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AUTOLOGOUS OSTEOCHONDRAL MOSAICPLASTY RATIONALE AND CLINICAL PRACTICE

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INTRODUCTION

Articular cartilage defects may either be localised to chondral surface or both chondral and subchondral bone[1]. In contrast to subchondral bone, chondral tissue is avascular and has very limited regeneration potential[2]. The diagnostics and treatment of focal chondral and osteochondral defects, mainly in knee region, have been the main concerns of research for decades. Until recent years, many techniques have been developed such as debridement, microfracture, abrasion arthroplasty for the treatment of focal chondral and osteochondral defects. By all of these techniques the recipient site has been healed by only fibrocartilage. Biomechanical and clinical results are demonstrated that fibrocartilage type resurfacement of weight bearing surfaces has only a limited value[2-14].

Recently, new techniques, like osteochondral allograft transplantation[15-18], autologous morselised osteochondral graft, autologousous osteochondral transplants[20], periosteal and perichondrial grafts[21-23] allogenic meniscal grafts[25-27], and transplantation of autologous cultured chondrocytes[28,29] gave new promises[4,30-53]. Among these techniques, autologous osteochondral mosaicplasty is one of the most widely used procedure and the only one that provides hyaline cartilage for the recipient site structurally identical to the normal articular hyaline cartilage[35,41-47,49]. Mosaic-like osteochondral autograft transplantation has been introduced in clinical practice in 1992 in Hungary[41,42,44,55-61].

In studies performed on German Shephard dogs and horses, it has been observed that transplanted hyaline cartilage continues to live in the recipient site and ~80% of the defected area has been filled by hyaline cartilage, while ~20% fibrocartilage fills the gaps between the transplanted autografts. Furthermore, donor site has been filled with cancellous bone covered by fibrocartilage in 8 weeks. For evaluating the clinical results and the quality of the transplanted cartilage, many follow up evaluations, such as clinical scoring, MRI, second-look arthroscopy, cartilage stiffness indentations (Artscan-1000) and histologic examination of biopsy materials have been used in these studies. Clinical results have been evaluated by HSS (Hospital for Special Surgery), ICRS (International Cartilage Repair Society), Lysholm, modified Cincinnatti, and Hannover Scoring Systems (for ankle) as well as Bandi Scoring System (for donor site disturbances)[42,45]. Successful results of mosaicplasty is not only specific for knee region, but also 92% accomplishment is obtained in femoral condyle, 88% in tibial plafond, 81% in patellofemoral region and 94% in talar dome implantations in 3-6 years follow-up in clinical studies[62].

Although arhroscopic methods are preferred because of minimal invasiveness, mini-arthrotomy or open surgery may be performed according to the disadvantageous location and size of the lesions. It is a main advantage of this technique, that accompanying pathologies can be treated at the same operation, but the patient should be informed of all possible interventions.

INDICATIONS AND CONTRAINDICATIONS

Size of the graft obtained from non-weight bearing surface is important in autologous osteochondral transplantation. Harvest of several small-sized, cylindrical grafts provides more tissue to be transplanted while preserves donor site integrity and has excellent adaptation on recipient defective surface because of the mosaic-like implantation[34,38,41,49,52,63,64]. For an advantageous clinical outcome, size of the chondral or osteochondral defects should be between 1-4 cm^2 and the patient should be younger, than 50 years old. Successful results can be obtained not only in the femoral condylar defects, but also in tibial, patellotrochlear, talar surfaces, humeral and femoral head and in capitellum humeri.

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Although there are few studies of osteochondral transplantation performed for 8 cm^2 defects[44], autologous osteochondral mosaicplasty is recommended for defects smaller than 4 cm^2. Other contraindications involve defects arising from infectious or tumoral origin, osteochondral defects deeper than 10 mm, lack of appropriate donor area, patients above 50 years of age[34,38,52,64], and generalised degenerative or rheumatoid arthritis.

PREOPERATIVE PLANNING

Anamnestic data and actual clinical findings – such as tenderness in the medial or lateral joint space, retropatellar pain, swelling, clicking etc.- may support the presence of a cartilage defect, but there are nonspecific signs as well, which could determine the exact type and location of existing chondral damages.

Standard and standing X-ray examinations are basic elements of the preoperative diagnostic, but Rosenberg view and tangential patellofemoral images are also recommended. CT-scan may inform about the subchondral bony condition; ultrasound investigation or special sequences of MRI can give useful information about the location and extension of the chondral defect, but the severity of these damages cannot be always exactly determined. The last step is usually the arthroscopic examination, which should determine the exact location and stage of the damages, evaluate the quality of the donor area and check all the other intraarticular conditions.

SURGICAL TECHNIQUE

Preoperative preparations should include antibiotic prophylaxis. General or regional anaesthesia with tourniquet control is recommended. Patient is positioned supine with knee capable of 120° flexion, contralateral extremity is placed in a stirrup. Standard arthroscopic instrumentation and Mosaic Plasty Complete System (Smith & Nephew, Inc., Endoscopy Divison; Andover, MA 01810 U.S.A.) is required; fluid management system may support the procedure.

Choosing a procedure (arthroscopic – miniarthrotomy – open) depends on the type, size and exact location of the defect determined during arthroscopy. As placing the grafts perpendicular to the surface is paramount to the success of the operation. The first task is to determine whether arthroscopic or open procedure is required. Although certain trochlear defects can be resurfaced arthroscopically, patellotrochlear and tibial lesions require and open procedure. Most of the femoral condylar defects can be managed arthroscopically, as for most of these lesions, central anterior medial and central anterior lateral portals will allow correct perpendicular access.

An open procedure may be chosen when first performing the technique or when an arthroscopic approach is not practical due to size or location of the lesion. Arthroscopic or open mosaicplasties have the same steps and technique.

ARTHROSCOPIC MOSAICPLASTY

Portal Selection

As previously has been emphasized perpendicular access to the lesion is critical to proper insertion of the grafts. Take care in making the viewing and working portals. Use a l.2 mm K-wire or 18 gauge spinal needle initially to locate the portal sites. It should be noted that these portals tend to be more central, than the standard portals due to the inward curve of the condyles.

Defect Preparation

Use a full radius resector or curette, and a knife blade to bring the edges of the defect back to good hyaline cartilage at a right angle. Clean the base of the lesion with an Abrader or half-round rasp to viable subchondral bone. Abrasion arthroplasty of the defect site promotes fibrocartilage grouting from the bony base. As tapping the cutting edge of the guide into the bony base and removal of it can mark the defect site, use the drill guide to determine the number and size of grafts needed. Filling of the defect by same sized contacting rings allows about 80-90% filling rate, but use of additional sizes to cover the dead spaces and cutting the grafts into each other can improve the coverage up to 90-100%. Finally, measure the depth of the defect with the dilator.

Graft Harvest

The medial femoral condyle periphery of the patellofemoral joint above the line of the notch is the most preferred arthroscopic harvest site. The lateral femoral condyle above the sulcus terminalis and – in exceptional cases – the notch area can serve as additional donor areas. Grafts harvested from the notch area have less favourable features as they have concave cartilage caps and less elastic underlying bone. The medial patellofemoral periphery has easier access than the lateral one.

The best view for harvesting grafts is obtained by introducing the scope through the standard contralateral portal. Extend the knee and use the standard ipsilateral portal to check the perpendicular access to the donor site. Extended position should provide perpendicular access to the most superior donor site. Step by step flexion will allow the harvest of additional grafts from the lower portions of the patellofemoral periphery. If the standard portals don't allow a perpendicular approach, use a spinal needle or a K-wire to determine the location of additional harvesting portal.

As necessary portal has been determined introduce the proper sized tube chisel filled with the appropriate harvesting tamp. Once the site has been clearly identified, the chisel is located perpendicular to the articular surface and driven by hammer to the appropriate depth. The minimal length of the graft should be at least 2x its diameter, but - as a rule take - 15 mm long grafts to resurface chondral lesions and 25 mm long plugs for osteochondral defects. It is important to hold the chisel firmly to avoid it shifting at the cartilage-bone interface, producing a crooked graft. By flexing the knee lower sites can be obtained. The lower limit is the level of the top of the intercondylar notch (sulcus terminalis). Insert the appropriate harvesting tamp into the cross hole in the tubular chisel and use as a lever. The chisel should be toggled and not rotated, causing the graft to break free at the chisel tip. Push the grafts from the chisel by sliding the appropriate sized chisel guard over the cutting end. Use the tamp to push out the graft onto gauze in a saline wetted basin. The donor site holes will eventually be filled with cancellous bone and covered by fibrocartilage in a short time.

During the learning curve the grafts can also be obtained through a mini arthrotomy. (1.5-2.0 cm).

Implantation of The Grafts: Drill-Dilate-Deliver (3D Grafting)

Flex the knee and establish good distension. Reintroduce the drill guide using the dilator as an obturator. Place these tools perpendicularly to the defected surface. By rotating the arthroscope, the drill guide and the perpendicularity of the laser mark can be seen from different angles, ensuring proper orientation. Tap the cutting edge of the guide into the subchondral bone. Insert the appropriately sized drill bit and drill to the desired depth. Generally, a recipient hole - a few mm deeper, than the length of the graft - is desirable to minimize the high intraosseal pressure. Reduce the inflow to minimize leakage. Finally, remove the drill bit.

Insert again the conical shaped dilator into the drill guide. Tap it to the desired depth depending on the actual features of the recipient bone. Stiff bone conditions need more dilation than normal or soft bone. Hold firmly the drill guide and remove the dilator from the hole.

Deliver

Adjust the delivery tamp by turning the handle to initially allow the graft to sit slightly higher than the depth of the defect. This will minimize the likelihood of over-penetrating the graft. Stop the inflow, otherwise fluid flow can push the graft out of the tube. Deliver the graft under direct visualization into the recipient hole through the drill guide with the use of the delivery tamp. Insert the graft deeper by turning the delivery tamp handle counter clockwise. The graft should be flush with the original articular surface. Remove the drill guide to inspect the graft. If the graft is proud, reinsert the drill guide and tap the graft down gently with the tamp of the appropriate size. Insert the subsequent grafts in a similar fashion by placing the drill guide immediately adjacent to the previously placed grafts. Such kind of step by step graft implantation will result in several advantages. Whilst dilation of the actual recipient hole allow an easy graft insertion (low insertion force on the hyaline cap), on the other hand dilation of the next hole will impact the surrounding bone to the previously implanted grafts, which can result in a very safe press fit fixation (Fig. 1).

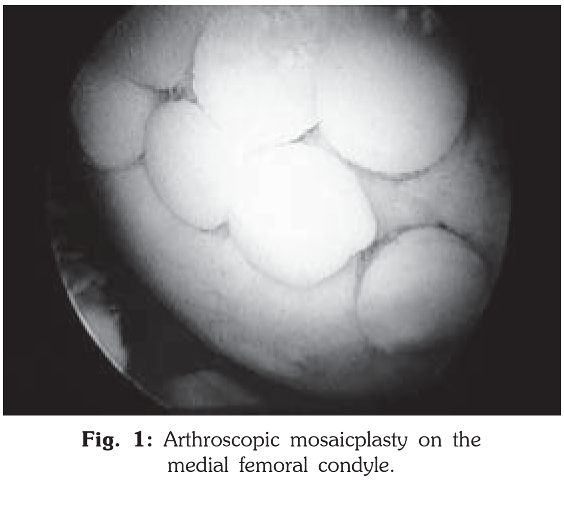

Fig. 1: Arthroscopic mosaicplasty on the medial femoral condyle.

When all the holes are filled and the grafts seated, put the knee through a range of motion and make varus or valgus stress depending on the site of the resurfacement. Close the portals and introduce a suction drainage into the joint through a superior portal. Use an elastic bandage to fix the appropriate dressing.

Pitfalls and How to Avoid Them

One of the most common problem is to neglect the main requirement of the operation. Perpendicular harvest and implantation of the grafts is crucial for a successful transplantation. Oblique harvest and insertion may result in contour differences on the surface. Careful control by the arthroscope from different angles should help to avoid such problems.

The other most usual mistake is to implant a graft deeper than the desired level. First of all, appropriate use of the delivery tamp can help to avoid too deep insertion of the grafts. If the graft has been inserted too deep, the following steps are recommended. Insert the drill guide next to the previously implanted graft. Drill an appropriate recipient hole. Remove the guide and use the arhroscopic probe to remove the previously implanted graft to the proper level. Recipient hole adjacent to the implanted graft should allow such manipulation. As soon as the expected graft level has been achieved, continue the recommended sequence for the further insertions.

OPEN MOSAICPLASTY

If an arthroscopic approach will not be practical, it may be necessary to create a medial or lateral anterior sagittal incision, or an oblique incision to perform a miniarthrotomy mosaicplasty (Fig. 2). Patellotrochlear and tibial implantations may require extended anteromedial approach. Further steps and technique of the implantation are identical with the open procedure. Mosaicplasty outside the knee - such as talar resurfacement – usually requires an arthroscopic garft harvest from the knee and open procedure for the implantation (Fig. 3-5).

POSTOPERATIVE REHABILITATION

The drain should be removed in 12-24 hours. In early post-operative period, pain treatment by NSAI drugs, cool therapy, and for three weeks thrombosis prophylaxis are suggested. As early motion is critical for nourishing of transplanted cartilage, immobilization is forbidden.[11,65-68].

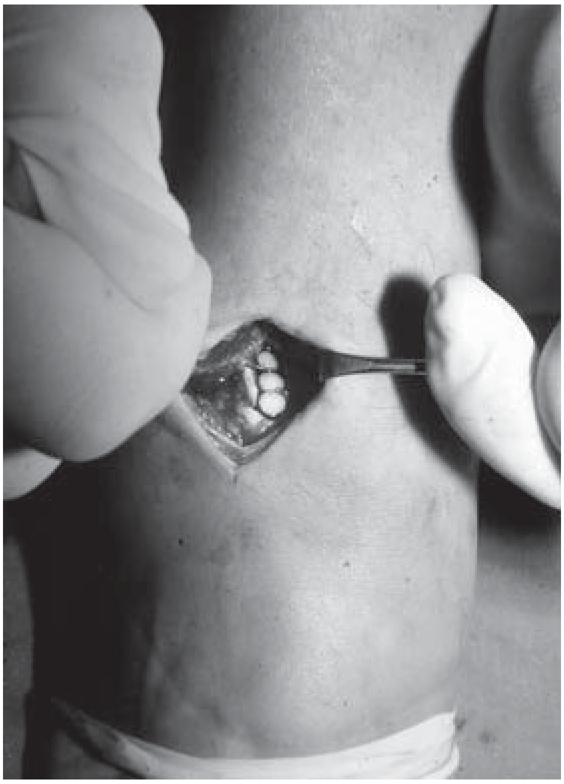

Fig. 3: Mosaicplasty on the lateral talar dome implantation of 3 plugs of 4.5 mm in diameter.

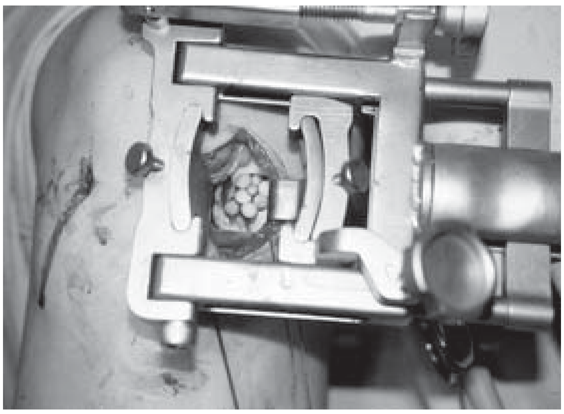

Fig. 2: Miniarthrotomy mosaicplasty supported by a minimal invasive retractor (Jakoscope).

Fig. 4: Osteochondritis dissecans of the capitulum humeri treated by 2 plugs of 8.5 mm in diameter.

Fig. 5. Mosaicplasty on the femoral head-dislocation of the caput femoris is required for a perpendicular approach.

For the first 2-4 weeks, ambulation is initiated with non weight-bearing by double crutches. Then, partial weight-bearing (30-40 kg) by crutches is encouraged. Total weight-bearing without crutches is possible in 4-5 weeks. Extent, type and location of the defect may modify weight-bearing status.

CPM is begun immediately for defects of 2-4 cm^2 as much as patient's tolerance of pain in the first week. Full extention is permitted, but extreme flexion shouldn't be forced. Isometric exercises of quadriceps and hamstrings in different angles should begin immediately. Stationary bicycling exercises in 3 weeks, climbing stairs in 4-5 weeks, descending stairs in 5-6 weeks are recommended. Concentric quadriceps exercises against resistance in 2 weeks, excentric exercises in 3-4 weeks, balance exercises on weight-bearing in 5-6 weeks are started. Jogging is possible in 10 weeks, straight line running in 3 months, directional changes in 4-5 months and returning back to sportive activities in 5-6 months.

For femoral and tibial condylar chondral defects under 15 mm, weight-bearing is not allowed for the first week, then partial weight bearing is recommended for 1-3 weeks. This period will be 2 weeks and 2-4 weeks accordingly for chondral defects larger than 15 mm; 3 weeks and 3-5 weeks for osteochondral defects of femoral or tibial condyle.

While partial weight-bearing is permitted in 2 weeks for patellar defects under 15 mm, it is possible after 3 weeks for defects larger than 15 mm. Strengthening of vastus medialis is important for patellar defects. Isometric exercises in extension and patellar mobilization should be started immediately. Isometric exercises at different angles of knee during the first week, open chain exercises in 2 weeks, closed chain exercises in 2-3 weeks, and excentric exercises against the resistance in 4-5 weeks are permitted.

It is a main advantage of mosaicplasty, that rehabilitation protocol can be adapted to concomitant operations, such as ACL reconstruction, meniscal repair, reconstruction of patellar retinaculum and high tibial osteotomy, that are performed for accompanying pathologies[44,45].

HTO Combined with Mosaicplasty

In a case of closed wedge osteotomy weight bearing (for 4 weeks only with crutches and only in extension) is up to the mosaicplasty, pain, and degree of the correction of the varus (lower correction-non-weight bearing, overcorrection-early weight bearing). Open wedge osteotomy may require 3 weeks non weight bearing followed by 3 weeks partial loading period (Fig. 6).

Fig. 6. 8 weeks old loading X-ray of an open wedge osteotomy combined with mosaicplasty on the medial femoral condyle.

ACL and/or PCL Reconstruction Combined with Mosaicplasty

Weight bearing status should be determined by the rehabilitation protocol of the ligament reconstruction.

COMPLICATIONS

Complications can be prevented by prophylaxis of infection and thromboembolism. Most frequently encountered complication is hemarthrosis related to the bleeding from donor site (8%) Drainage for postoperative bleeding, bandage and cool therapy are recommended.

According to extended clinical follow up by several evaluations there is only a low rate long term donor site morbidity. Patellofemoral complaints, like pain revealed by activity and swelling are seen in 3%and this morbidity correlates with the results investigated by the Bandi scoring system.

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