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## Introduction

The role of the meniscus in the knee function is well documented in the literature. The menisci play a very important role in shock absorption and load distribution. Moreover, they contribute in articular geometry and congruency and they provide joint stability, lubrication and proprioception [1].

Consequently, the goal in treating meniscus pathology is to preserve as much functional meniscal tissue as possible. Many authors have documented the detrimental effect of total and subtotal meniscectomy and the increased risk of cartilage degeneration of the tibiofemoral joint and early osteoarthritis [1].

Nevertheless, not all meniscus tears can be repaired and subtotal or total meniscectomy remain a common orthopaedic procedure. Development of post-meniscectomy knee pain, localized in the affected compartment is a challenging clinical problem. Conservative measures (physiotherapy, intra-articular injections etc) could provide relief without though changing the biomechanical environment of the knee joint. The surgical alternative, for those patients who had undergone total meniscectomy, is the transplantation of allograft meniscus. A growing body of evidence suggests that following meniscal transplantation, pain relief and functional improvement may reliably be achieved at short- and medium-term follow-up, and even, in some cases, at long-term (>10 years) follow-up [2].

Biomechanical studies have shown that the affected contact area and peak stresses after meniscectomy, can be improved to near normal after meniscus restoration [3]. Moreover, animal studies have documented that the chondroprotective role of the meniscus could be restored also, after meniscus transplantation [4].

However, allograft meniscus transplantation is only indicated for patients with total meniscectomy and is not suitable for patients with partial meniscectomy. Meniscal scaffolds have been developed for those patients with residual meniscus tissue to achieve regeneration by ingrowth of fibro vascular tissue. CMI (Collagen Meniscus Implant, Ivy Sports Medicine, Gräfelfing, Germany) and Actifit (Orteq Bioengineering, London, United Kingdom) are the synthetic

## Mini Review

# Meniscal Scaffolds: a Mini Review

### Abstract

Partial meniscal defects can be the cause of knee joint line pain. Synthetic meniscal scaffolds have been used as substitutes for the meniscal defect. CMI (Collagen Meniscus Implant, Ivy Sports Medicine, Gräfelfing, Germany) was the first product designed and Actifit (Orteq Bioengineering, London, United Kingdom), a polyurethane scaffold, is a more recent one. Both implants have been proven safe and clinically efficient so far. The indications, surgical technique, postoperative regime, results and complications are discussed.

scaffolds that have been used in vivo and investigated for their clinical and radiographic outcomes. CMI is a collagen matrix implant comprised of bovine type I collagen and Actifit is a polyurethane highly interconnected porous implant.

### Indications

The use of meniscal scaffolds is mainly indicated in the post-meniscectomy knee joint line pain. Patients with traumatic or iatrogenic meniscal tissue loss of more than 25% with normal articular cartilage or minimal chondral lesions (Kallgren-Lawrence grade I, II, Outbridge I, II) are suitable for meniscal scaffold transplantation [5].

Intact anterior-posterior horn attachments and a circumferential rim are prerequisites for the implantation. As a result, patients with previous total meniscectomy do not meet the criteria for this treatment. As with all implants, allergy to the scaffold materials is a possible side effect and should be kept in mind.

### Surgical Technique

The procedure could be completed fully arthroscopically using the two standard anteromedial and anterolateral portals. Enlargement of the anteromedial or anterolateral portal, for medial or lateral meniscus implant, allows easier passage of the scaffold. The location of the portals should be low and adjacent to the patellar tendon lateral margins in order to obtain optimal angle of suture insertion [5,6]. An accessory portal 2-3 cm lateral to the medial or lateral portal can be useful if the implantation is to be at the anterior third of the meniscus.

The procedure [7,8] begins with a complete diagnostic arthroscopy. In medial meniscus implantation, many surgeons suggest MCL release in order to improve the view of the affected medial compartment and protect the healthy articular cartilage. After all, this is chondro-protective procedure. The release is carried out only to the extent that is needed, in order to obtain the desired access to the medial meniscus. The meniscus is thoroughly evaluated and the presence of intact anterior-posterior horn attachments and a circumferential rim is confirmed. Other concomitant intra-articular lesions are recognized and treated accordingly. Preparation of the meniscus consists of removing any flaps, loose or degenerative tissue. The goal is to leave healthy and uniform meniscal rim. The anterior and posterior attachment points are trimmed in order to have a square shape, thus allowing precise fit of the scaffold. In order to

promote adequate blood supply, especially in cases in red-white zone, puncture holes are made to the existing healthy meniscal tissue using an awl or a spinal needle.

Measurement of the defect is made with a flexible rod loaded in a rigid cannula starting at the posterior end of the lesion. It is important to cut the scaffold at the optimal size (10% larger than the in situ measurement). Both implant tends to shrink after implantation and suturing hence the suggested oversizing. The scaffold is then soaked in a saline solution for a few seconds before implantation.

All of meniscal suturing techniques are utilized for the scaffold stabilization. The posterior horn is best stabilized with the all-inside technique while the outside-in technique is the most suitable for the anterior horn. Inside-out or all inside sutures are used for the rest of the meniscus scaffold. Horizontal sutures are usually used for the posterior and anterior junctions, while vertical, oblique or horizontal sutures every 5mm are used in the corpus of the implant.

An in vitro study by Hardeman et al. [9] on the most appropriate suturing method, suturing materials and instrumentation recommends the use of PDS No 0 suture versus Ethibond 0, horizontal and diagonal versus vertical sutures and promising results for Fast-Fix and Sequent commercial devices.

### Combined Procedures

Preoperation planning and diagnostic arthroscopy very often reveals other pathologies such as axial deviation, ACL or other ligament deficiency and focal chondral lesions. Correction of the mechanical axis with a high tibial or distal femur osteotomy is mandatory in cases of malalignment, while knee stability should be restored prior to meniscus transplantation or in one setting. Focal chondral lesions should also be treated concomitantly. Approximately four combined procedures are performed for every ten patients [8].

### Postoperative-Protocol

The rehabilitation program focuses on restricting ROM and weight bearing in order to protect scaffold incorporation [8]. On the other hand, early post-operative exercises are recommended so as to avoid muscle atrophy and knee stiffness. In general, the program is similar, but at a lower pace a compared to that following meniscus repair.

Immediately post-operatively, all necessary modalities are used in order to reduce pain and swelling. Isometric exercises and neuromuscular electrical stimulation begin early post-operatively to allow patient mobilization. The ROM increases gradually, using a knee brace, up to full flexion at 8-10 weeks. Patella mobilization is very helpful in order to accomplish full flexion. Partial weight-bearing to full weight bearing is permitted according to patient comfort and compliance at 8-10 weeks. Walking without crutches should be pain free and without knee swelling. The brace is discontinued after having gained full ROM and weight bearing. A special rehabilitation program to achieve normal strength and neuromuscular control is designed for every patient according to his other conditions and needs. Normal workload is anticipated 4 months post-operatively and return to unrestricted activity at 6 to 12 months [6,7].

## Results

Although it is almost two decades since the first introduction of meniscal implantation techniques, there are not many studies available. Most of the studies use the standard scoring systems such as Lysholm, VAS pain, KOOS, IKDC and Tegner. Second look arthroscopy, MRI and histological findings have been also used for the evaluation of these patients.

The only prospective randomized trial to our knowledge was contacted by Rodkey et al. [10] with a five year follow-up. They studied 157 patients with an irreparable medial meniscus injury (acute group) and 154 patients with previous medial meniscectomy (chronic group). Patients were randomized either to receive the CMI or to serve as a control subject treated with a partial meniscectomy only. The patients that were treated with the CMI underwent a second-look arthroscopy that demonstrated significantly increased meniscal tissue. In the chronic group, the patients who had received an implant regained significantly more of their lost activity and underwent significantly fewer non-protocol reoperations compared to the control patients. No differences were detected between the two treatment groups in the acute group.

Zaffagnini et al. [11] compared the CMI to partial meniscectomy in 33 patients. The choice of the procedure was decided by the patients. Pain, activity level, and radiological outcomes based on MRI were significantly improved in the group of patients that received the CMI at 10 years follow-up.

Monllau et al. [7] studied 22 patients after a minimum of 10 years post CMI implantation. Clinical and functional outcomes were satisfactory. Radiographic evaluation demonstrated either normal or no narrowing of the joint line. MRI evaluation revealed nearly normal images in 64% of the cases and normal images in 21%. They reported two failures and no complications.

The effect of CMI implantation along with ACL reconstruction was studied by Bulgheroni et al. [12]. They reported that chronic meniscal tears treated with medial CMI reported lower levels of post-operative pain compared to meniscectomy, while acute lesions treated with medial CMI showed less knee laxity.

The results of the Actifit implant were first reported in a multi-center study by Verdonk et al. [13]. They reported 9 failures out of 52 patients (17.3%). All patients had clinically and statistically significant improvements compared with baseline. At 3 months post-operatively, evidence of tissue ingrowth in the periphery of the scaffold was demonstrated in 86% of the patients.

Promising clinical results were also reported by Schüttler et al [14]. All 18 patients but one had statistically significant improvements in the outcome scores. Complete resorption of the scaffold occurred in one patient representing a failure to treatment (5.5%).

It is of interest a paper by Gelber et al. [15] who studied the use of Actifit scaffold in the medial meniscal-deficient varus knees undergoing open-wedge high tibial osteotomy. Based on the short-term functional results of this study, the data did not support medial meniscal substitution with a polyurethane scaffold.

## Complications

Specific acute complications related to the scaffolds have not been described. Complications such as pain, effusion, infection etc have been reported to be at 12.6% which is similar to those of meniscal repair [8]. Also, the definition of failure used by the authors so far lacks uniformity. Non-immunological reaction or disease transmission episodes have been reported so far. The average failure rate reported is 6.1% which is comparable to the meniscus repair failure rate [16].

## Discussion

Current available literature supports the use of meniscus scaffold in the post-meniscectomy knee joint line pain. CMI has proven its efficacy in the long term studies and its superiority over meniscectomy in the comparative studies [17]. On the other hand, only short term results are available for the Actifit. The procedure has been proven safe and the results are promising so far.

It is probably the chondroprotective role of the newly formed meniscus that plays a critical role in the clinical outcome. Many authors [7,10,11,13] reported that there was no progression of the articular cartilage degeneration after the scaffold implantation. Joint space narrowing was prevented, quality of cartilage did not change significantly and ICRS and Outerbridge scores did not deteriorate over time. Nevertheless, it is difficult to fully assess the chondroprotective role of the meniscal scaffolds, since cartilage degeneration is multifactorial pathology.

MRI, second-look arthroscopy and histologic analysis have been used for objective evaluation of the scaffold incorporation. MRI findings are, in general, satisfactory. Nevertheless, the newly formed tissue demonstrates a different MRI signal. One can notice hyperintensity, while reduction in size and extrusion may also be found [7,12]. These findings, however, are not correlated with the clinical outcome [6]. Second-look arthroscopy and histological results are probably of great value but very difficult to obtain. Ethical and economic reasons do not allow re-operating asymptomatic patients. As a results the main tool for patient evaluation are the clinical scores and MRI.

The definition of failure differs among studies. Pain, infection, mechanical blocking, chronic synovitis, no benefit from the surgery and reoperation are different ways of defining failures [8]. Also, it is difficult to define the failure in patients who usually have multiple knee pathologies at the index procedure and lack homogeneity between the different studies. The failure rate reported is about 6% [8], comparable with that of meniscus repair which is remarkable, considering the synthetic nature of the scaffold.

There is evidence to indicate the use of scaffolds in chronic patients. An important question for future studies to answer is whether the scaffolds could be used in acute cases as a preventive measure or not.

While combined surgery seems to affect the result, the effect of timing of intervention is not clear yet. In general the studies demonstrate significant improvement in all scores especially in patients with chronic meniscal injury [10]. Equally some authors support the use of scaffolds in acute lesions, for preventive reasons

and noted better results in patients who had their meniscii repaired with scaffolds soon after meniscectomy [12]. Without any doubt, newer, better designed studies are needed to determine whether the meniscal scaffolds have a role in the acute meniscal tear or not.

## Conclusion

CMI has been used for many years and long-term studies are available in the literature while for Actifit only short to mid-term clinical results are available. Both scaffolds are safe and clinically efficient in chronic meniscus deficient knees. Histological and MRI evidence support the use of these implants. However, further studies are needed to define and possibly broaden the indications in acute meniscal lesions.

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