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Original article

ANALYSIS OF MEDIUM-TERM RESULTS ACHIEVED AFTER MICROFRACTURES AND PERFORATIONS (DRILLING) IN LOCALIZED CHONDRAL LESIONS IN THE KNEE JOINT

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ABSTRACT

Introduction: The main advantage of perforative techniques is their atraumatic, non-invasiveness and possibly being done under arthroscopic control.

Purpose: This study aims to compare two methods of operative techniques in the treatment of chondral lesions of the knee.

Materials and methods: The clinical study included 237 symptomatic patients with chondral defects from the period of 2010 – 2018. Patients were divided into 2 groups. The first group included 49 (32.11%) patients with arthroscopic micro-fractures. The second group included 54 (35.49%) patients with arthroscopic subchondral perforation (drilling). The term of follow-up was 36 months. Each patient had at least 4 documented follow-up visits.

Results: Results from grading scales – Lysholm, KOS, MRI – scales, as well as our own scale for evaluating knee function (PS) scale, were documented in each patient's separate file. The average pre-operative Lysholm score was 41.5 ± 6.6 in the microfracture group and 43.0 ± 5.6 in the perforation group. At the 36th-month average, Lysholm's score increased to 86.9 ± 7.3 in the microfracture group and to 86.1 ± 6.6 in the perforation group. During the study, it was also found that a correlation exists between the received results and the age of the patient, the size of the chondral defect, and the tracking period.

Conclusion: The effectiveness of osteoperforative techniques relies on many factors: the age of the patient, the size of the defect, and the tracking period. In the end, mesenchymal stimulation of chondrogenesis results in positive mid-term results in patients with small-sized chondral lesion.

Keywords: Arthroplasty, Subchondral, Knee Joint, Lysholm Knee Score,

INTRODUCTION

Osteochondral defects are common problems with which patients present to the physician [1, 2]. Unfortunately for these patients, such defects rarely heal spontaneously, and they would commonly be offered an operative treatment [3, 4, 5].

The main advantages of the techniques stimulating pluripotent mesenchymal stem cells of the bone marrow are their atraumatism, non-invasiveness, and the possibility of performance under arthroscopic control. Perforation of the subchondral bone plate leads to the migration of the mesenchymal stem cells from the bone marrow into the area of the defect and results in the consequent filling of the defect with fibrous tissue.

The conditions required to achieve good results post microfractures and subchondral bone tunnelisation include the presence of a good blood supply of the subchondral bone, as well as the depth of the chondral lesion not being in excess of 7mm (as determined by MRI).

For us, the surgical community, it is crucial to have an objective outlook and evidence-based information to decide which procedure is best to use [6].

Clinical research was conducted in the Clinic of Orthopaedics and Traumatology of University Hospital Pleven "Dr Georgy Stranski" from 2010 to 2018. During this period, 237 patients with symptomatic osteochondral and chondral lesions underwent arthroscopy. The lesions were localized in the loading areas of the medial and lateral femoral condyles and had previously failed conservative treatment. Of these 103 cases that were studied and followed, all patients were operated on by the same surgeon in the same clinic. All patients included in the study have provided informed consent.

This study aimed to investigate and compare two methods of operative treatment of osteochondral and chondral lesions of the knee joint with the aim of developing a rational surgical approach which ensures optimal anatomical and functional results.

MATERIALS AND METHODS

Patients were divided into 2 groups in accordance with the used surgical technique used for treatment. The second group included 54 (35.49%) patients treated

arthroscopically with microfractures of the subchondral bone plate. The first group included 49 (32.11%) patients who underwent subchondral drilling.

Table 1. Inclusion and exclusion criterias

Inclusion criteria	Exclusion criteria
Symptoms of knee dysfunction (Pain, recurrent oedema, mechanical symptoms)	Degenerative knee osteoarthritis (Advanced stage)
Isolated chondral and osteochondral lesions located in loading areas of femoral condyles	Systemic inflammatory disease (Rheumatoid arthritis)
Defect diameter of 1 – 5 cm^2	Collagenous or vascular diseases
Normal or correctable axial deviation of the knee	Obesity (BMI >35)
Normal or correctable ligamentous stability of the knee	Long-term immunosuppressive treatment (Corticosteroids)
Functional meniscal structure (>50% of intact meniscus)	Two-pole (kissing) lesions of the knee
Between 19 – 55 years of age	Osteochondral lesions over 8 cm^2
Adequate patient compliance	Depth of osteochondral lesion over 10mm
	Over 60 years of age
	Non-corrected axial deviation or knee instability
	All patients who missed their last appointment, as well as all patients who missed more than 2 follow-up appointments

The overall length of the follow-up period was 36 months. Each patient had 4 documented visits, with the first visit being the last pre-operative meeting. The next appointments were done during the 3rd, 12th, and 36th months after surgery.

The data recorded from each patient included their personal data, clinical and radiological assessments, as well as results from assessment scales – Lysholm, KOS (Knee Outcome Survey Activities of Daily Living Scale), and MRI scale – for evaluation of the knee joint surface restoration, as well as own scale for assessment (PS). These records were documented and updated upon each visit in patient separate files.

During the consultation in the pre-operative period, all patients were informed of the amount of future surgery required, as well as the possible risks of intra and post-operative complications connected with arthroscopy itself. All data from arthroscopy was registered in the standard protocol.

Subchondral drilling

The subchondral drilling technique was performed as described by Pridie in 1959, with the idea of treating isolated chondral defects of the knee joint as well as in cases of osteochondritis dissecans. The technique entails the perforation of chondral and sclerotic subchondral bone tissue until bleeding occurs from cancellous bone. The resulting effect is the replacement of the defect with fibrocartilaginous tissue [7].

Subsequently, the technique was implemented into arthroscopic surgery and today is performed with the help of a K-wires of 1.5 – 2 mm, which is introduced perpendicularly 5 to 6 mm apart with a depth of 2 to 4 cm.

Operative technique

Methods of mesenchymal stimulation of chondrogenesis are suitable in case of discovery of small lesions on femoral condyles (1 - 2 cm^2) and 3 or 4th-grade chondromalacia accompanied with exposure of subchondral bone.

The first stage of the operation is the arthroscopic diagnostics of the knee. All necessary intra-articular procedures are performed prior to perforations, as is the preferred method in this study. In the investigated group, 20 patients (41%) with chondral lesions were found alongside meniscal lesions.

In 13 cases (26%), medial meniscus lesion were found and in 7 cases (14%) lesions of the lateral meniscus. In all cases, partial meniscectomy was done during an operative intervention.

In 3 cases, anterior cruciate ligament (ACL) ruptures were identified, therefore ACL reconstruction with a tendon graft from the Gracilis and the Semitendinosus was done. In 1 patient, the lateral release was done due to luxation of the patella.

Through an anteromedial portal, arthroscopic shaver, and under arthroscopic control, debridement of all damaged, free, or unstable cartilage was completed until the formation of a stable, vertical wall to adjacent intact cartilage.

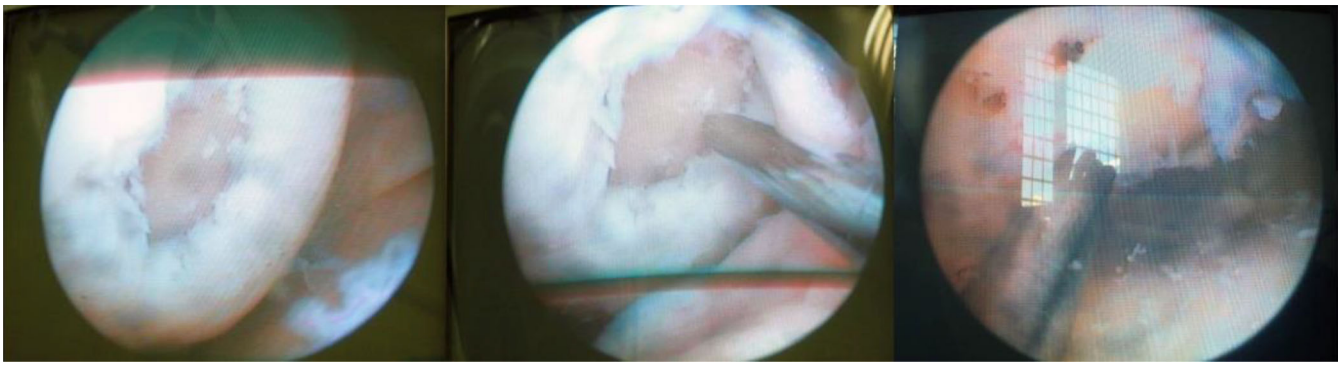
The perforation was performed from the periphery to the central point of the defect until the perforation of the subchondral bone plate. Drilling was performed using a K-wire of 1.8 mm. A K-wire was placed into the center of the defect perpendicular to the articular surface, which prevents the chance for convergence. Therefore, in cases where central zones of the femoral condyles are in-

volved, it is required to have the opportunity to flex the knee above 90 degrees.

This was followed by perforation of the bone plate with the K-wire and creating the necessary number of canals 4-5 mm apart, and 2 – 4 cm depth in various directions till bleeding from the trabecular bone was visualized. At the end of the arthroscopic procedure, we stop the inflow of solution and release the tourniquet. An indicator of a correctly performed procedure of perforation is the appearance of blood from the openings. In the event of no bleeding, the procedure was repeated with a greater depth.

Utilizing a 1 mm K-wire in oscillating mode with a minimum of 8 mm in depth does not create overheating and contributes to the release of more active pluripotent cells (Fig. 1).

Fig. 1. A Clinical example of a patient of 42 years with a post-traumatic IV grade chondral defect, according to Outbridge, with exposed subchondral bone and rupture of the lateral meniscus. After a partial meniscectomy and thorough debridement, perforation of the lesion was performed with a 1.8mm K-wire.



After such procedures, immobilization of the joint is not performed, walking with aids without weight bearing on the operated limb is allowed from the 2nd day, and partial weight bearing is allowed after 5-6 weeks and full weight bearing after an additional 6 – 7 weeks.

Microfractures

The technique and primary results were first published by Steadman in 1994. This operative method involves performing microfractures of the subchondral bone plate, maintaining the plate's integrity by use of the Steadman instrument at a depth of 4 mm and up to 3 – 4 perforations at 1 cm^2.

The obvious advantage of the microfracture technique is the avoidance of tissue necrosis, which occurs in drilling during perforation due to heating. This method is often the first therapeutic option due to its performance simplicity, cost-effectiveness and low post-operative morbidity.

The surgical arthroscopic technique includes debridement of the defect until stable chondral edges are achieved, with the removal of the calcified cartilage zone. Microfractures were done with an arthroscopic perforator (30, 45, or 90-degree angle) or Steadman instrument perpendicularly to the surface. The pit from the defect, surrounded with normal cartilage, forms a pool helping to hold the bone-marrow clot. An important requirement is the preservation integrity of the subchondral bone plate. Removal of calcified cartilage is recommended, as the attachment of the regenerative tissue to the subchondral bone is optimized after the procedure.

Surgical technique – microfractures

Microfractures were performed as described by Steadman in 54 (34%) of cases [8].

The first step of the operation was diagnostic arthroscopy with the observation of the intraarticular lesions. In all cases, all intraarticular procedures were done before performing microfractures. In the studied group, 26 patients (48%) were identified to have meniscal lesions. Medial meniscus lesions were found in 20 cases (36%), and lateral meniscus lesions in 6 cases (12%). In all of these patients, partial meniscectomy was performed during an operative intervention. In 4 cases, ACL ruptures were identified, and thus ACL reconstruction with a tendon graft from the Gracilis and the Semitendinosus was done.

The size of the chondral lesion was determined with a calibrated probe. After the visual evaluation of the chondral lesion, debridement and resection of all unstable, free moving and marginally attached fragments was completed in the zone of the lesion.

After the procedure, if the chondral lesion is determined to be lacking a surrounding intact wall of cartilage, which is required to hold the blood clot in place, the microfracture technique is deemed an unacceptable treatment method. In the next phase, we cautiously removed the calcified zone of cartilage at the base of the lesion. We agree with Mithoefer et al. [9], who stated the importance of this step in the operation, and that it is better to remove the calcified zone with curettage rather than with an arthroscopic burr. The removal of this zone should be conducted carefully to prevent the involvement of the subchondral bone plate, which depends on tactile feedback and the surgeon's experience. The integrity of the subchondral bone plate ensures congruency of the joint surface. Extensive removal of subchondral bone may also lead to its overgrowth, which leads to relative thinning and worsening of biological and biomechanical quality of fibrocartilaginous regenerate. This way, the preparation of de-

fect with stable perpendicular edges to surrounding unchanged cartilage creates a pit, which helps to hold mesenchymal rich bone-marrow clot.

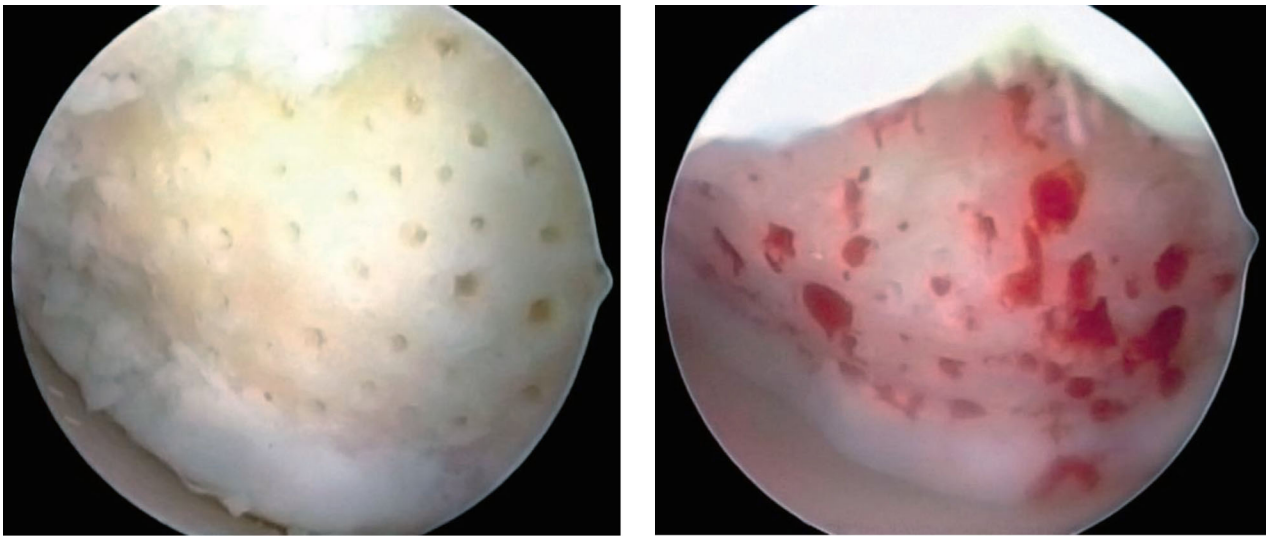
After forming the defect as described above, with the help of an arthroscopic instrument of 45-degree perforation or the Steadman instrument, the subchondral bone plate was perforated [10].

The use of the Steadman instrument this way ensures perpendicular punctures, as well as better control in the depth of the puncture compared to drilling with a K-wire.

Microfractures are done in a circumferential manner from the periphery to the centre of the defect. A systematic approach such as this guarantees an even distribution of microfractures to open the whole cartilaginous defect and to hold the newly formed mesenchymal blood clot (Fig. 2). An important requirement is to perpendicularly puncture subchondral bone, 3 – 4 mm apart, in order to achieve 3 – 4 perforations per 1 cm^2.

Visualization of lipid particles can confirm that the required depth of entrance is achieved, which is required to be around 4 – 5 mm (Fig. 2). In order to evaluate the success of the procedure, after completing perforations, the pressure of the tourniquet is decreased, allowing lipids and RBC particles to be released from completed perforations. Afterwards, evacuation of the arthroscopic fluid from the knee joint is performed, and skin sutures are placed. Vacuum drainage interferes with the stabilization of the blood plaque from the medulla and hinders fibrocartilage regeneration, and thus is not recommended.

Fig. 2. Microfractures are placed evenly with a distance of 3 – 4 mm apart and a depth of 4 – 5 mm. Visualization of lipid and RBC's drops confirms the correctly performed technique.



RESULTS

Results from study

According to the results of the study, 95 (63%) of the patients are males, and 55 (37%) are females. The average age of included patients was 38.5 ± 12.04.

According to the results from a study, the medial femoral condyle was affected in more than 80% of operated patients, with the remaining 20% being the lateral condyle ($p < 0.01$).

Clinical-radiological studies and diagnostic arthroscopy found all 103 patients included in this research were diagnosed as the following: in 41 (40.54%) of cases chondromalacia 3 – 4 degrees, in 45 (44.59%) of cases traumatic osteochondral and chondral lesions and 14 (14.86%) cases with osteochondritis dissecans 3 – 4 stages ($p = 0.0001$; $r = 0.44$).

The average defect size was 2.27 cm^2 (1 – 3.5) in the microfracture group and 2.42 cm^2 (1.4 – 4) in the perforation group. Indicating a lack of statistical difference between the size of osteochondral lesions between 2 groups ($p = 0.009$).

According to results from pre-operative X-rays and MRI's, the majority of lesions on the joint cartilage were located centrally on the femoral condyle. Nonoperative treatment, on average, took 4.2 months (from 2 to 8 months).

The average interval from the appearance of the first symptoms to surgical treatment was 5.4 months, which is similar in both groups ($p = 0.007$). The preliminary Lysholm score and base physical activity were relatively the same ($p = 0.008$). Body mass index (BMI <30) was normal in both groups, and no significant difference was found ($p = 0.0001$).

Surgical time was approximately 36 min (from 28 to 45 min) in the microfracture group and 34 min (from 24 to 40 min) in the perforation group ($p < 0.07$).

In 62.6% of cases, additional intra-joint lesions of the knee joint were identified, which required additional surgical manipulation during the chondroplasty surgery. With the largest relative share are patients with partial meniscectomy (36.1%), followed by ACL reconstruction (9.5%) and the removal of free intra-articular bodies (7.5%).

Result from a pre-operative diagnostic procedure

Result from clinical research

Pain during weight bearing on the knee was found in all patients, and the average VAS score was 7.3 (5 – 8) for 1st and 7.6 (5 – 9) for 2nd group. Crepitations and locking were found in 46% of the patients in the 1st group and 38% in the 2nd group. Patients reported occasional edema in 67% of cases.

The direct pressure on the medial condyle of the femur with simultaneous extension and internal rotation of the knee from 90 degrees of flexion (Wilson test) provoked pain in 74% (50.7) in the 1st group and 68% of the 2nd group. The Bohler symptom was positive in 48.7% of cases, McMurray in 34%, and the Lachman test was positive in 6.4%. 73 (47.4%) Patients were found to have weakness in their connective tissue, and 39 (25.3%) had familial history. 57.7% of patients reported having high physical loading, and 32.4% of patients were active sportsmen.

Results from grading scales

According to the Lysholm scale of V1, there was a significant difference (p = 0.001) between the averages of the first (37.1 from 24 to 49) and the second group (41.5 from 25 to 52) defines these pre-operative values as poor.

According to the KOS scale in the investigated groups, the average first group's score was 41.9 from 27.4 to 51.3, and 2nd the group score was 42.6 from 31.4 to 54.6, respectively. No significant difference was discovered between them (p > 0.05), and this defines these pre-operative values as poor.

The average PS score for V1 was 38 (21 – 45) for the 1st group and 42 (24 – 49) for the 2nd group without significant difference between them (p = 0.06) and defines these pre-operative values as poor.

According to the VAS score, the average score for the V1 group was 6.4 (4 to 8), and for the 2nd group was 6.1 (4 to 8).

Result from the treatment of patients by perforation of subchondral bone

A group was made up of 49 (32%) patients. Each of them was treated by perforation according to the Pridie technique. The average follow-up for them was 23 months (from 10 to 48 months). Approximately half of the patients (n = 20, 41.6%) connect the advancement of the morbidity to some sort of traumatic event in the past. Others (n = 28, 58%) deny any previous traumatic event. The average time of the operation was 34 min (from 24 to 40 min). Method of perforation (drilling) was used on 28 patients (59.18%) with chondromalacia from 3rd to 4th grade, 19 patients (38.7%) with osteochondral lesions, and 1 patient (2.04%) with osteochondritis dissecans.

The right knee joint was injured in 25 patients (51%), and the left was injured in 23 (49%) patients. The most commonly affected area was the medial femoral condyle (89% of patients). 69.3% of the lesions were localized in the central zone of the femoral condyle, 11.3% dorsally, and 19.4% in the anterior quadrant.

In relation to the size of the defect, the group was subdivided additionally into 3 sub-groups with lesions 1 - 2 cm^2, 2 - 4 cm^2, and above 4 cm^2 accordingly.

Seven of the operated patients had a history of previous endoscopic surgery for meniscectomy, and 1 patient with abrasichondroplastic due to chondromalacia of 3rd degree on the medial femoral condyle.

There were 24 (50%) operated patients who had extra intra-joint lesions. These patients required additional surgical treatment. Partial meniscectomy was performed in 17 patients (35.4%), partial synovectomy in 2 patients (4.1%), extraction of free-floating bodies in 3 patients (6.18%) and in 3 patients' resection of hypertrophic synovial plicae (6.18%). ACL rupture was confirmed in 3 patients (6.18%) for whom ACL reconstruction was performed. Additionally, 6 patients were noted to have early arthritic changes the knee.

The methods of mesenchymal stimulation through subchondral perforation with an average follow-up of 23 months achieved excellent results in 34 (69%) patients, with the joint function being fully restored and patients returning to work or sports (Table 2).

In 13 (27.17%) patients, there were no complaints, and they were also able to return to their daily life activities or sports, and on the control x-ray, no data for degenerative changes were found. MRI follow-ups after 6-8 months post-operation have shown insignificant subchondral edema, the heterogenic structure of regenerate, without cracks, with insignificant swelling around cartilage. The average size of the chondral defect was 1.7 cm^2. The average score of the knee joint function, according to Lysholm, in these patients was 90.1 points, which was determined as an excellent result (p = 0.001).

Table 2. Result from the operative treatment of patients from the 1st group (according to Lysholm scale) 36 months post-operation.

Result from surgical treatment	Amount of patients	
	N	%
Excellent	13	27.17
Good	21	42.66
Satisfactory	12	27
Unsatisfactory	2	4.17
Overall	48	100

The results of operative treatment in the 2nd group, according to Lysholm for V2, V3 and V4, depict a significant difference, especially between V1 and V4 (p = 0.001).

Result of treatment of patients by microfracture

This group included 54 patients. Each patient underwent arthroscopy and microfractures as described by Steadman's [8] original technique. The average follow-up

period was 26 months (from 9 to 54 months). More than half of the patients, 29 (54%), had a history of earlier sporting trauma, 18 (33.3%) of which described domestic injuries, and the remaining 11 (20.3%) indicated trauma of the knee. 15 (46%) patients did not associate their illness with any sort of previous traumatic event. 16 patients (29.6%) were employed in physically demanding jobs, while a further 14 patients (25.9%) said that they were active sportsmen. The average functional score of the knee, according to Lysholm, was 41.5, this is deemed unsatisfactory. The KOS subjective scale score was 42.6, this, too, is unsatisfactory. The average operative time was 36 min (24 – 50 min).

Distribution of patients in the 2nd group according to the clinical diagnosis is 10 (18.5) with dissecting osteochondritis, 26 (48.2%) with traumatic osteochondral and chondral lesion, and 18 (33.3) with chondromalacia 3 – 4-degree ICRS.

The right knee was involved in 29 cases (56%), the left knee in 25 cases (44%) and the medial femoral condyle in 94% of these cases. Clinical diagnosis was confirmed in 92% and 66.6%; the chondral pathology was localized centrally, in 9.2% dorsally, and in 18.5% on the anterior third of the femoral condyle. The average size of the osteochondral defect in this group was 2.27 cm^2 (from 1 to 3.5 cm^2), with patients subdivided into 2 groups: the first group of 28 (51%) with the size of the defect from 1 to 2cm^2 and the second group of 25 (49%) with the size of the defect from 2 to 4 cm^2.

Eight of the operated patients had a previous medical history of arthroscopic surgery: 6 patients with meniscectomy and 2 patients with resection of hypertrophic mediopatellar plicae. In 29 (53.7%) of operated patients had other combination of procedures done during the surgery.

The results from the complex evaluation of the subjective and objective condition of the knee, based on an average observation period of 26 months, found excellent and good results in 42 patients (78%). The function of the knee joint was fully restored, and all of them returned to usual daily life activities. The average score of the functional state, according to Lysholm score was 86.9. Statistically, this is significant when compared with the pre-operative average scores of 41.5 ($p = 0.0007$) and determines the result as good. The average score of the subjective status was 87.6 points according to the KOS scale compared to the pre-operative score of 42.6 ($p = 0.0001$). The average p-score of V4 is 80 ($p = 0.0001$).

No complaints were registered in 26 patients (48.15%) post-surgery, and all of them have returned to daily life activities. Control MRI after 8 months post-surgery showed in 75% homogenic structure in fibrous regenerative tissue, moderate hypertrophy, moderate edema and satisfactory, marginal integration with the surrounding cartilage.

The defect size was found to be 2.7 cm^2 on average. The Lysholm score was 91.03 on average, denoting excellent results ($p = 0.001$).

Table 3. Results from operative treatment.

Result from operative treatment	Number of patients	
	n	%
Excellent	26	48.15
Good	16	29.6
Satisfactory	10	18.5
Unsatisfactory	2	3.7
Overall	54	100

Moderate pain during heavy loading and minimal edema was reported in 5 patients (9.25%) with osteochondritis dissecans, 4 patients (7.4%) with traumatic osteochondral lesions, and 3 patients with chondromalacia of 3rd grade (ICRS). Control x-rays demonstrated newly formed osteochondral tissue at the site of the necrotic lesion and the articular surface having smooth lines. The working capacity of patients was fully restored. On the control x-ray, we found the replacement of necrotic centers with newly formed bone tissue and joint surface with a smooth line. Overall, the evaluation of knee function according to Lysholm's score was 84, which is considered good.

Negligible difficulty during stair climbing and light pain was reported in 4 patients. Two of these patients had a history of osteochondritis dissecans, and the other 2 patients disclosed trauma history. On control x-rays, after 6 and 12 months, insignificant degenerative changes were noted according to Fairbanks criteria. Data for control MRIs in patients with osteochondritis dissecans showed filling of the defect with regenerative tissue and moderate sclerosis of the subchondral bone. The average Lysholm score was 81. Good results were received.

A more difficult recovery was noticed in the subgroups of patients who had a history of previous surgical intervention – Lysholm 63 ± 20 vs 78 ± 14.2 on the 12th month ($p = 0.04$) and 68.7 ± 24.8 vs 83.0 ± 16.4 after 24 months follow-up.

Regarding the surgeries, which entailed additional surgical procedures, these patients had lower basal KOS scores compared to patients who were subject only to the microfracture procedures (34.1 ± 16.1 vs 47.9 ± 13.2; $p = 0.008$).

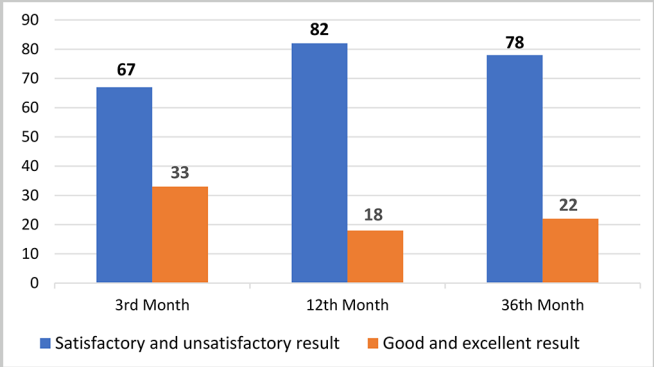
This specific subgroup of patients had lower clinical results on the 12th and also on the 24th month ($p = 0.018$ and $p = 0.016$, accordingly). In 2 symptomatic patients, 4 months after microfracture treatment, a secondary arthroscopy was performed for investigative purposes. These patients were found to have lost fibrocartilaginous regenerative tissue in place of the defect, which required revision with mosaicplasty.

The unsatisfactory result was recorded in 2 patients, for whom the average Lysholm score was 62.4. Both patients were above 55 years old and had a history of previous knee surgery - meniscectomy. Lesions of approximately 4 cm^2 were discovered with the stripping of the os-

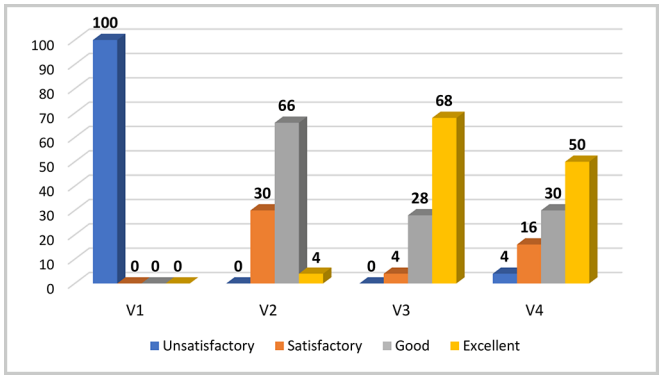
teochondral bone, and early arthritic changes were noted. During post-operative meetings, these patients complained about knee joint pain after a short-length walk (<2 km), instability and weakness in the knee, and difficulty in going upstairs.

Control x-rays conducted after 12 months of surgery have shown arthritic changes, subchondral sclerosis, marginal osteophytosis, and deformation of the affected condyle. Patients eventually were hospitalized on the 3rd and 6th month later on and underwent total knee arthroplasty. Results for the studied group for different periods are given in Graph 1 and Graph 2.

Graph 1. Results from the operative treatment of the 2nd group according to Lyshom score for V2, V3, V4, which demonstrates significant differences between V1 and V4 (p = 0.0001).



Graph 2. Results from the operative treatment of the 2nd group according to KOS score for V1, V2, V3, V4, which demonstrates significant differences between V1 and V4 (p = 0.0002).



Comparative evaluation of results received through perforation and microfractures in patients with local defects on the joint surface of the femoral condyle

The pain was graded according to a visual analogous scale (VAS). The second group demonstrated a significant change in pain post-operatively, from 3.4 to 0.3. The first group was found to have a similar decrease from 3.2 to 0.5 (p <0.02 respectively for both groups). Between 1st and 2nd groups, there is no significant difference according to VAS.

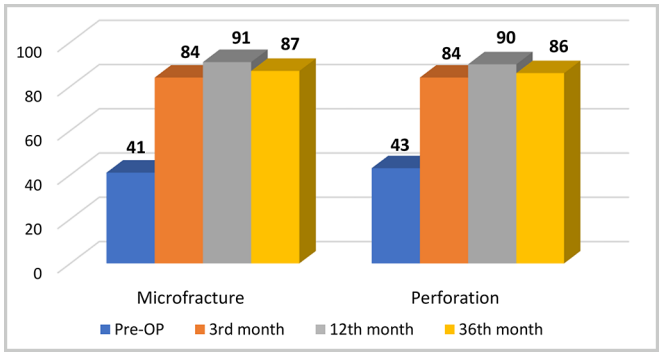
The result from the analysis of the Lysholm scale in each group on different visits is given in Table 4.

Table 4. Average Lysholm value on separate visits from 2 groups.

	n	L1	L2	L3	L4
Microfracture	54	41.5 ±6.6	83.7 ±4.9	91.1 ±3.7	86.9 ±7.3
Perforation	48	43.0 ±5.6	84.2 ±4.4	90.8 ±4.0	86.1 ±6.9

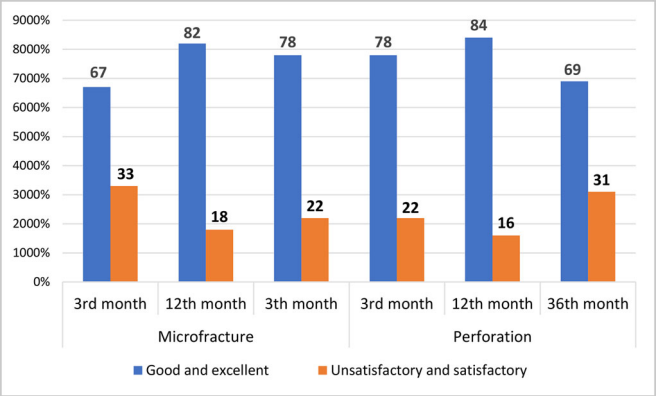
On average, the pre-operative Lysholm grade was 41.5 ± 6.6 in the microfracture group and 43.0 ± 5.6 in the perforation technique group. There was no significant pre-operative difference between the two groups. In the second and third periods of follow-up, there was a significant rise in Lysholm values in both groups (91.1 ± 3.7; 90.8 ± 4 (ð = 0.0007)). At the 36th month, the average Lysholm value had increased to 86.9 ± 7.3 in the microfracture and 86.1 ± 6.6 in the perforation group. Worsening was also found in both groups at the 36th month post-operative checkup (Graph 3).

Graph 3. Average Lysholm values pre-operatively, as well as on the 12th, 24th and 36th month after both surgical interventions. Results are much better compared to initial scores in both groups (p = 0.002 for microfractures and p = 0.005 for perforation).



Patients from the 2nd group (microfracture) who had a lesion in the central part of the medial femoral condyle and patients with lesions larger than 2 cm^2 had significantly worse clinical results compared with patients who had lesions in the other weight-bearing areas of the knee. In both groups, full-grade post-traumatic defects of joint cartilage have shown significantly better clinical results in contrast to those with osteochondritis dissecans (p = 0.004). Independent of the choice of treatment, younger patients (under 30 years of age) had better clinical and functional outcomes than older patients (p = 0.008). According to the Lysholm criteria, good and excellent results were achieved in 78% of the group with microfractures and 69% of patients with perforation of subchondral bone. Graph 4 demonstrates the distribution of these results according to groups.

Graph 4. Relative assessment of Lysholm scores in two operative techniques for the studied period.

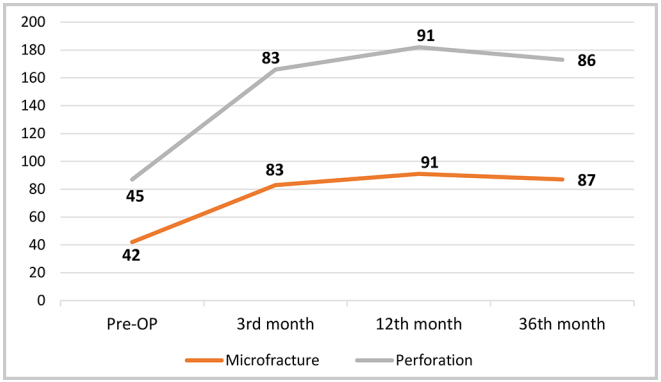


The result from the KOS scale analysis for each group during their various follow-up visits is shown in Table 5, and their evolution can be seen in Graph 5.

Table 5. Average KOS scores for 2 groups on different visits.

	n	KOS 1	KOS 2	KOS 3	KOS 4
Microfracture	54	42.6±5.8	83.1±5.4	91.3±4.2	87.6±7.5
Perforation	48	45.4±6.4	83.5±6.0	91.2±4.5	86.2 ±6.6

Graph 5. KOS score dynamics of 2 operative techniques for the studied period.



The second arthroscopy and a biopsy was done on 7 consenting patients from the microfracture group. In 4 (57%) samples in the microfracture group, histology showed formed fibrocartilage and superficial flickering, and in the other 3 patients (43%), histology showed fibroelastic tissue, which was different from adjacent normal articular cartilage.

DISCUSSION

Analysis of results of 2 surgical techniques

A comparative study was conducted, analyzing the results of two different surgical techniques in the treatment of 103 patients. These patients had isolated defects on the joint surface of a femoral condyle. All patients experienced good results immediately post-operatively, without infection or complication.

The average in-patient stay post-operatively was 3-4 days. The average follow-up period was from 6 months to 3 years.

Results on KOS, Lysholm, and MRI scales were acquired by utilizing questionnaires in all patient groups. During the process of investigation, a scale (P-score) with which to grade pain and motor function in the knee was created.

Relation between results and size of the defect

The Lysholm score was found to have a significant dependence on the size of the osteochondral lesion, as is shown in both groups. In the second group (microfracture), this dependence is calculated with an equation Lysholm = 97.7 – 4.8 x size of the defect (r = - 0.41; p=0.003). In the first group (drilling), this dependence is calculated with an equation Lysholm = 97.7 – 4.9 x size of the defect (r = - 0.43; p=0.003).

Interestingly, the given data suggests that an increase greater than 2 cm^2 in the defect area negatively influences the outcome of both treatment options. However, the treatment result remains good if the defect is smaller than 2 cm^2.

Based on the received data, each patient group was divided into 2 groups, depending on the size of the defect: <2 cm^2 and >2 cm^2. The results from treatment in relation to the size of the defect and operative technique is seen in Table 6.

Table 6. Result from treatment in relation to the size of the defect and operative technique.

Method	Defect size	Treatment result								Overall
		Excellent		Good		Satisfactory		Unsatisfactory		
		n	%	n	%	n	%	n	%	
Microfracture	< 2 cm^2	19	61.29	10	32.25	2	6.45	0	0	31
	> 2 cm^2	7	30.43	6	26.08	8	34.78	2	8.69	23
Perforation	< 2 cm^2	10	33.33	16	53.33	4	13.33	0	0	30
	> 2 cm^2	3	16.66	5	27.77	8	44.44	2	11.11	18

Results from patients with smaller lesions (<2 cm^2) show that both microfracture and drilling technique treatment leads to good mid-term results in case of such pathology.

Satisfactory and unsatisfactory results in two of these groups are mainly seen in patients with osteochondral lesions in the weight-bearing areas of the femoral condyles with sizes from 2 – 5 cm^2 (p = 0.01), as shown in Table 6.

Comparing differences according to the Student criteria indicates a pronounced tendency for result to worsening from the treatment with this method of mesenchymal chondrogenesis as the defect size increases.

In the majority of cases, studies have shown that patients with smaller lesions have a better clinical outcome and quality of recovered cartilaginous tissue after microfractures compared to patients with bigger damages [11, 12, 13, 14, 15].

Dependence of results on the presence of soft tissue lesions in the knee and previous surgical procedures

Patients with a history of previous knee surgery tended to have poorer results compared to those who did not, as shown in this study. Patients who attained satisfactory results were those who had a previous arthroscopy due to other reasons, which coincided with a longer history of complaints. Early arthritic changes were noticed in part of these patients according to the Fairbank criteria, and several of them underwent total knee arthroplasty in 16 – 30 months. Patients with previous surgeries on the knee have shown worse results at 12 months on follow-up (p = 0.048). These patients were also confirmed to have struggled more during the rehabilitation period, especially the subgroup with previous cartilage surgery: 63.4 ± 14.0 compared to 72.4 ± 12.2 on the 12th month, according to Lysholm (p = 0.04) and 74.7 ± 23.1 compared to 86.0 ± 14.2 according to Lysholm after 24-month follow-up. This specific subgroup had lower clinical results on the 12th as well as on the 24th month.

Dependence of results on age

Another finding of this study was a dependence of the results relative to the age of the patients.

This study found that an increasing patient age correlated with a poorer clinical outcome in both surgical techniques. This inverse relationship is calculated by the equation: KOS = 102.73 - 0.345 x age (r = -0.60; p=0.001) and Lysholm = 101.9 – 0.34 x age (r = -0.59; p=0.001). Satisfactory and unsatisfactory results are reported in patients above 50 years of age. Patients around the age of 20 and 30 years old had better mid-term results in all groups. The largest regression is found with an increase in age in the second and first groups.

Steadman et al. [16] obtained similar results, with an average follow-up of 11 years, after the microfracture treatment in patients with traumatic chondral lesions in the knee. Positive results were obtained in all patients above 45 years of age who had undergone surgery.

Contrary to this, however, was a study done by Kreuz et al. [17], who determined that clinical results after microfracture in patients with whole-depth cartilage lesion depended on the age of the patient. Worsening starts 18 months after the operation and becomes much more noticeable in patients above 40 years of age. Patients 40 years and younger, though, were still found to have the best prognosis in the event of femoral condyle defects.

Mithoefer et al. in 2009 made a systemic review of published articles regarding microfractures [18]. Their conclusion was that microfractures ensure effective near-term improvement of knee function, but not enough data exists for a long-term result.

Disadvantages of the technique include limited recovery of hyaline tissue, variable recovery of cartilage, and possible worsening of function. Kreuz et al. [17] presented data linked with the influence of age on the result of microfractures in the knee joint. ICRS results have shown worsening between 18 and 36 months in the age group above 40 years. There is evidence from the literature that patients under 30 – 40 years may use more than one microfracture technique [17, 19]. One possible explanation for these findings could be a higher biological quality of nascent stem cells as well as better nutritional help on regenerative tissue, which is based on a more effective blood supply in younger individuals.

Dependence on the results from the tracking period

Patients in both groups have almost equal results at the 12th and 24th months of follow-up. After 36 months, a regression was established in the results of the second and first groups. According to the data from the prospective analysis regarding the effectiveness of the operative methods – microfracture and perforation, within the period of observation of 3 – 7 years according to Lysholm criteria, Bobic et al. reported 89% to have excellent and very good results in the 3rd year and 69% in the 7th year after microfracture and 80% and 65% after perforation accordingly [20].

Steadman and Mithoefer [16, 21] used ICRS in order to analyze results after bone-marrow stimulation techniques (perforation, microfractures and abrasio-chondroplastics), af-

ter which the results were worse than those previously found. Although clinical improvement was observed in the first 18 months, the function of the knee joint steadily worsened in half of the cases. Subsequent MRI has shown data for appeared chondral defects, which in 25% of cases were replaced with bone tissue.

In the study of Kreuz et al. [17], clinical results after microfracture worsens after 18 and 36 months, depending on the age of the patient and/or place of the lesion.

During the 48th-month study, Mithoefer et al. [18] determined that during everyday activities, the results of IKDC get better up to 24 months after microfractures, after which they become significantly worse in the period between 24 – 36 months. However, after 48th months, there appears to be little difference between pre-operative and post-operative results. In another study of sportsmen, active sports activity first increases but later on decreases in almost half of the patients [15].

Similar findings are also reported by Gudas et al. [22] and Gobbi et al. [12], which demonstrate that in long-term studies (average follow-up of up to 6 years), knee function improves significantly after microfractures. Gudas et al. [22] and Gobbi et al. [12] found that 70% of patients even self-reported their well-being as normal or almost normal. Despite that, high-energy sports activity is improved in 80% of patients, although after a 2-year follow-up, only 55% of patients were found to have better results in the final phase of the study [12, 23]. Conclusions on durability are controversial.

In a prospective study by Gobbi et al. [12], 109 cases with cartilage lesions of the knee and treated with microfracture registered a decrease in IKDC score in 80% of cases during the final follow-up (approximately 72 months later). Around 70% of patients show a decrease in sports activity. In conclusion, Italian authors stated that microfractures provide clinical and functional improvement in physically active patients, but maybe this method is not for the definitive treatment of cartilage lesions of the knee in the active sportsman [12].

CONCLUSION

The treatment of cartilaginous defects in the knee joint represents a problem in orthopedics and traumatology. Many discussions and efforts are put into the restoration of areas of hyaline cartilage, which has led to the introduction of multiple surgical techniques. Arthroscopic perforation, microfractures and mosaicplasty are just a few to name; there are many more such as chondroplastics utilizing collagenous hydrgogel, chondrocyte transplantation and transplantation of freshly frozen allografts.

There is still much debate surrounding the use of arthroscopic methods to treat localized cartilage tissue defects in the knee joint.

The surgical technique should be chosen based on the defect's location, size, and depth, as evaluated by Outbridge and ICRS criteria, and considering the patient's age and BMI.

As a result of the analysis of the data from the completed questionnaires, as well as data from early and mid-term results of the treatment of the surveyed 103 (100%) patients, this study found:

1. Arthroscopic microfracture in a group of 54 patients – results were good and excellent in 42 (78%) of patients, satisfactory and unsatisfactory in 12 (22%) of patients

2. Arthroscopic perforation in a group of 49 patients – results were good and excellent in 34 (69%) of patients, satisfactory and unsatisfactory in 20 (31%) of patients

To conclude, based on the data from the research conducted, this study achieved that good results with regard to the intensity of the pain in the early post-operative period in a group of patients who underwent microfractures. Application of osteoperforation arthroscopic intervention led to poorer clinical results (3 years post-operatively).

In conclusion, we need to underline that mesenchymal stimulation of chondrogenesis produces positive results in these cases, with small defect areas specifically located in non-weight bearing areas. The most promising results are found in relatively young patients with no history of soft tissue injuries or prior surgeries.

Abbreviations:

ACL – Anterior cruciate ligament

BMI – Body mass index

KOS – Knee Outcome Survey Activities of Daily Living Scale

PS – Own scale for assessment

VAS – Visual analogous scale

REFERENCES:

1. Mano JF, Reis RL. Osteochondral defects: present situation and tissue engineering approaches. *J Tissue Eng Regen Med.* 2007 Jul-Aug;1(4):261-73. [PubMed]

2. Litwic A, Edwards MH, Dennison EM, Cooper C. Epidemiology and burden of osteoarthritis. *Br Med Bull.* 2013;105:185-99. [PubMed]

3. Willers C, Wood DJ, Zheng MH. A current review on the biology and treatment of articular cartilage defects (part I&part II). *J Musculoskelet Res.* 2003 Sep-Dec;7(3-4):157-81. [Crossref]

4. Gracitelli GC, Moraes VY, Franciozi CE, Luzo MV, Belloti JC. Surgical interventions (microfracture, drilling, mosaicplasty, and allograft transplantation) for treating isolated cartilage defects of the knee in adults. *Cochrane Database Syst Rev.* 2016 Sep 3;9(9):CD010675. [PubMed]

5. Sophia Fox AJ, Bedi A, Rodeo SA. The basic science of articular cartilage: structure, composition, and function. *Sports Health.* 2009 Nov;1(6):461-8. [PubMed]

6. E Albuquerque RP, Giordano V, Calixto A, Malzac F, Aguiar C, do Amaral NP, et al. Analysis on the modified Lysholm functional protocol among patients with normal knees. *Rev Bras Ortop.* 2015 Nov 16;46(6):668-74. [PubMed]

7. Howell M, Liao Q, Gee CW. Surgical Management of Osteochondral

Defects of the Knee: An Educational Review. *Curr Rev Musculoskelet Med.* 2021 Feb;14(1):60-66. [PubMed]

8. Steadman JR, Rodkey WG, Briggs KK. Microfracture: Its History and Experience of the Developing Surgeon. *Cartilage*. 2010;1(2):78-86. [PubMed]

9. Mithoefer K, Williams RJ 3rd, Warren RF, Potter HG, Spock CR, Jones EC, et al. Chondral resurfacing of articular cartilage defects in the knee with the microfracture technique. Surgical technique. *J Bone Joint Surg Am.* 2006 Sep;88 Suppl 1 Pt 2:294-304 [PubMed]

10. Erggelet C, Vavken P. Microfracture for the treatment of cartilage defects in the knee joint - A golden standard? *J Clin Orthop Trauma.* 2016 Jul-Sep;7(3):145-52. [PubMed]

11. Bae DK, Yoon KH, Song SJ. Cartilage healing after microfracture in osteoarthritic knees. *Arthroscopy.* 2006 Apr;22(4):367-74. [PubMed]

12. Gobbi A, Nunag P, Malinowski K. Treatment of full thickness chondral lesions of the knee with microfracture in a group of athletes. *Knee Surg Sports Traumatol Arthrosc.* 2005 Apr;13(3): 213-21. [PubMed]

13. Knutsen G, Drogset JO, Engebretsen L, Grøntvedt T, Isaksen V, Ludvigsen TC, et al. A randomized trial comparing autologous chondrocyte implantation with microfracture. Findings at five years. *J Bone Joint Surg Am.* 2007 Oct;89(10):2105-12. [PubMed]

14. Miller BS, Steadman JR, Briggs KK, Rodrigo JJ, Rodkey WG. Patient satisfaction and outcome after microfracture of the degenerative knee. *J Knee Surg.* 2004 Jan;17(1):13-7. [PubMed]

15. Mithoefer K, Williams RJ 3rd, Warren RF, Potter HG, Spock CR, Jones EC, et al. The microfracture technique for the treatment of articular cartilage lesions in the knee. A prospective cohort study. *J Bone Joint Surg Am.* 2005 Sep;87(9):1911-20. [PubMed]

16. Steadman JR, Briggs KK, Rodrigo JJ, Kocher MS, Gill TJ, Rodkey WG. Outcomes of microfracture for traumatic chondral defects of the knee: average 11-year follow-up. *Arthroscopy.* 2003 May-Jun;19(5):477-84. [PubMed]

17. Kreuz PC, Steinwachs MR, Erggelet C, Krause SJ, Konrad G, Uhl M, et al. Results after microfracture of full-thickness chondral defects in different compartments in the knee. *Osteoarthritis Cartilage.* 2006 Nov;14(11):1119-25. [PubMed]

18. Mithoefer K, McAdams T, Williams RJ, Kreuz PC, Mandelbaum BR. Clinical efficacy of the microfracture technique for articular cartilage repair in the knee: an evidence-based systematic analysis. *Am J Sports Med.* 2009 Oct;37(10):2053-63. [PubMed]

19. Steadman JR, Rodkey WG, Briggs KK. Microfracture to treat full-thickness chondral defects: surgical technique, rehabilitation, and outcomes. *J Knee Surg.* 2002 Summer;15(3):170-6. [PubMed]

20. Bobic V, Morgan CD, Carter T. Osteochondral autologous graft transfer. *Oper Tech Sports Med.* 2000 Apr;8(2):168-178. [Crossref]

21. Mithöfer K, Peterson L, Mandelbaum BR, Minas T. Articular cartilage repair in soccer players with autologous chondrocyte transplantation: functional outcome and return to competition. *Am J Sports Med.* 2005 Nov;33(11):1639-46. [PubMed]

22. Gudas R, Kalesinskas RJ, Kimtys V, Stankevicius E, Toliusis V, Bernotavicius G, et al. A prospective randomized clinical study of mosaic osteochondral autologous transplantation versus microfracture for the treatment of osteochondral defects in the knee joint in young athletes. *Arthroscopy.* 2005 Sep;21(9):1066-75. [PubMed]

23. Gobbi A, Francisco RA, Lubowitz JH, Allegra F, Canata G. Osteochondral lesions of the talus: randomized controlled trial comparing chondroplasty, microfracture, and osteochondral autograft transplantation. *Arthroscopy.* 2006 Oct;22(10):1085-92. [PubMed]

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