Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/xxx
DOI URL: http://dx.doi.org/10.21474/IJAR01/xxx

RESEARCH ARTICLE

THE OUTCOME OF OSTEOCHONDRAL AUTOGRAFT TRANSFER FOR TREATMENT OF FOCAL ARTICULAR CARTILAGE DEFECTS OF THE FEMORAL CONDYLES.

[*]Mohamed Othman, Mohamed Abd-Alfattah and Ahmed El-Malt.
Department of Orthopedics, Faculty of Medicine, Zagazig University, Egypt.

Manuscript Info

Manuscript History

Received: 18 March 2016 Final
Accepted: 29 April 2016 Published
Online: May 2016

Keywords:
Articular cartilage injuries of the knee. Osteochondritis dissecans of the knee. Full-thickness articular cartilage defects of the knee. Osteochondral autologous transplantation, transfer or graft. Knee mosaicplasty.

Abstract

Background: Repair of full thickness defects of articular cartilage in the knee is a challenging problem but important to prevent progression to early osteoarthritis. The *purpose* of this study was to evaluate the outcome of osteochondral autograft transfer for treatment of focal articular cartilage defects of the femoral condyles.

Patients and Methods: A prospective study was conducted at our institution, between 2012 and 2015, on osteochondral autograft transplantation (OATS technique) for treatment of symptomatic focal chondral and osteochondral defects of the femoral condyles in 15 knees of 15 patients (who were available for follow-up examination). The mean age of the patients was 29 ± 7.2 years (range: 16 – 41 ys.). The defects was in the weight-bearing part of the medial (n=11) or lateral femoral condyle (n=4). The mean size of the defects was 2.1 ± 0.8 cm^2 (range: 1 – 3.5 cm^2). Aetiologically, 10 cases were posttraumatic and five cases were due to osteochondritis dissecans. Nine patients had a grade III / IV cartilage lesion, according to the Outerbridge classification system and six patients had osteochondral defects. The exclusion criteria were: age > 45 years, body mass index >30, un-reliable patients, lesions >3.5 cm^2, reciprocal lesions, uncorrected malalignment, uncorrected ligamentous instability, previous total meniscectomy, infection, tumor, advanced osteoarthritis or inflammatory arthritis.

Four cases were performed arthroscopically, while 11 cases through a mini-arthrotomy.

Results: The mean follow-up period was 12 ± 4 months (range: 10 - 18 months). The results were evaluated by history taking, physical examination, patient satisfaction, Lysholm score, radiography and MRI in all cases and a second-look arthroscopy, only in two patients. The mean total Lysholm Score improved from a preoperative value of 49.5±14.2 points to a value of 85.4±11.5 points at the final follow-up. Excellent and good results were achieved in 12 cases (80%) and fair result in 3 cases (20%), but no poor results. Postoperative complications included: (a) mild–moderate joint effusion in two patients (13.3%) (b) superficial wound infection in one patient (6.6%) with open procedure, but no deep infection (c) hemarthrosis in three cases (20%) (d) knee stiffness in two cases (13.3%) (e) temporary donor site knee pain in four cases (26.7%). There was no significant correlation of the results

Corresponding Author:- Mohamed Othman.
Address:- Department of Orthopedics, Faculty of Medicine, Zagazig University, Egypt.

with the underlying diagnoses [posttraumatic or osteochondritis dessicans] or the used method [mini-arthrotomy or arthroscopy].
Conclusions: The OATS-technique is an effective and relatively safe treatment of focal chondral and osteochondral defects of the femoral condyles. It achieves a high good to excellent results, with relatively minor complications. It is a low-cost; one-step operation; with low morbidity and independent on laboratory. However, it is not suitable for lesions >4-5cm². The associated meniscal or ligamentous injuries and malalignment should be corrected first in a separate session or concomitantly with OATS.

……

Introduction:

Articular cartilage (AC) is critical for proper joint function [1]. There are two types of articular cartilage lesions: focal and degenerative lesions. Focal lesions are well delineated lesions, usually caused by trauma, osteonecrosis or osteochondritis dissecans (OCD). Degenerative defects are typically poorly demarcated and usually associated with meniscal injuries, ligamentous instability, malalignment or osteoarthritis [2]. Focal chondral and osteochondral defects of the knee often cause several problems for the patient, such as pain, recurrent effusion, giving way and locking [2-5,7-10]. Untreated lesions can predispose to premature osteoarthritis because cartilage has a poor intrinsic capacity for repair due to its avascular nature and limited stem cell content [1-6, 8-11]. They are commonly found during arthroscopy in the general population and more frequently in athletes. In a report on 31,516 arthroscopies, they occurred in a minimum of one of every 100 knee arthroscopies [7]. The treatment of AC lesions is one of the most challenging clinical problems for orthopaedic surgeons [2,3,12-14]. The goals of treatment are to alleviate patient complaints and to prevent early osteoarthritis [1,4,5,7,9,10,15]. Many surgical techniques have been studied in an attempt to to repair full-thickness AC defects of the knee. However, there is no consensus of opinion on the best method [10,13-16]. In general, these techniques can be categorized into two main groups: *(a) marrow stimulation techniques,* by utilizing the body's own pluripotent marrow stem cells to create reparative tissue composed of fibrocartilage. These include microfracture, abrasion chondroplasty, and subchondral drilling. They remain popular due to their simplicity, low cost, potential to relieve symptoms and their ability to fill the defect, at least partially, with a repair tissue. The principal disadvantages of fibrocartilage tissue are its poor wear characteristics and less durability over time [1-6,15-20], *(b) hyaline or hyaline-like cartilage restoring techniques:* including mosaicplasty [or osteochondral autografts (OATs)], osteochondral allografts, autologous chondrocyte implantation (ACI) procedures..etc. The goal of these techniques is to restore the normal articular contour of the joint and to provide a more resilient, hyaline-like cartilage surface [3,6,11,17-22]. The proposed advantages of these procedures must be weighted against its disadvantages, including; a technically more demanding procedure, increased costs, longer rehabilitation, and potential complications [21-25].

The purpose of this study was to evaluate the outcome of 15 patients undergoing osteochondral autograft transfer to repair focal chondral and osteochondral defects of the femoral condyles.

Patients and Methods:

A prospective study was conducted at our institution, between 2012 and 2015, on osteochondral autograft transplantation (OATS technique) for treatment of focal chondral and osteochondral defects in 15 knees of 15 patients (who were available for follow-up examination). Nine patients were male and six were female, with a mean age of 29 ± 7.2 years (range: 16 – 41 ys.). These patients had focal articular cartilage defects in the weight-bearing part of the medial (n=11) or lateral femoral condyle (n=4). The mean size of the defects was 2.1 ± 0.8 cm² (range: 1 – 3.5 cm²). Posttraumatic defects were found in 10 cases, while osteochonritis dissecans (OCD) was the cause in five cases. Nine patients had a grade III / IV cartilage lesion, according to the Outerbridge classification system [26], whereas six patients had osteochondral defects. The presenting symptoms were weightbearing-related knee pain in all of patients, giving way in 11 of 15 knees (73.3%), catching/locking in 13 of 15 cases (86.7%), recurrent effusion in 13 of 15 knees (86.7%) and periodical to constant limp in all cases. The mean duration of symptoms from the onset to the operation was 6 ± 3.4 months (range: 3 – 10 months). All of them were primary operations. The exclusion criteria were: age > 45 years, body mass index >30, un-reliable patients, lesions >3.5 cm², reciprocal

(kissing) lesions, uncorrected malalignment, uncorrected ligamentous instability, previous total meniscectomy, infection, tumor, advanced osteoarthritis or inflammatory arthritis.

The study was approved by Institutional Ethical Committee and a written consent to participate in the study [after explanation of risks and benefits] was taken.

Preoperative Evaluation:

Preoperative assessment included history taking, clinical examination, functional assessment by the Lysholm knee scoring scale [27,28], radiographs, magnetic resonance imaging (MRI) and lastly, diagnostic arthroscopy. The objective was diagnosis of AC lesion (including its severity, aetiology,…) and search for coexisting pathology such as meniscal tears, ligament injuries or varus/valgus malalignment, which may affect the outcome of treatment of chondral lesions.

Table.1: The Lysholm Knee Scoring Scale [27,28]:
>94 points: excellent, 84-94 points: good, 65-83 points: fair, <65 points:poor

VARIABLE (points)	**VARIABLE** (points)
SECTION 1 - limp - no. (5) - a slight or periodical limp when walk. (3) - a severe and constant limp when walk. (0)	**SECTION 2 – Using cane or crutches** - no (5) - use a cane or crutches with some weight-bearing. (2) - Putting weight on hurt leg is impossible. (0)
SECTION 3 – Catching sensation/ Locking in knee - no. (15) - catching sensation but no locking. (10) - locks occasionally. (6) - locks frequently. (2) - feels locked at this moment. (0)	**SECTION 4 - Giving way** - No. (25) - rarely , only during athletics or vigorous activity. (20) - frequently during athletics or other vigorous activities (15) - frequently during daily activities. (10) - often during daily activities. (5) - gives way every step. (0)
SECTION 5 – Pain in knee - no. (25) - intermittent or slight pain during vigorous activities. (20) - marked pain during vigorous activities. (15) - marked pain during or after walking > 1 mile 2km. (10) - marked pain during or after walking < 1 mile 2km. (5) - constant pain. (0)	**SECTION 6 – Swelling in knee** - no. (10) - swelling on1y after vigorous activities. (6) - swelling after ordinary activities. (2) - swelling constantly. (0)
SECTION 7 – Climbing stairs - no problems. (l0) - slight problems. (6) - can climb stairs only one at a time. (2) - impossible. (0)	**SECTION 8 – Squatting** - no problems. (5) - slight problems. (4) - cannot squat beyond a 90º Bend in knee (1) - impossible because of knee. (0)

Surgical procedures:

Procedures were performed under spinal or general anaesthesia with a tourniquet-controlled bloodless field

i- Knee arthroscopy: We started with it in all cases. Their objectives were (a) diagnosis and assessment of the AC lesion (b) assessment of the donor sites for pathology (c) diagnosis and management of concomitant knee pathologies such as synovitis, loose bodies, and partial menisctomy.

ii- Osteochondral grafting technique: Four cases were performed arthroscopically, while 11 cases through a mini-arthrotomy [using a small parapatellar incision] because of; a large defect size (n=6) or a posterior lesion site (n=5)], which were not accessible arthroscopically due to the difficult perpendicular orientation needed to deal with them.

The Arthrex osteochondral transfer instruments [OATS, Arthrex, Inc., Naples, Fla, USA] were used in all cases. The principal steps in both techniques were (a) Defect preparation and assessment: by debridement of damaged and detached AC to the bleeding subchondral bone and measuring the size and depth of the lesion, (b) Graft harvest: The donor site was at a less-weight-bearing part of the femur condyle, such as the lateral rim of the femoral condyle above the sulcus terminals or at the superiolateral site of the inter-condylar notch. With a perpendicular access to AC, 1.0 mm oversized osteochondral plugs were harvested. Their diameters were 8, 9 or 10 mm and their length was 15 mm for chondral lesions and 20 mm for osteochondral lesions, (c) Implantation of the osteochondral plug at the recipient site by the press-fit technique; with a perpendicular orientation to AC and 1.0 mm proximity to each other when more than two plugs were used. Their surfaces were made flush with the surrounding AC [or one mm. proud rather than too deep], (d) The donor site was left open to be filled with fibrocartilage within a couple of weeks, (e) The knee was taken through a range of motion, to make sure that the grafts were perfectly stable. (f) The wound was closed in layers over a suction drain and a crepe bandage was applied [12,29].

Postoperative care:

During the 1st. 3-6 Weeks: No weight-bearing for the fear of sinking of the graft. Active and passive physiotherapy was begun from the 2nd postoperative day to promote joint nutrition and to prevent adhesions (including stretching exercises, straight-leg raises, and passive motion). The range of motion was limited from 0° to 90° during the first two weeks, and then it was increased gradually. After the first 4 weeks, the protocol involved isometric exercises, proprioceptive facilitation exercises and muscular strengthening, which were gradually increased. ***After 6 Weeks:*** Full range of motion (ROM) and 50% weight-bearing were allowed. ***After 9 Weeks:*** Full weight-bearing. ***After 12_Weeks:*** Open chain strengthening: activity-specific conditioning. ***After 6 months:*** Return to sports activities involving cutting and contact [15]**.**

Statistical analysis:

Results were expressed as means ±SD (standard deviation). The data obtained from the 15 patients according to Lysholm score were analyzed by Paired T test. A statistical significance was set at $p<0.05$

Results:

The intra- operative findings:

(a) Synovitis was found in eight cases (53.3%) and was treated by arthroscopic shaving.
(b) Meniscal tears were detected in five patients (33.3%); four in the medial meniscus and one in the lateral meniscus. Partial meniscectomy was performed for all.
(c) Loose bodies were found and removed arthroscopically in five patients (33.3%).
(d) The size of the defect ranged between 1cm² and 3.5cm² with a mean of 2.1 ± 0.8 cm². The number of graft plugs used per defect ranged between 1 to 3 plugs with a mean of 2 ±1.1.

Assessment of the final outcome:

The mean follow-up period was 12 ± 4 months (range: 10 - 18 months).

Clinical Assessment:

Preoperatively, all patients complained of knee pain ranging from mild to severe. Postoperatively, 10 of 15 knees (66.7%) had no pain and 4 knees (33.3%) complained of mild pain (p=0.002). The duration to pain relief ranged from 6 to 16 weeks postoperatively. Giving way was present in 11 of 15 knees (73.3%) preoperatively and in only 2 knees (13.3%) postoperatively (p=0.004). Knee catching/locking was present in 13 of 15 cases (86.7%) preoperatively and in only 3 cases (20%) postoperatively (p=0.001). Recurrent knee effusion was present in 13 of 15 knees (86.7%) preoperatively and in only 1 knee (6.7%) postoperatively (p=0.003). Periodical to constant limp was present in all cases pre-operatively and in only 3 cases (20%), postoperatively (p=0.004). The mean knee ROM was 110.5°±6.7° preoperatively vs 130.5°±6.8° postoperatively (p=0.005). The mean total Lysholm Score improved from a preoperative value of 49.5±14.2 points to a value of 85.4±11.5 points at the final follow-up (p=0.007). The overall final outcome was excellent in 4 cases (26.7%), good in 8 cases (53.3%), fair in 3 cases (20%), but no poor results.

Correlations of the results:

The outcome assessed by Lysholm score showed a statistically-insignificant difference between the two used techniques [mini-arthrotomy and arthroscopic techniques], and also, between the two aetioliologic diagnoses [traumatic defect and OCD] (p>0.05).

Patient Satisfaction:
Tweleve patients (80%) were satisfied with the outcome of the surgery, while 3 patients (20%) were not.

Radiologic assessment [Radiographs and MRI]: demonstrated graft integration and continuity of the articular surface at the former defect.

Second look arthroscopy: was not a routine work, principally for economic reasons or refusal of the patients. However, it was required in two cases; for a stiff knee arthrolysis, seven months postoperatively in one and for traumatic medial meniscal injury, eight months postoperatively in another one. It showed graft integration to adjacent AC with a normal shiny appearance, color and consistancy of the grafted area.

Postoperative Complications:
(a) Mild–moderate joint effusion occurred in two patients (13.3%), that disappeared within two months.
(b) Superficial wound infection occurred in one patient (6.6%) with open procedure and it recovered completely on frequent wound care and antibiotics.
(c) Hemarthrosis occurred in three cases (20%); [two after the mini-open technique and one after the arthroscopic technique]. It was treated successfully by aspiration under complete aseptic conditions, ice, elastic bandaging, anti-oedematous medications, antibiotics and rest.
(d) Knee stiffness occured in two cases (13.3%) . One case needed arthroscopic arthrolysis, and the other improved by physiotherapy.
(e) Donor site knee pain occurred in four cases (26.7%). It disappeared spontaneously after 3-6 months.
(f) We had no cases of deep infection, graft fracture, condylar fracture, graft slippage, failure of graft integration or prolonged donor site morbidity (fibrocartilage hypertrophy).

Discussion:

Focal chondral and osteochondral defects of the femoral condyles often cause symptoms, such as pain, recurrent effusion, clicking, and giving way, and may lead to early osteoarthritis of the knee joint [1,2,,25]..Various techniques were described for restoration of full-thickness articular cartilage defects. Resurfacing techniques where the defect is filled with hyaline cartilage, like the OATS technique, are more physiological and durable than fibrocartilagous remodelling techniques[1,11,13,25].

In this study, the mean total Lysholm Score improved from a preoperative value of 49.5±14.2 points to a value of 85.4±11.5 points at the final follow-up. Excellent and good results were achieved in 12 cases (80%) and three cases (20%) were fair, but no poor results.

The results of our study were comparable with other reported series [1, 8, 16,19,20,29,30]. Oztürk et al. [20] reported an improvement of the mean Lysholm score from 45.8 points preoperatively to 86.5 points postoperatively. Chow et al. [29] achieved improvement of the mean Lysholm score from 43.6 to 87.5 points and had excellent or good outcome in 81.3% in a series of 33 patients. Barber and Chow [30] reported an improvement from 44 to 84 points in a series of 36 patients. Solheim et al. [19] reported improvement of the mean Lysholm score from 48 to 82 points at one year follow up in a series of 33 patients aged up to 50 years, with AC defects sizing 1 to 5 cm^2**.** In the series of Atik et al. [16] 85% of them became pain-free and the mean Lysholm score improved from 56 to 86 points postoperatively. In a similar series excuted by Muller et al. [1] on 15 knees in 14 patients, eleven out of 13 patients rated the function of the knee higher after the operation and two patients gave the same score before and after. The mean Lysholm-score was 80.9. Six patients scored excellent/good and eight patients scored fair. Twelve out of 13 patients could return to sports at a medium or high level. In a retrospective study excuted by Wang [8] on 15 patients with 16 knees, good or excellent clinical results were achieved in 80% after a 2- to 4-year follow-up.

Our results were superior to the results of Ulstein et al. [18], who excuted OAT-technique in 15 patients with a mean age of 32.7 years and a lesion size between 2-4 cm^2 through a long medial parapatellar arthrotomy. Their mean Lysholm score improved from 49.2 to 69.7 points at 2 year follow up. This may be in part due to large wound problems that may delay rehabilitation.

Our results were inferior to the results of Ma et al.[17]; who treated 18 patients with posttraumatic focal osteochondral defects of the knee by mosaicplasty. The mean Lysholm score improved from 47.5 to 92.4 points and

good to excellent outcome was achieved in 16 patients (89%). It might be due to the small size of the defect (1 to 2.5cm²) and the cause of leions was posttraumatic and not pathological. Hangody et al. [14], reported 91% good or excellent results in 57 of 227 patients undergoing an osteochondral graft of the knee with more than 3 years' follow-up.

Wang [8], found no correlation of the results with the underlying diagnoses, including osteonecrosis, osteochondritis dessicans and traumatic cartilage defect. This was in agreement with our findings.

The improvement of symptoms appeared to be *time-dependent*. In our series and that of Wang[8], the average duration to pain relief ranged from 6 to 16 weeks after surgery. These results may be explained and supported by the studies by Lane et al.[31] and Wang et al.[32] performed in animals, that knee pain improved when the graft became stable, with remolded subchondral bone healing in 4–6 weeks after the osteochondral graft and eventual cartilage healing in approximately 12 weeks or longer.

The reported *complications* in the literature are variable. Karataglis et al.[33]; reported postoperative complications in 9 out of 42 patients (21%); [stiffness in four cases and a superficial wound infection in one, but no donor-site morbidity]. Solheim et al.[19] reported superficial wound problem in 3 patients, haemarthrosis in two, septic arthritis in one patient and deep vein thrombosis in one patient. Muller et al.[1] reported three out of 15 patients had a second look operation. One patient needed lavage for a purulent arthritis and two patients for sustained complaints caused by an exophyte at the donor site and a remaining cartilage defect. Hangody et al.[14], reported four deep infections, painful hemarthroses and thromboembolic complications. Atik et al. [16] reported slight joint effusion that disappeared within two months, with no donor-site morbidity. Postoperative complications in our study included: (a) Mild–moderate joint effusion in two patients (13.3%). (b) Superficial wound infection in one patient (6.6%) with open procedure, but no deep infection (c) hemarthrosis in three cases (20%); [two after the mini-open technique and one after the arthroscopic technique]. (d) Knee stiffness in two cases (13.3%). (e) Donor site knee pain in four cases (26.7%), that disappeared spontaneously after 3-6 months.

Donor tunnels may cause early transient and/or long-term donor site morbidity [1,5]. *Early donor site-related morbidities* are more frequent and transient [5]. Painful *hemarthrosis* occured in three cases (20%) in our series. Bartha et al.[5], reported 36 painful intra-articular bleedings following mosaicplasty. Donor sites may be left open or may be filled with either cancellous bone or a graft substitute especially, if larger multiple grafts were taken, to lessen hemarthrosis [1,5]. Donor site *pain* occurred in four of our patients (26.7%). Spontenous recovery occured after 3 to 6 months postoperatively; that coincided with the findings of Bartha et al [5] and Treme and Miller [34]. Bartha et al. [5] proposed that full recovery of the donor site is due to good filling of the donor site defects with fibrocartilage [without hypertrophy] as well as the peripheral position chosen for the donor area, the small size and proper spacing of the individual grafts, that allow the joint to reconstitute structurally and to accept the relatively low loads in these parts of the knee. *Long-term donor-site morbidity* does not occur frequently[5]. In the series of LaPrade and Botker [35], two patients suffered from 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. Simonian et al. [36], excuted a biomechanical study that demonstrated relatively high loading forces in the donor area, but stated that, to date, there has been no evidence that graft harvest would result in *degenerative changes*.

The OATS-technique can be done via *arthroscopic or mini-arthrotomy* procedures, with no difference in the outcome except for the wound in open procedure [8,14]. In this study, there was no significant difference in the outcome between the two techniques.

The key elements for success of this technique are (a) good selection of the patient (b) correction of associated meniscal lesions, ligamentous instability or malalignment either concomitantly or as a primary stage (c) meticulous technique considering perpendicular orientation for both harvest and implantation and a gentle press-fit implantation (d) good postoperative rehabilitation, with an emphasis on early motion and gradual load bearing and reducing the postoperative effusion and a graduated exercise program as the patient becomes more comfortable [4,5,14].

For evaluation of the outcome of OATS-technique including the repair tissue, clinical scores as well as several other methods have been used [5]. Ripoli et al [37] and Recht et al [38] used *MRI*. Others used a *second-look arthroscopy* in selected cases to assess AC at the grafted and donor sites and of the whole knee [5]. Barber et al [30]

and Leo et al [39] reported *histological* analysis of biopsy materials supporting consistent survival of the transplanted hyaline cartilage in their samples. Reviewing the literature showed that a second-look arthroscopy is not a routine and if any, it was performed in selected cases [5]. In this study, the results of the OATS technique were evaluated by history taking, physical examination, patient satisfaction, Lysholm score, radiography and MRI in all cases. We performed a second-look arthroscopy, only in two patients [for arthroscopic arthrolysis, seven months postoperatively in one and for traumatic medial meniscal injury, eight months postoperatively in another one]. In both, it showed graft integration to adjacent AC with a normal shiny appearance, color and consistancy of the grafted area. Muller et al [1], did not perform a control arthroscopy in their series due to ethical and financial reasons. Atik et al [16] performed a second-look arthroscopy in five out of 12 patients and demonstrated a normal shiny appearance and colour of the grafted area. Wang [8], performed a second-look arthroscopy at 24–32 months postoperatively in eight patients with 9 knees. Six of them were asymptomatic, while two were symptomatic. In the six asymptomatic knees, the grafts were viable and had a smooth articular surface and good consistency and there was a complete bonding of the graft to the adjacent cartilage. In the three symptomatic knees, it showed mild fissuring and scanty fibrous tissues between the grafts and the host tissues. Bartha et al. [5] performed 83 second-look arthroscopies out of 831 mosaicplasties excuted at their institutions. In 19 patients it was performed between 2 months and 6 years postoperatively due to persistent or recurrent symptoms; in 23 patients it was performed between 1 and 9 years postoperatively for a second trauma; and in 41patients it was performed between 2 and 4 months postoperatively to evaluate the quality of the resurfaced area and to determine the earliest time to return to a professional sports activity. In 69 of them, it demonstrated congruent gliding surfaces, histological evidence of the survival of the grafts and donor sites filling by fibrocartilage.

The healing and type of repair tissue of recipient and donor sites after OATS-technique is an important issue. *At the grafted area*, combinations of various graft sizes enables an 80−100% filling rate and a congruent surface. Autologus graft plugs incorporated well with defect tunnels, due to prescence of cancellous bone that acts as stabilizing plateform for catilage cap , a conduct for the bridging fibrocartilage to allow integration of the transplanted cartilage with surrounding hyaline cartilage 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. This repair tissue consists of about 80−90% of transplanted hyaline cartilage and 10−20% of regenerative fibrocartilage. *Donor holes* (if left empty), fill up with cancellous bone, covered by fibrocartilage tissue in 8−10 weeks [29,40,41].

In the literature, *various other therapeutic options* have been described to treat cartilage lesions. One of these options is *lavage ± debridement*; to wash out the inflammatory mediators and the debris. It gives symptomatic but temporary improvement in 45-88% of the cases, because it does not correct the underlying pathology and not prevent further progression [9]. *Marrow-stimulation techniques* such as abrasion, subchondral drilling and microfractures repair the defect by fibrocartilage filling. Although being less invasive, fibrocartilage is more vulnerable than healthy hyaline cartilage and therefore, they have a short-term success rate [4-6,11]. Another option is the *autologous chondrocytes transplantation (ACI).* With ACI, the hyaline cartilage is recovered and several studies showed good long-term results, with success rates of up to 91% [4-6,10,18]. However, the costs are high, needs laboratory and a second operation is needed [5]. Several researchers described the advantages of the OATS technique [13-17,19,29,32]. Gudas et al., *compared* the outcomes of OATS and of microfractures techniques for treatment of cartilage defects in the knees of active athletes [6]. They demonstrated a significant superiority of OATS over microfractures, with good to excellent results in 96% and in 52% of patients respectively. Horas et al. compared the OATS technique with ACI in a randomized clinical trial. According to the postoperative Lysholm score, the recovery of patients treated with ACI was slower than the patients treated with the OATS technique. The Meyer and Tegner scores did not show a significant difference in either group after two years. The OATS technique showed better histological results[42]. However Bentley et al. found no significant difference in Cincinnati and Stanmore functional assessment scores between the OATS group and ACI in a randomized clinical trial after one year. But after one year the International Cartilage Repair Society grading by arthroscopy was significantly better for ACI than for OATS-technique [43]. Both randomized clinical trials differed in the following parameters: lesion size and allowing weight bearing directly after the procedure or not. The OATS technique is less viable for cartilage defects > 4 cm^2 because it is limited by the available donor areas. The ACI seems to be better for larger defects [5].

The advantages of OATS-technique are (a) removal of abnormal sclerotic bone from the defect,(b) transfer of physiologic and durable hyaline cartilage that functions at the transfer site, (c) the avialibility of cancellous bone in graft plug that unite rapidly with surrounding bone (d) low cost, one-stage procedure (e) no risk of disease

transmission or graft rejection (f) with low morbidity (g) independent on laboratory. The *Disadvantages* are (a) lesions > 5cm² (2.5 cm in diameter) cannot be completely resurfaced because it is limited by donor-site availibilty due to the limits of donor site area (b) donor site pain and morbidity (c) potential for donor /recipient surface geometry mismatch [1-6,14-16,21,39,43]

Conclusions:

OATS-technique is an effective and relatively safe treatment of focal chondral and osteochondral defects of the femoral condyles. It achieves a high good to excellent results, with relatively minor complications. It is a low-cost; one-step operation; with low morbidity and independent on laboratory. However, it is not suitable for lesions >4-5cm².

Fig.1: A 21 ys old patient, with a symptomatic traumatic osteochondral defect of MFC, of four months-duration, with a preoperative Lysholm score of 46 points. (A-E) Preoperative X-ray and MRI (F,G) Mini-arthrotomy view of prepaired defect and OAT. (H,I) Final MRI showing filling of the defect and incorporation of the graft.. At the final follow-up, 12 months-postoperatively, Lysholm score improved to 86 points, outcome rated good and the patient was satisified.

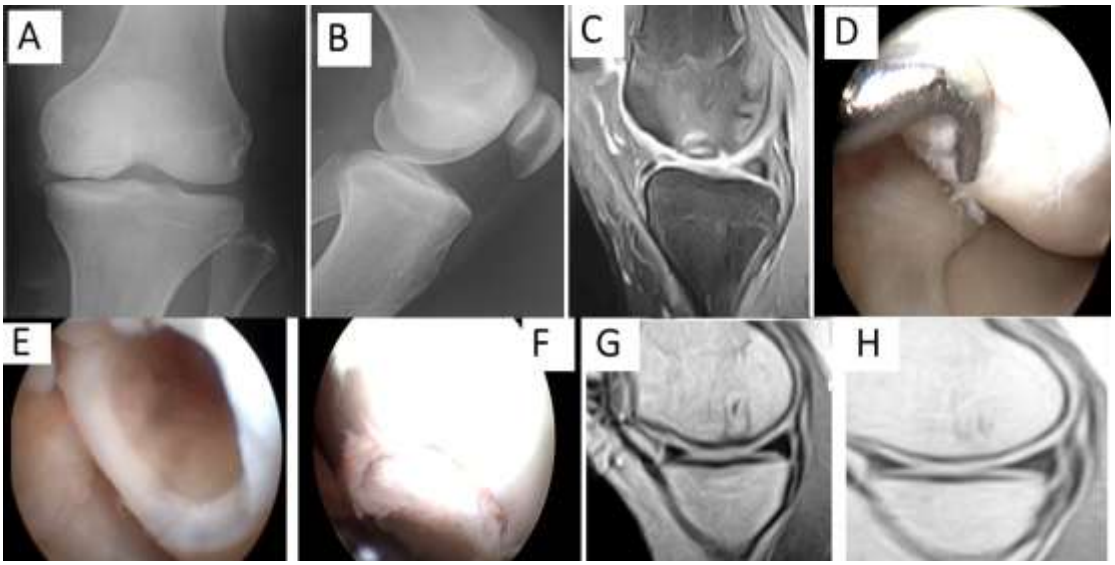

Fig.2: A 20 ys. old male with a symptomatic traumatic osteochondral lesion of MFC patient, of four months-duration, with a preoperative Lysholm score of 57 points. (A-C) Preoperative X-ray and MRI. (D) Arthroscopic assessment. (E) Arthroscopic preparation of defect (F) arthroscopic insertion of plug [10 mm]. (G,H) MRI after one

year showed good integration of the plug in MFC. The final postoperative Lysholm score was 95 points. The end result was excellent and the patient was satisfied.

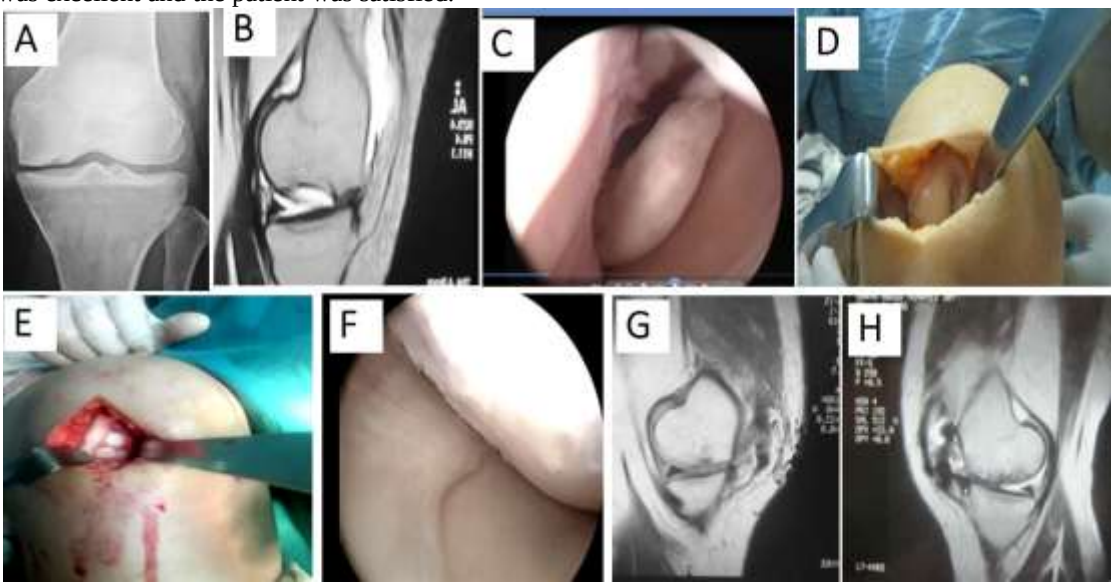

Fig 3: A 29 ys old female patient, with a symptomatic traumatic osteochondral defect in MFC, with a preoperative Lysholm score of 30 points. (A,B) Preoperative plain X-ray and MRI. (C): Arthroscopic view of a loose body in the lateral gutter. (D,E): Mini-arthrotomy approach showing the defect and the repair. (F): A secondry look arthroscopy done seven months-postoperatively [for arthrolysis of joint stiffness] showing integration of the graft. (G,H): Final MRI showing defect healing and good integratation of the grafts. At the last follow-up visit 18 months postoperatively; she regained 30º from lost ROM, the lysholm score was 66 points, the overall result was fair and the patient was unsatisfied.

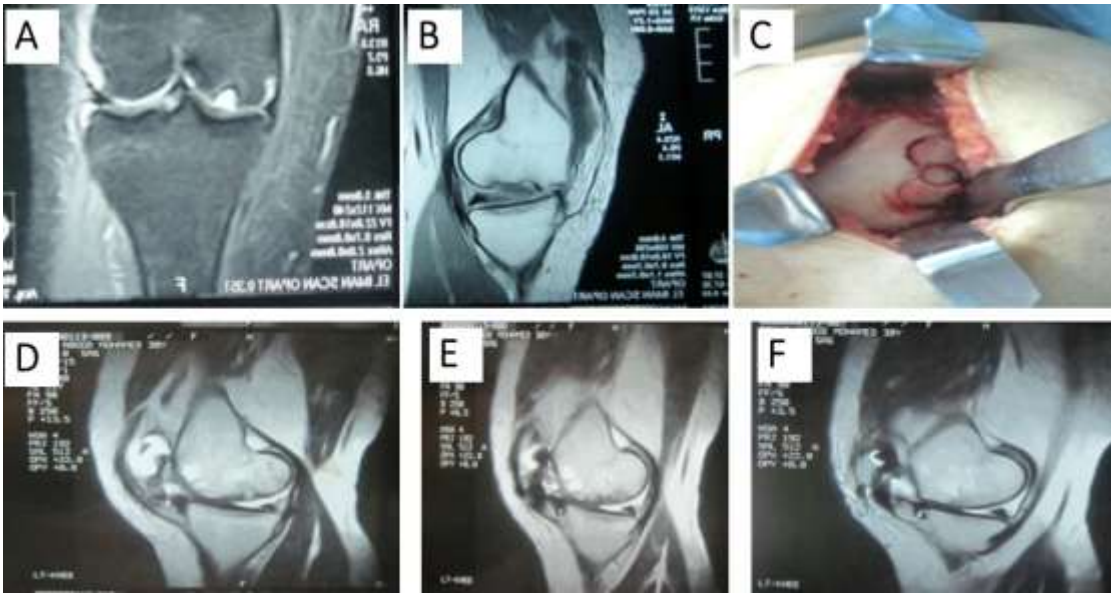

Fig. 4: A 26 ys old female patient with a symptomatic traumatic condral lesion of MFC, of three months-duration, with a preoperative Lysholm score of 45. (A,B) Preoperative MRI. (C) Mini-arthrotomy OAT using three grafts. (D-F) Postoperative and final MRI. At the last follow-up 12 months postoperatively, Lysholm score was 92 and rated good and she was very satisfied.

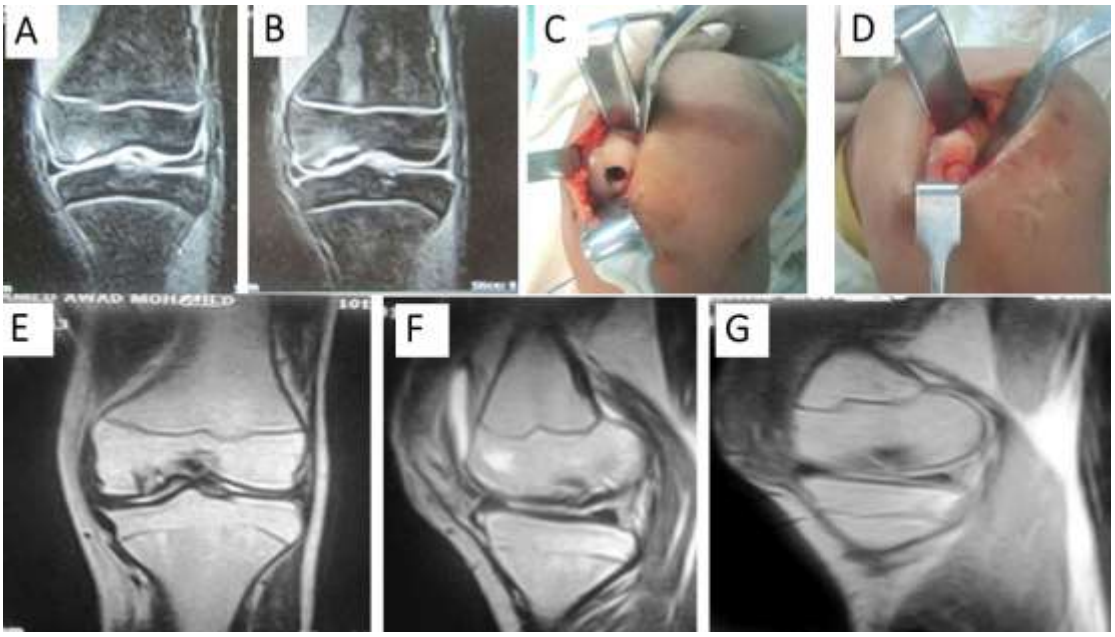

Fig. 5: A 16 ys. old patient, with a symptomatic unstable OCD. of MFC, with no history of trauma. The pre-operative Lysholm score was 52. (A,B) Preoperative MRI. (C,D) Mini-arthrotomy view of prepaired defect and graft. (E-G) Postoperative MRI, 11 months postoperatively. Final Lysholm score was 89 and rated good.

References:

1. Muller S, Breederveld RS, Tuinebreijer WE (2010). Results of Osteochondral Autologous Transplantation in the Knee The Open Orthopaedics Journal, 2010, 4, 111-114
2. Craig W, David JW, Ming HZ (2003) A current review on the biology and treatment of the articular cartilage defects (part I & part II). J Musculoskelet Res 7(3&4):157–181
3. Makris E A, Gomoll AH, Malizos KN, Hu JC, Athanasiou KA (2015). Repair and tissue engineering techniques for articular cartilage. Nat. Rev. Rheumatol. 11, 21–34.
4. Montgomery SR, Foster BD, Ngo SS, Terrell RD, Wang JC, Petrigliano FA, McAllister DR (2014).Trends in the surgical treatment of articular cartilage defects of the knee in the United States. Knee Surg Sports Traumatol Arthrosc; 22:2070–2075
5. Bartha L, Vajda A, Duska Z, Rahmeh H, Hangody L (2006). Autologous Osteochondral Mosaicplasty Grafting. J Orthop Sports Phys Ther;36(10):739750.
6. Gudas R, Stankeviius E, Monastyreckiene E, Pranys D, Kalesinskas RJ. (2006) Osteochondral autologous transplantation versus microfracture for the treatment of articular cartilage defects in the knee joint of athletes. Knee Surg Sports Traumatol Arthrosc; 14(9): 834-42.
7. Curl WW, Krome J, Gordon ES, Rushing J, Smith BP, Poehling GG. (1997). Cartilage injuries: a review of 31,516 knee arthroscopies. Arthroscopy;13:456–460.
8. Wang CJ. (2002). Treatment of focal articular cartilage lesions of the knee with autogenous osteochondral grafts; A 2- to 4-year follow-up study. Arch Orthop Trauma Surg; 122:169–172
9. Minas T, Nehrer S. (1997). Current concepts in the treatment of articular cartilage defects. Orthopedics; 20(6): 525-38.
10. Erggelet Ch, Browne JE, Fu F, Mandelbaum BR, Micheli LJ, Mosely JB (2002). Autologous chondrocyte transplantation for treatment of cartilage defects of the knee joint. Clinical results. Zentralbl Chir; 125(6): 516-22.
11. Browne JE, Branch TP (2000). Surgical alternatives for treatment of articular cartilage lesions. J Am Acad Orthop Surg 8(3):180– 189
12. Robert H (2011). Chondral repair of the knee joint using mosaicplasty .Orthopaedics and traumatology surgery and research ; 97 (4): 418
13. Hangody L, Feczko P, Bartha L, Bodo G, Kish G (2001). Mosaicplasty for the treatment of articular defects of the knee and ankle. Clin Orthop; 391:328-36.

14. Hangody L, Fules P (2003). Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints. J Bone Joint Surg Am;85:25-32.
15. Hangody L, Vasarhelyi G, Hangody LR, Sukosd Z, Tibay G, Bartha L, Bodó G (2008). Autologus Osteochondral grafting –technique and long-term results . Injury,International J.Care Injured; 3951: 532-539
16. Atik OS, Uslu MM, Eksioglu F (2005) Osteochondral multiple autograft transfer (OMAT) for the treatment of cartilage defects in the knee joint. Bulletin of the Hospital for Joint Diseases.Volume 63,Number 1&2.
17. Ma HL, Hung SC, Wang ST, Chang MC, Chen TH (2004). Osteochondral autografts transfer for post-traumatic osteochondral defect of the knee. Injury, Int. J. Care Injured; 35:1286-1292 , Elsevier.
18. Ulstein S, Arøen A, Røtterud JH, Løken S, Engebretsen L, Heir S (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. Springer.
19. Solheim E, Hegna J, Øyen J, Harlem T, Strand T. (2010). Results at 10 to 14 years afterosteochondral autografting (mosaicplasty) in articular cartilage defects in the knee. The Knee; 17 (84-87), Elsevier.
20. Ozturk 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
21. Craig D, Morgan D (1998). Chondral autograft transfer. Chondral resurfacing: Arthroscopy association of North America.
22. Brittberg M, Lindahl A, Nilson A (1994). Treatment of deep cartilage defects in the knee with autologous chondrocyte transplantation. N Engl J Med; 331(14): 889-95.
23. Peterson L, Minas T, Brittberg M, Linddahl A (2003). Treatment of osteochondritis dissecans of the knee with autologous chondrocyte transplantation: Results at two to ten years. J Bone Joint Surg Am; 85-A(Suppl 2): 17-24.
24. Minas T (1998). Chondrocyte implantation in the repair of chondral lesions of the knee: Economics and quality of life. Am J Orthop; 27(11): 739-44.
25. Miller JD, Smith MV, Matava MJ, Wright RW, Brophy RH (2015). Microfracture and osteochondral autograft transplantation are cost-effective treatments for articular cartilage lesions of the distal femur. American Journal of Sports Medicine; 43(9):2175–2181.
26. Cameron ML, Briggs KK, Steadman JR (2003). Reproducibility and reliability of the outerbridge classification for grading chondral lesions of the knee arthroscopically. Am J Sports Med; 3: 8386
27. Tegner Y, Lysholm J (1985). Rating systems in the evaluation of knee ligament injuries. Clinical Orthopaedic and Related Research.; 198: 43-49.
28. Lysholm J, Gillquist J (2006). Evaluation of knee ligament surgery with special emphasis on use of scoring scale. Am J Sports Med; 34: 1680-4.
29. Chow JC, Hantes ME, Houle JB, Zalavras CG (2004). Arthroscopic autogenous osteochondral transplantation for treating knee cartilage defects: A 2- to5-year follow-up study. Arthroscopy 20:681-690.
30. Barber A, Chow J, (2006). Arthroscopic Chondral Osseous Autograft Transplantation for Femoral Defects. The Journal of Arthroscopic and Related Surgery, Vol 22, No 1 (January): pp 10-16.
31. Lane JM, Brighton CT, Ottens HR, Lipton M (1997). Joint resurfacing in the rabbit using an autologous osteochondral graft. A biochemical and metabolic study of cartilage viability. J Bone Joint Surg Am 57: 218–222
32. Wang CJ, Chen HS, Cheng SM (2000). Cartilage repair by osteochondral graft in the knees of pigs – a histological study. J Musculoskeletal Res 4: 135–14
33. Karataglis D, Green, MA, Learmonth, DJA (2006). Autologous osteochondral transplantation for the treatment of chondral defects of the knee. The Knee; 13 : 32-35.
34. Treme, G. and Miller. M. (2008): Autograft Osteochondral Transfer. In Cole B (ed.) Operative techniques in Sports Medicine, Elsevier (16):18-88.
35. LaPrade RF, Botker JC (2004). Donor-Site Morbidity After Osteochondral Autograft Transfer Procedures. The Journal of Arthroscopic and Related Surgery; 20 (7): 15.
36. Simonian PT, Sussmann PS, Wickiewicz TL, Paletta GA, Warren RF (1998). Contact pressures at osteochondral donor sites in the knee. Am J Sports Med.;26:491-494.
37. Ripoli PL, de Prado M, Ruiz D, Salmeron J (2000). Transplantes osteocondrales en mosaico: estudio de los resultados mediante RMN y segunda artroscopia. Cuadernos Artroscopia; 6:11-16.(English abstract).
38. Recht M, White LM, Winalski CS, Miniaci A, Minas T, Parker RD (2003). MR imaging of cartilage repair procedures. Skeletal Radiol; 32:185-200.
39. Leo BM, Turner MA, Diduch DR (2004). Split-line pattern and histologic analysis of a human osteochondral plug graft. Arthroscopy; 20 Suppl 2:39-45.

40. Feczko P, Hangody L, Varga J, Bartha L, Dioszegi Z, Bodo G, Kendik Z, Modis L (2003). Experimental results of donor site filling for autologous osteochondral mosaicplasty. Arthroscopy.;19:755-761
41. Williams, R.J. (2006). Articular Cartilage Repair: Clinical Approach and Decision Making. Operative Techniques in Orthopaedics .pp.118-225 . Elsevier.
42. Horas U, Pelinkovic D, Herr G, Aigner T, Schnettler R (2003). Autologous chondrocyte implantation and osteochondral cylinder transplantation in cartilage repair of the knee joint. A prospective, comparative trial. J Bone Joint Surg Am; 85-A(2): 185-92.
43. Bentley G, Biant LC, Carrington RW, Akmal M, Goldberg A, Williams AM, Skinner JA, Pringle J (2003). A prospective randomised comparison of autologous chondrocyte implantation versus mosaicplasty for osteochondral defects in the knee. J Bone Joint Surg Br; 85(2): 223-30