Treatment of Osteochondral Defects of the Knee Joint by Osteochondral Autograft Transfer

Riad Mansour Megahed, Mohamed Elsayed Refaie*,
Hossam Fathi Mahmmoud, Mohammed Attia Abdelmoeti
Department of Orthopedic Surgery, Faculty of Medicine, Zagazig University, Egypt
***Corresponding author:** Mohamed Elsayed Refaie, **E-Mail:** mohamadalrefay63@gmail.com

ABSTRACT
Background: Osteochondral autograft transfer (OAT) is very helpful in managing osteochondral defects of knee joint.
Objective: Evaluation of the radiological and functional results of osteochondral autograft in treatment of osteochondral defects.
Patients and Methods: Eighteen patients with chondral and osteochondral lesions in the knee joint treated by Osteochondral Autograft Transport System (OATS) were included. Patients were recruited from Zagazig University Hospital outpatient clinic and followed up for more than six months.
Results: The best results were generally encountered in small lesions, chondral and osteochondral defects, that had normal articular cartilage surrounding the lesion, and the average final subjective chondral defect score at the end of the follow up was with (50.1 ± 6.4) in comparison to the average preoperative subjective score was (27.4 ± 6.9). There was a statistically significant difference between the mean of the preoperative and the final postoperative subjective chondral defect scores, indicating marked postoperative subjective improvement. Also, highly statistical significant increasing in postoperative Lysholm Score (88.3 ± 8.7) when compared with preoperative one (46.5 ± 15.2).
Conclusion: OATS were proved to be a useful procedure in treatment of osteochondral defect of the knee joint as it produced a high good to excellent outcome in our series patients with minor complications.
Keywords: Osteochondral autograft transfer, Osteochondral Defects.

INTRODUCTION

Osteochondral defect is a known as localized defect of the subchondral bone and articular cartilage [(1)]. Many damage to the knee's articular cartilage result in whole or partial thickness lesions, as **Curl *et al.*** found in their evaluation of more than 30.000 arthroscopic surgeries on the joint [(2)].

A shearing-type damage, twisting paired with an axial load, or substantial blunt trauma resulting in an impaction injury are the most common causes of chondral and osteochondral injuries. Weight-bearing causes the patient to experience an increase in pain. Additionally, the collecting and locking of recurring effusions [(3)].

Standard diagnostic imaging should include a standard weight-bearing anteroposterior radiograph of both knees in full extension, along with a lateral view, and an axial view of the patellofemoral joint. It is possible to determine the extent of articular cartilage lesions with the aid of magnetic resonance imaging [(4)].

Surgical treatment of symptomatic chondral abnormalities seeks to reduce symptoms, improve joint congruence, and prevent additional cartilage damage [(5)].

Palliative, reparative, and restorative treatment options are all subcategories of the more general term "alternative". Lesions in patients with low demand are better treated with palliative techniques like debridement and lavage. Drilling, abrasion arthroplasty, or microfracture are examples of marrow-stimulating treatments that can be used to improve fibrocartilage repair in the area of the defect. There are a variety of procedures for replacing injured cartilage, including autologous chondrocyte implantation and autografting, fresh osteochondral allografting, and fresh osteochondral allografting [(6)].

Osteochondral autograft transfer is a procedure in which undamaged cartilage and subchondral bone are transferred from a region of minimal load bearing to a full-thickness lesion in the knee. Arthrotomy or arthroscopic surgery are two options for doing the procedure. Complications like as donor-site morbidity and the limited amount of tissues that can be harvested are well-documented [(5)].

Osteochondral lesions can only be successfully treated if hyaline cartilage regeneration can be avoided. Excellent results can be achieved with appropriate usage of (OATs), which can have a long-lasting and functional influence, low morbidity rates, and reasonable expenses. Although it has restricted the indication, expanding the criteria for its use has demonstrated encouraging mid- and long-term results [(2)].

It was the goal of this work to evaluate the radiological and functional results of osteochondral autograft in treatment of osteochondral defects.

PATIENTS AND METHODS

This study was undertaken in the Orthopedic Surgery Department of Zagazig University Hospitals, eighteen patients with chondral lesions in the knee joint treated by Osteochondral Autograft Transport System (OATS) were included. Patients were recruited from Zagazig University Hospital outpatient clinic and followed up for more than six months.

Ethical consent:

Received: 28/11/2021
Accepted: 26/01/2022

An approval of the study was obtained from Zagazig University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study (ZU-IRB#6829). This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria: Age to be lower than 50 years old, focal, (International Cartilage Repair Society (ICRS) grade III or IV) smaller than 4 cm^2 in size lesions on the weight-bearing area of the femur's condyles, and osteochondral fracture and osteochondritis dissecans.

Exclusion criteria: Osteoarthritis, lower limb deformity, infection, and systemic inflammatory disorders.

All patients were subjected to:

Full history: Name, age, sex, residence, medical history of chronic and metabolic diseases, date of examination and/or admission, contact information and other habits of medical interest.

Clinical examination: General examination, Local examination and Neurovascular examination were done.

Laboratory investigations: CBC, random blood sugar, Renal and liver function tests, Virology (HCV, HBV, HIV), as well as bleeding profile.

Radiological investigations:

Plain radiography was done for all patients in the form of anteroposterior and lateral views.

MRI was done in all of the cases, to assess the lesions site, size, depth, stability of the osteochondral fragments.

Chondral defect scoring system (CDSS): This study used CDSS since it is a straightforward, particular method for studying the cartilage dilemma.

The Lysholm score: Eight questions make up the Lysholm score. In order to arrive at a final score, you must add up the eight possible responses, each worth a maximum of 100 points. Patients with cartilage injuries can benefit from the Lysholm score, which was validated primarily for ligament repair or rebuilding[(7)].

Preoperative diagnostic arthroscopy:

Positioning: The patient was lying down. Up to 120 degrees of flexion should be attainable. Inflated tourniquet put on injured limb. Arthroscopically, the defect is right across the anterolateral, anteromedial, and accessory instrumental portals. A long needle was used to assess the condylar defect in order to select an instrumentation portal that is directly perpendicular to it. Preliminary examination because arthroscopic visual inspection and probing are the most useful diagnostic technique for the following reasons, arthroscopic examination was performed in all patients: **Assessment** of the defect size after debridement, the defect is precisely measured with a short probe whose length is known or with a long and tapered probe, the mean size of our studied patients was 2.2 ± 0.51 with minimum size of 1.1 and maximum size of 3. There were 9 patients (50%) < 2.2 cm and 9 patients (50%) > 2.2 cm in the studied patients.

Surgical Grafting Technique: It was open in 15 patients (83.3%) and arthroscopic in 3 patients (16.7%).

***Arthroscopic procedure* (Figures 1 and 2):**

The recipient harvesting tube was introduced into the access portal, which could be adjusted to enable perpendicular access to the defect, to begin the lesion preparation process. Hammering on the T handle while maintaining perpendicular access, the tube was inserted to a depth of 15 mm.

The core was removed after rotating the T handle three or four times in a clockwise and counterclockwise direction.

The graft harvesting tube was attached after the harvesting tube was removed from the T handle. Above the sulcus terminalis of the medial femoral condyle (M.F.C.) or lateral femoral condyle (L.F.C.), harvested plugs were obtained. Tubes were delivered perpendicularly under vision from inside or outside the knee by scope or vision until the length taken was a 15 mm tube lateral to the superior patellar portion of the patella. Rotated 90 degrees clockwise and anticlockwise with rocking in two directions, the tube was then evacuated while spinning slowly, and a cartilage guard attached. The graft tube was inserted in the prepared tunnel, and the grafts were hammered while ensuring that they were perpendicular and could be seen via the tube's slot. The graft should be hammered to a flat surface with the condyle until the cartilage has been broken in place.

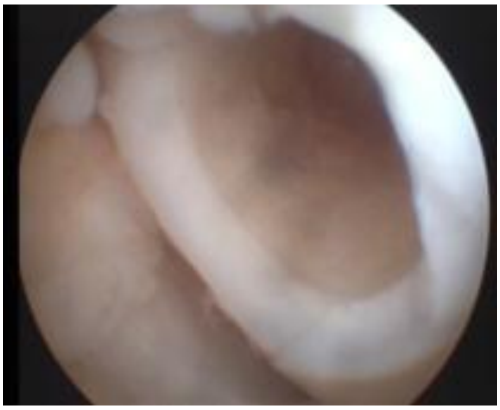


Figure (1): The socket was drilled in the recipient site of the femoral condyle

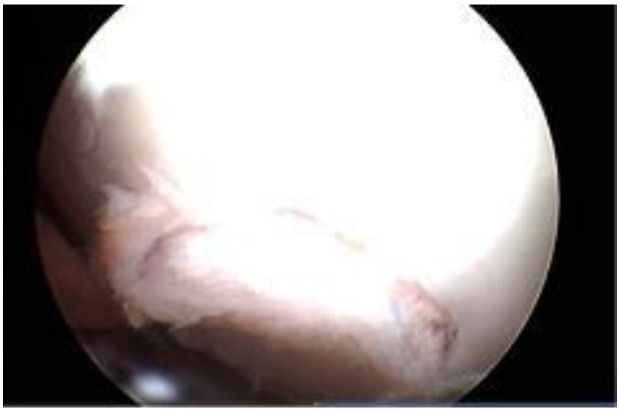


Figure (2): The graft was inserted in the defect

***Open (mini-invasive arthrotomy) Technique* (Figures 3 and 4):**

An arthroscopic mini-arthrotomy to examine articular cartilage lesions for femoral condyle defects was performed. The incision should be long enough to view the lesion with the knee flexed and long enough to view the superior aspect of the trochlea (where donor grafts can be obtained) when the knee is extended. As with an arthroscopic surgery, the defect was prepared:

1) Tube was delivered perpendicular to the cartilage and hammered until the length taken was a 15 mm then the tube was rotated as previously mentioned, and then was extracted while rotating gently. As previously stated, the tube was hammered perpendicular to cartilage and then rotated while rotating gently, then the tube was inserted into the prepared tunnel with the grafts hammered while maintaining their perpendicularity. The tube was then extracted while rotating gently, then the tube was placed at the prepared tunnel and grafts hammered while securing its being perpendicular, and visualised through its slot in the tube. If the graft is not flush with the condyle's surface after being hammered, then the second plug should be hammered as well.
2) **As regard graft number:** 1 graft was used in 2 patients (11.1%), 2 grafts were used in 13 patients (72.2%) and 3 grafts were used in 3 patients (16.7%).

Figure (3): Plug Grafting

Figure (4): Final seating of the grafts

Follow up:

The period of follow-up ranged from 6 to 12 months with a mean of 7 months. Follow-up visits were every 3 months after end of phase III of rehabilitation. The patients were examined for pain, swelling, and range of motion. Plain radiographs were also examined. In the last follow-up visits the chondral defect score, Lysholm score and patient satisfaction were assessed. Satisfaction was assessed by asking the patient if he was satisfied by the procedure or not) for each patient. Plain radiographs and MRI images were also examined.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for the Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Wilk test. Qualitative data were represented as frequencies and relative percentages and were compared by chi square test (X^2). Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value < 0.05 was considered significant.

RESULTS

Demographic data of the studied patients are shown in **table 1.**

Table (1): Distribution of the studied patients according to demographic data

Age (years)	**Mean ±SD**	**24.6 ± 7.3**	
	Min – Max	**15 – 38**	
		No	**Percentage %**
Sex	**Male**	**16**	**88.9%**
	Female	**2**	**11.1%**
Side	**Right side**	12	66.7%
	Left side	6	33.3%

There was highly statistically significant difference between preoperative and postoperative range of movement (ROM), pain and swelling in the studied patients **(Table 2)**.

Table (2): Comparisons of preoperative and postoperative (ROM, pain and swelling) in all studied patients

		Pre-op (N = 18)		**Post-op (N = 18)**		**Stat. test**	**P-value**
ROM	**Normal**	0	0%	11	61.1%	**X^2 = 15.8**	**< 0.001**
	Loss of flexion	18	100%	7	38.9%		
ROM (loss of flexion)	**Mean±SD**	47.2± 27.6		18.5± 8.9		**T = 2.66**	**0.014**
Pain	**No**	0	0%	3	16.7%	**X^2 = 28.9**	**< 0.001**
	Mild	2	11.1%	15	83.3%		
	Moderate	10	55.6%	0	0%		
	Severe	6	33.3%	0	0%		
Swelling	**No**	0	0%	8	44.4%	**X^2 = 28.9**	**< 0.001**
	Mild	2	11.1%	10	55.6%		
	Moderate	15	83.3%	0	0%		
	Severe	1	5.6%	0	0%		

Regarding X-rays' findings in our studied patients, there wasn't loose body in all the patients **(Table 3).**

Table (3): Description of post. X rays findings

		Studied patients (N = 18) Number	percentage
Post. X rays Findings	**Absent Loose bodies**	18	100%
	Protuberance of the plug	2	11.1%

Regarding MRI finding in our studied patients, there was osseous integration, absent bone marrow edema, and ulcer coverage in all the patients **(Table 4).**

Table (4): Description of post. MRI Findings

		Studied patients (N = 18) Number	percentage
Post. MRI Findings	**Surface congruency**	16	88.9%
	Osseous integration	18	100%
	Absent Bone marrow edema	18	100%
	Ulcer coverage	18	100%

There was highly statistically significant increased postoperative subjective, objective, and total chondral defect score compared to preoperative values **(Table 5)**.

Table (5): Comparisons of preoperative and postoperative chondral defect score system in all studied patient

Chondral defect Score System		Pre-op (N = 18)	Post-op (N = 18)	Stat. test	P-value
Subjective	**Mean±SD**	27.4±6.9	50.1±6.4	**T = 10.2**	**< 0.001**
Objective	**Mean±SD**	22.6±4.6	37.8±4.9	**T = 9.5**	**< 0.001**
Total	**Mean±SD**	50±8.5	87.9±9.7	**T = 12.4**	**< 0.001**

There was highly statistically significant increased postoperative subjective Lysholm Score when compared with preoperative level **(Table 6).**

Table (6): Comparisons of preoperative and postoperative Lysholm Score in all studied patient:

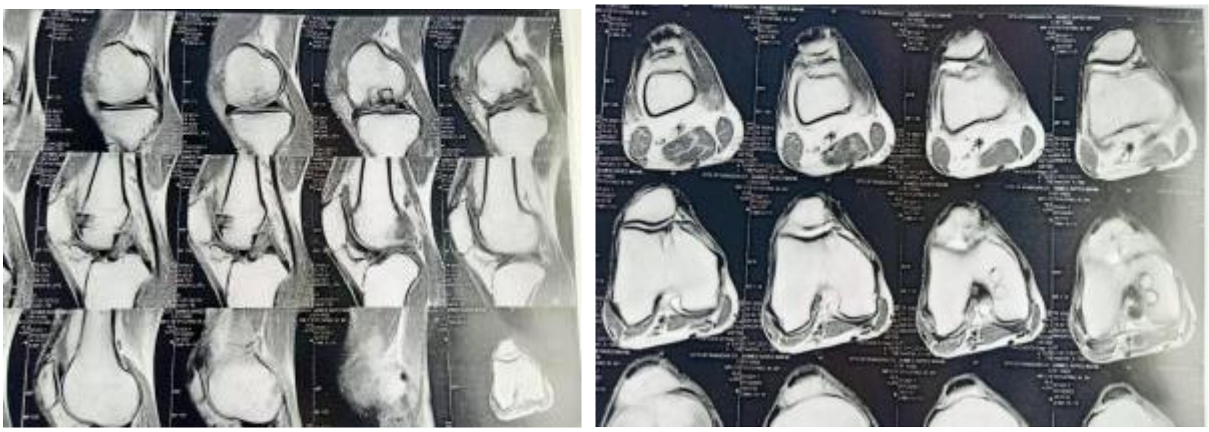
		Pre-op (N = 18)	Post-op (N = 18)	Stat. test	P-value
Lysholm Score	**Mean±SD**	46.5±15.2	88.3±8.7	**T = 10.1**	**< 0.001**

The description of postoperative clicking, complications and Lysholm Score end results in all studied patients is shown in **Table 6.**

Table (7): Description of postoperative clicking, complications and end results in all studied patients

		Studied patients (N = 18)	
Postoperative clicking	**No**	7	38.9%
	Yes	11	61.1%
Postoperative complications	**No**	6	33.3%
	Hemarthrosis	4	22.2%
	Pain over donor site	8	44.4%
Lysholm score end results	**Fair**	2	11.1%
	Good	11	61.1%
	Excellent	5	27.8%

(A)



(B)

Figure (5): A 38 years old male with BMI (24.9) worker. He had history of repeated trauma with recurrent history of pain, difficult in climbing stairs and downstairs, difficult range of motion in his right knee, he had a pain at rest and swelling with usual activities and intermittent locking. On examination moderate swelling, range of motion was near full extension and loss of last 60 degree of flexion with painful range in last 100 degrees of flexion. Tender medial joint line was detected. All knee ligament stability tests were negative. Mini-arthrotomy approach was done by 2 to 3 cm long medial parapatellar sagittal incision to perform a mini-arthrotomy OATS. Knee arthroscopy after closure of medial retinaculum to assess the level of grafts and congruity (a) MRI showing MFC ulcer with bone marrow edema (B) MRI after six months show good incorporation and filling of the defect.

DISCUSSION

Damaged joint surfaces have long been recognised for their inability to repair on their own. It was **Hunter** who said in 1743 that damaged cartilage "cannot be healed" [(8)]**.** Progress in understanding why articular cartilage is limited in its ability to self-repair has been made, although hyaline cartilage cannot be regenerated. Cartilage lacks the ability to heal entirely due to the lack of vascularity, the immobility of chondrocytes, and the limited ability of mature chondrocytes to reproduce. The size and depth of the wound determine how much and how well it heals. In addition, untreated chondral abnormalities may grow in size in active individuals, resulting in degenerative arthritis [(9)].

Young patients usually achieve better outcome, because of better graft incorporation and fewer osteoarthritic changes. In our study age data of the patients ranged between 15 and 38 years with a mean 24.6 years (SD ±7.3)**.** We divided the age group in this study into two groups; first from 15 to below 25 years old and second group from 25 to 38 years old. Results were better in younger age group, with insignificant difference in final outcome. These results of our study are similar to **Barber and Chow** [(10)]**, Chow** ***et al.*** [(11)]**,** and **Karataglis** ***et al.*** [(12)]**;** they found no relation between patient age at operation, and the functional outcome

OAT technique can be done via arthroscopic or mini-arthrotomy procedure. In our study final follow up Lysholm score were comparable with each other; it was open in 15 patients (83.3%) and arthroscopic in 3 patients (16.7%). As regard open procedure postoperative end results were fair in 2 patients, good in 8 patients, excellent in 5 patients. In the arthroscopic procedure the 3 patients had good results. There was no significant difference in our study between open mini arthrotomy and arthroscopic procedure. This result coincided with **Keeling** ***et al.*** [(13)] who reported that mini-open and arthroscopic techniques were equally employed with no statistically significant differences.

Chondral defect scoring system was utilized to assess the results of this study. It was found that the mean subjective score improved from 27.4 (±SD 6.7) preoperatively to 50.1 (±SD 6.4) postoperatively. And the mean of objective score improved from 22.6 (SD±4.6) preoperatively to 37.8 (±SD 4.8) postoperatively. The mean of total objective and subjective improved from 50 (±SD 8.5) preoperatively to 87.9 (±SD 9.7) postoperatively. Those results were close to the results of **Chow *et al.*** [11]**;** who had 30 patients for 2 years follow-up and reported an improvement of mean score from 46 to 83. Similar results were reported by **Hangody *et al.*** [14]**.** They carried out their study on 40 patients aged between 17 to 45 years. Follow up was 12-24 months. The mean chondral defect score improved from 52 preoperatively to 86 postoperatively.

Lysholm score system was also utilized for assessment of results of this study. The total score showed significant improvement from 46.5 points (±SD 15.2) preoperatively to 88.3 points (±SD 8.7) postoperatively**.** The results in this study were comparable with the results of **Oztürk *et al.*** [15]**;** their study Lysholm score improved from 45.8 points preoperatively to 86.5 points postoperatively. The two studies had a similar number and age of the patients. **Chow *et al.*** [11] had a study on 33 patients and achieved improvement of Lysholm score from 43.6 to 87.5 points, and **Barber and Chow** [10] reported an improvement from 44 points preoperatively to 84 points postoperatively in a study done on 36 patients.

Our results were superior to the results of **Ulstein *et al.*** [16] that had 15 patients with a mean age of 32.7 years (±SD 7.8), and lesion size between 2-4 cm diameter. They used complete medial parapatellar arthrotomy. Their study mean Lysholm score improved from preoperative 49.2 points to postoperative 69.7 points at 2 years follow up. This may be attributed to large wound problems that may delay rehabilitation, but in our study; we used the arthroscopic or the mini-invasive procedure. **Solheim *et al.*** [17] reported a comparable result. They had Thirty-three patients aged up to 50 years. Articular cartilage defects were from 1 to 5 cm in diameter. Clinical outcome was evaluated by Lysholm score; the mean preoperative score was 48 points and improved postoperatively to 82 points at one year follow up.

This study results were inferior to results of **Ma *et al.*** [18]**;** mosaicplasty was used in the treatment of 18 individuals with post-traumatic localised osteochondral defects of the knee. With an average age of 29, there were 12 men and six women (from 16 to 51 years). Preoperative Lysholm scores averaged 47.5 points, and postoperative Lysholm ratings averaged 92.4 points. It could be because the defect was so small (1 to 2.5 cm in diameter) and the lesions were caused by posttraumatic, rather than pathologic, factors.

The outcome of our study at the last follow-up visit showed; excellent result in 5 patients (27.8%), good in 11 patients (61.1%), and fair in 2 patients (11.1%), which was close to **Oztürk *et al.*** [15] end results. Who had an excellent outcome in seven patients (27%), good in 11 patients (58%) and fair in one patient (15%). Excellent and good results of our study were 88.9% that coincided with **Chow *et al.*** [11]**;** who had excellent or good outcome (81.3%). Also close to **Marcacci *et al.*** [19] study that had 2-year follow-up showed 78.3% of excellent and good results.

Complications of this procedure in our study were hemarthrosis presented in 4 cases that was improved by early use of ice packs, analgesic, antiedematous and intravenous antibiotic. Donor site pain occurred in 8 cases. It decreased with further follow up (See later). We did not encounter another complications like stiffness as all patients were satisfied with their range of motion, wound site infection, graft fracture, condylar fracture, graft slippage, donor site morbidity, or failure of graft integration. Those complication are comparable with those found by **Karataglis *et al.*** [12]**;** 9 patients (21%) out of 42 patients. As authors had 4 cases (9%) with postoperative stiffness, one patient had a superficial wound infection, and no donor-site related morbidity. Other complications were found with **Solheim *et al.*** [17]**;** as deep vein thrombosis occurred in one patient, septic arthritis occurred in one patient, two patients experienced hemarthrosis postoperatively, and superficial wound problem was seen in 3 patients.

The fair outcome occurred in our study were attributed to the donor site pain and large size of the defect. Postoperative donor site pain occurred in 8 patients. Spontaneous recovery occurred after 3 to 6 months postoperatively due to good filling of the donor site defects with fibrocartilage without hypertrophy; this coincided with **Treme and Miller** study [5]**.**

LaPrade and Botker [20] found 2 patients who suffered from moderate pain and mechanical symptoms at the graft harvest site; caused by fibrocartilage hypertrophy. Both patients were treated with shaving of the overgrowth, and one patient required grafting of the site with allograft plugs. This morbidity did not occur in our study. **Hangody and Kish** [14]**;** stated that autologous graft plugs incorporated well with defect tunnels, due to presence of cancellous bone that act as stabilizing platform for cartilage cap, a conduct for the bridging fibrocartilage, and affects the integrity of the cartilage tissue because the articular cartilage is supplied with oxygen and nutrients from synovial membrane and the subchondral vascular network.

CONCLUSION

OATS were proved to be a useful procedure in treatment of osteochondral defect of the knee joint as it produced a high good to excellent outcome in our series patients with minor complications. It is lowcost; one-step operation; with low morbidity and independent of laboratory.

Financial support and sponsorship: Nil.
Conflict of interest: Nil.

REFERENCES

1. **Gorbachova T, Melenevsky Y, Cohen M *et al.* (2018):** Osteochondral lesions of the knee: differentiating the most common entities at MRI. Radiographics, 38(5): 1478-1495.
2. **Curl W, Krome J, Gordon S *et al.* (1997):** Cartilage injuries: a review of 31,516 knee arthroscopies. Arthroscopy: The Journal of Arthroscopic & Related Surgery, 13(4): 456-460.
3. **Williams R, Brophy R (2007):** Decision Making in Cartilage Repair procedure. In Cartilage Repair Strategies, Edited by Williams R.J. 1st edition, Human Press Inc , Totowa , New Jersey. Pp: 37-54. https://www.academia.edu/38976766/ Treatment_of_Knee_ Osteochondral_ Defects_with_Mosaicoplasty_Technique
4. **Fathi H, El -Elesh H, Kelany O *et al.* (2015):** Mosaicplasty technique for treatment of osreochondral defects of the knee. British Journal of Science, 12: 1-10.
5. **Gulati A, McElrath C, Wadhwa V *et al.* (2018):** Current clinical, radiological and treatment perspectives of patellofemoral pain syndrome. Br J Radiol., 91(1086): 20170456.
6. **Treme G, Miller M (2008):** Autograft Osteochondral Transfer: In operative technique Sports Medicine, Elsevier, Pp. 18-88. https://www.journals.elsevier.com/operative-techniques-in-sports-medicine
7. **Miniaci A, Tytherleigh-Strong G (2007):** Fixation of unstable osteochondritis dissecans lesions of knee using arthroscopic (Mosaicplasty). The Journal of Arthroscopic and Related Surgery, 23 (8): 845-851.
8. **Lysholm J, Gillquist J (1982):** Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. Am J Sports Med., 10:150-154.
9. **Hayes D, Brower R, John K (2001):** Articular cartilage. Anatomy, injury, and repair. Clin Podiatr Med Surg., 18(1):35-53.
10. **Messner K, Maletius W (1996):** The long-term prognosis for severe damage to weight-bearing cartilage in the knee: A 14-year clinical and radiographic follow-up in 28 young athletes. Acta Orthop Scand., 67(2):165-168.
11. **Barber A, Chow J (2006)**: Arthroscopic chondral osseous autograft transplantation for femoral defects. The Journal of Arthroscopic and Related Surgery, 22: 10-16.
12. **Chow J, Hantes M, Houle J *et al.* (2004):** Arthroscopic autogenous osteochondral transplantation for treating knee cartilage defects: A 2-to5-year follow-up study. Arthroscopy, 20:681- 690.
13. **Karataglis D, Green M, Learmonth D (2006):** Autologous osteochondral transplantation for the treatment of chondral defects of the knee. The Knee, 13: 32-35.
14. **Keeling J, Gwinn D, McGuigan F (2009)**: A comparison of open versus arthroscopic harvesting of osteochondral autografts. The Knee, 16: 458–462.
15. **Hangody L, Kish G, Karpati Z *et al.* (1997):** Arthroscopic autogenous osteochondral mosaicplasty for the treatment of femoral condylar articular defects. Knee Surgery Sports Traumatol Arthroscope, 7: 312-322.
16. **Oztürk A, Ozdemir M, Ozkan Y (2006):** Osteochondral autografting (mosaicplasty) in grade IV cartilage defects in the knee joint: 2- to 7-year results. International Orthopaedics (SICOT), 30: 200– 204.
17. **Ulstein S, Arøen A, Røtterud J *et al.* (2014):** Microfracture technique versus osteochondral autologous transplantation mosaicplasty in patients with articular chondral lesions of the knee: a prospective randomized trial with long-term follow-up. Knee Surgery Sports Traumatol Arthroscopy, 22: 1207-1215.
18. **Solheim E, Hegna J, Øyen J *et al.* (2010):** Osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee. The Knee, 17: 84-87.
19. **Ma H, Hung S, Wang S *et al.* (2004):** Osteochondral autografts transfer for post-traumatic osteochondral defect of the knee. Injury, Int J Care Injured, 35:1286-1292.
20. **Marcacci M, Kon E, Zaffagnini S *et al.* (2005):** Multiple osteochondral arthroscopic grafting (Mosaicplasty) for cartilage defects of the knee: Prospective study results at 2-year follow-up. The Journal of Arthroscopic and Related Surgery, 21(4): 462-470.
21. **LaPrade R, Botker J (2004):** Donor-site morbidity after osteochondral autograft transfer procedures. The Journal of Arthroscopic and Related Surgery, 20 (7): 15-19.