were statistically more likely ($p = 0.0001$) to receive THA.

Many authors discuss the importance of patient selection and diagnostic criteria for selecting patients to undergo microfracture. Horisberger et al (22) conducted a study assessing short-term results for patients treated concurrently for FAI and labral and chondral damage, who also were found to have severe cartilage lesions or damage intraoperatively.

Out of 20 patients included in the study, 15 (75%) received microfracture. Of the original 20 patients, 50% required conversion to THA at point of last follow-up, at a mean of three years. However, a large percentage of the patients (55%) had Tönnis grades >2, which at our centre is a relative contraindication for arthroscopic intervention. The authors do report in their study that patients with higher Tönnis grades were statistically more likely to need THA ($p = 0.03$). Additionally, the authors advocate arthroscopic treatment in FAI addressing degenerative lesions is contraindicated in patients with Tönnis grades >3.

Strengths/limitations

The greatest strength of our study was the dedicated prospective assessment of clinical outcomes of microfracture using four PRO scores. Many previous microfracture studies have evaluated microfracture as a subgroup within a larger cohort, or in very specific populations such as elite athletes or patients requiring second look or revision procedures. Additionally, no previous study of microfracture has assessed outcomes using four different PRO measures. A limitation of our study is the small sample size. As in other studies, concomitant procedures were performed in all cases, creating a challenge in isolating the outcomes of the microfracture itself. Our cohort is quite heterogenous and numerous variables may influence outcomes. Future use of a matched-pair control group would provide additional insight into the outcomes related to microfracture in the hip.

CONCLUSION

The results of this study demonstrate patients reported statistically significant clinical improvement in PROs after receiving microfracture during arthroscopic hip surgery at minimum two-year follow-up. A high survivorship was noted, and those patients who were not survivors had diffuse degenerative changes. We conclude that the presence of diffuse degeneration may be a negative prognostic factor, but results of microfracture in focal chondral defects of the hip are favourable.

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