Tissue Ingrowth After Implantation of a Novel, Biodegradable Polyurethane Scaffold for Treatment of Partial Meniscal Lesions

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Background: A novel, biodegradable, aliphatic polyurethane scaffold was designed to fulfill an unmet clinical need in the treatment of patients with irreparable partial meniscal lesions.

Hypothesis: Treatment of irreparable partial meniscal lesions with an acellular polyurethane scaffold supports new tissue ingrowth.

Study Design: Case series; Level of evidence, 4.

Methods: Fifty-two patients (with 34 medial and 18 lateral lesions) were recruited into a prospective, single-arm, multicenter, proof-of-principle study and treated with the polyurethane scaffold. The scaffold was implanted after partial meniscectomy using standard surgeon-preferred techniques for suturing. Tissue ingrowth was assessed at 3 months by dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) and at 12 months by gross examination during second-look arthroscopy, in the course of which a biopsy sample from the inner free edge of the scaffold meniscus was taken for qualitative histologic analysis.

Results: Tissue ingrowth at 3 months was demonstrated on DCE-MRI in 35 of 43 (81.4%) patients. All but one 12-month second-look (43 of 44 [97.7%]) showed integration of the scaffold with the native meniscus and all biopsy specimens (44) showed fully vital material, with no signs of cell death or necrosis. Three distinct layers were observed based on morphologic structure, vessel structure presence or absence, and extracellular matrix composition.

Conclusion: The DCE-MRI demonstrated successful early tissue ingrowth into the scaffold. The biopsy findings demonstrated the biocompatibility of the scaffold and ingrowth of tissue with particular histologic characteristics suggestive of meniscus-like tissue. In conclusion, these data show for the first time consistent regeneration of tissue when using an acellular polyurethane scaffold to treat irreparable partial meniscus tissue lesions.

Keywords: Actifit; meniscus; biodegradable scaffold; meniscectomy; polyurethane scaffold; partial meniscectomy

Treatment of meniscal lesions is the most common surgical intervention performed by orthopaedic surgeons today, with over 1 million surgical interventions involving the meniscus performed annually in the United States and approximately 400,000 in Europe.28 These semilunar, fibrocartilaginous structures preserve a pain-free functional knee and play an important role in the biomechanical functions of the knee, including load bearing, load and force distribution between the femoral condyles and tibial plateau, joint stabilization, lubrication, and proprioception.10,16 Furthermore, it is now accepted that loss of all or part of the meniscus leads to long-term degenerative changes attributable to higher peak stresses on the articular cartilage in the meniscectomized compartment as a result of the decreased contact area.18

When an injury occurs in the nonvascularized white zone of the meniscus, no reparative natural tissue response takes place. Classic tissue repair can occur in the outer 10.0% to 25.0% of the meniscus (a vascularized region also referred to as the red zone),11,22 resulting in cellular fibrovascular scar tissue1 that eventually matures to
fibrocartilage, although the joint structure may remain compromised in the following months or years.16

Although repair of meniscal lesions is the preferred treatment, this is not always possible, particularly for lesions in the avascular portion of the meniscus. For such irreparable lesions, partial meniscectomy is the current standard of care. This involves removing the unstable fragments of the torn meniscus and contouring the remaining frayed meniscal edges while preserving as much of the meniscal structure as possible. Favorable results have been reported in the short term after partial meniscectomy; however, the risk of osteoarthritis and irreversible damage occurring in the long term remains.8,9 Meniscal regeneration appears to require the physical presence of a scaffold to encourage successful migration and colonization with precursor cells and vessels, eventually leading to the formation of organized meniscal tissue.15,18,20,21

Meniscal tears are frequently associated with anterior cruciate ligament (ACL) disruption. In such cases, it has been suggested that long-term results of ACL reconstruction are predicted by the concomitant meniscal lesion and its treatment. Therefore, tears in the avascular zone present a particular problem and techniques involving scaffolds and advancing repair to the avascular zone have been called for.10

Until recently, there has only been 1 meniscus scaffold that has been shown to replace lost or damaged meniscus tissue in human clinical studies. The type I, bovine collagen meniscus scaffold (Menaflex, formerly called CMI, ReGen Biologics, Franklin Lakes, New Jersey) is implanted arthroscopically after partial meniscectomy and aims to reduce pain, restore lost knee function, and potentially prevent or minimize progressive joint disease.18,22 Recently published data from a prospective, randomized controlled clinical trial show the safety and efficacy of the collagen scaffold in subjects with >50.0% loss of meniscal tissue at baseline; however, the collagen implant failed to show benefits for patients with an acute injury.17 Although the study data highlight the potential of meniscal scaffolds in the treatment of irreparable, partial meniscal tissue lesions, a number of limitations related to the collagen meniscal scaffold have been raised. Specifically, as the product is of animal origin, there is a risk of disease transmission and immunologic responses, with 1 report of a possible allergic reaction that manifested as a severe synovitis and eosinophilia.14 In addition, the integrity of the collagen-based scaffold changes under wet conditions, thus potentially increasing the risk of scaffold damage during implantation and making it difficult to suture.5 Degradation rate is of importance in meniscus tissue formation as shown in dog studies where degradation rates comparable with that of the collagen scaffold seemed to be too rapid to ensure sufficient time to allow for a satisfactory rate of new meniscus tissue formation.3,6,7 Therefore, the approximately 20-year degradation time for the collagen scaffold may be too short.

A novel biodegradable, synthetic, acellular scaffold composed of aliphatic polyurethane (Actifit, Orteq Ltd, London, United Kingdom) was designed to fill an unmet clinical need in the treatment of patients with irreparable partial meniscal tissue lesions. The treatment objective of the scaffold is to provide pain relief and restore lost meniscus functionality.

The scaffold comes in 2 configurations, 1 for the medial meniscus and 1 for the lateral. Design criteria were biocompatibility, strength, flexibility and ease of handling (insertion and suturing using standard arthroscopic techniques), high and interconnected porosity supporting tissue ingrowth, and, finally, degradation over a suitable time as new tissue forms and matures. The scaffold is highly porous, with approximately 20% of the structure composed of biodegradable aliphatic polyurethane and the remaining 80% being the pores.

The requirement of vascular ingrowth for meniscal healing to take place has been well established.4,11,13,22 When implanted into the void created in the meniscal tissue after a standard arthroscopic partial meniscectomy and connected to the vascularized portion of the meniscus, the scaffold provides a 3-dimensional matrix of interconnected pores for vascular ingrowth.

The Actifit polymer is a slowly degrading polymer with polycaprolactone and urethane segments. The degradation starts by hydrolysis of the ester bonds in the polycaprolactone segments. This process is expected to take about 5 years.23 The urethane segments are more stable than the polycaprolactone segments and will eventually be safely phagocytized by macrophages or giant cells or become integrated into the surrounding tissue.27,32

Preclinical canine studies with the scaffold have reported, at 3 months postimplantation, intensive integration with the periphery and complete infiltration of all pores of the implant with vascularized fibrous tissue that had produced an abundant extracellular matrix, showing abundant collagen type I antibody labeling throughout the implant. At 6 months after implantation, the scaffold was integrated with the peripheral capsule and was completely filled with tissue.24

The objectives of the study reported in this article included evaluation of the potential of the polyurethane scaffold to safely support new tissue ingrowth.

METHODS

Study Design and Main Inclusion/Exclusion Criteria

A prospective, single-arm multicenter proof-of-principle study was conducted in 9 centers in Europe. The investigators were chosen for their expertise and experience in performing meniscal surgery. The main inclusion criteria for the study were (1) irreparable medial or lateral meniscal tear or partial meniscus loss, with intact rim; (2) skeletally mature male or female patients; (3) age 16 to 50 years; (4) stable knee joint or knee joint stabilization procedure within 12 weeks of index procedure; (5) International Cartilage Repair Society (ICRS) classification ≤2; (6) patient willing and able to give consent to participate in the clinical study and attend all follow-up visits and procedures; and (7) no more than 3 prior surgeries on the involved meniscus.

Ethics

Independent ethics committee approvals for the study were obtained before patient recruitment. Written
informed consent was provided by each patient, and Good Clinical Practice (GCP) and the Declaration of Helsinki were strictly adhered to throughout the study.

Surgical Procedures

All patients underwent arthroscopic partial meniscectomy with surgical debridement back to the vascularized zone of the damaged portion of the meniscus. The resulting void was measured for sizing along the peripheral edge using the meniscal ruler guide and ruler supplied with the scaffold. The scaffold was cut to fit using a blunt-nosed grasper, placed into the knee joint through the anteromedial or anterolateral portal, and sutured to the native meniscus. The suturing techniques employed were all-inside, inside-out, or outside-in depending on the area to be sutured and the surgeon's experience and preference.

Postoperative Treatments and Rehabilitation

Postoperative medications and treatments were provided, if required, according to the standard practice at each investigational center. To ensure protection of the newly formed fragile tissue and to provide optimum conditions for healing, all patients were required to undergo a conservative rehabilitation program similar to that for a meniscal allograft. The rehabilitation protocol was followed for 16 to 24 weeks, with the patient non-weightbearing for the first 3 weeks. Partial weightbearing was permitted from week 4 onward, with a gradual increase in loading up to 100% load at 9 weeks after implantation. Progressive weightbearing was initiated in stages, increasing by 10 kg per week for patients weighing ≥60 and <90 kg and by 15 kg per week for patients weighing ≥90 kg. Full weightbearing with an unloader brace was allowed from week 9 onward, and without the use of the unloader brace from week 14 onward. Gradual resumption of sports was generally commenced as of 6 months at the discretion of the responsible orthopaedic surgeon; however, contact sports were to recommence only after 9 months.

End Points

Tissue ingrowth was assessed at 3 months after index surgery using dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) and at 12 months by histologic analysis of biopsy specimens taken during second-look arthroscopy.

Safety was assessed through evaluation of cartilage grades from MRI scans at 1 week, 3 months, and 12 months using the ICRS cartilage scoring system. Efficacy (ie, clinical outcomes—perceived pain, functionality, and quality of life) was assessed at 3, 6, 12, and 24 months after index surgery.

The subject of this article is tissue ingrowth assessment and safety with ICRS cartilage grade data up to 12 months. Efficacy data and tissue ingrowth up to 24 months, as well as 24-month ICRS cartilage grade data and other safety data will be reported separately.

Tissue Ingrowth Assessment

Diagnostic Imaging. A primary objective was to evaluate tissue ingrowth at 3 months after implantation. This was assessed using DCE-MRI, an established technique for assessing primarily the vascularization, perfusion, and capillary permeability of various tissues. The DCE-MRI technique involves the measurement of contrast agent influx (in this case, gadolinium) into the examined tissue for 3 minutes immediately after administration. Influx of contrast agent causes an increase in the signal intensity (SI), which is then measured. An increase in SI in the first minute can only be explained by the presence of blood vessels as the contrast agent has not yet entered the interstitial space in that time. For the purpose of this study, the inner peripheral half of the scaffold meniscus was designated as a specific region of interest and the posterior horn was the recommended and utilized position because it provides the best transection at 1 week. Importantly, the same area was measured at each time point (1 week and 3 months).

For DCE-MRI, the following protocol was followed: the dynamic contrast-enhanced sequence (repetition time [TR], 1100 ms; echo time [TE], 3 ms; inversion time [TI], 560 ms; flip angle, 12°; field of view [FOV], 160 mm; slice, 6 mm; matrix, 192 × 96) was positioned such that the meniscus, including the reparative matrix, was depicted as a triangle (Figure 1) and performed after administration of 10 to 20 mL of contrast agent (in this case, gadopentetatedimeglumine [Magnevist, Bayer Schering Pharma, Machelen, Belgium]), followed by 20 mL of saline (≥3 mL/sec). The amount of contrast medium injected was dependent on the patient's body weight (0.5 mL/kg). The dynamic sequence was started simultaneously with the bolus injection and consisted of a series of at least 120 images obtained with an acquisition time of ≤1 second during administration of the contrast agent. After dynamic imaging, sagittal and coronal T1-weighted images were obtained using identical imaging parameters as those used for the T1-weighted sequences.

All DCE-MRI was analyzed by an independent assessor, blinded to all clinical patient detail and data, at the Radiology Department, Ghent University Hospital, Belgium.

Histologic Analysis of Biopsy Specimens at 12 Months.

Tissue ingrowth at 12 months was assessed by analyses of biopsy specimens taken during second-look arthroscopy. The center of the inner free edge of the implanted scaffold was chosen for the biopsies because it is the area furthest away from the vascularized native meniscus rim and hence would be the area likely to be populated last. Furthermore, it was concluded that a biopsy in this area would be least likely to damage the scaffold meniscus.

All biopsy specimens were fixed in 4.0% buffered formol for at least 24 hours. Using the histochemical stains hematoxylin and eosin (H&E), Masson trichrome, Sirius red, and combined periodic acid Schiff–Alcian blue (PAS-AB), the biopsy sections were stained to enable visualization of specific tissue structures. In addition, immunohistochemical staining was performed on the biopsy sections using cellular and extracellular matrix (ECM) markers.
Markers for collagen type I, type II, and aggrecan were used for the ECM; and cartilage marker S100, the vessel markers CD31 and CD34, the smooth muscle marker SMA (smooth muscle actin), and the histiocytic marker CD68 were used as cellular markers.

Analysis was performed centrally at the Department of Bone and Soft Tissue Pathology, Ghent University Hospital, Belgium by 2 independent assessors blinded to all other patient data, with any discrepancies resolved by consensus.

### Safety Assessment

Assessment Grade of Articular Cartilage. At the 1-week and the 3- and 12-month follow-up visits, standard MRI was carried out to monitor any adverse changes to the articular cartilage, in particular in the index compartment. The articular cartilage was assessed using the ICRS cartilage scoring system, which gives a measure of the cartilage status and lesion depth,

All images were obtained according to a standardized MRI protocol. Sagittal and coronal dual echo proton-density and T2-weighted fast spin-echo sequences (TR, 4000 ms; TE, 24/96 ms; FOV, 140 mm; slice/gap, 3 mm/10.0%; matrix, 512 × 307; number of signals acquired, 2 [with and without fat suppression]), and T1-weighted spin-echo sequences (TR, 600 ms; TE, 15 ms; FOV, 140 mm; slice/gap, 3 mm/10.0%; matrix, 512 × 358; number of signals acquired, 1) were performed, with all sequences using the same positioning parameters. Although imaging parameters may have differed from site to site and from scanner to scanner, all parameters were unchanged throughout the study and for all follow-up examinations.

All MRI scans were analyzed by an independent assessor, blinded to all other patient detail and data, at the Radiology Department, Ghent University Hospital, Belgium.

Other Safety Assessment. In addition to specific assessment of the cartilage, safety was evaluated through analysis of the participant’s adverse event profile.

### Participant Demographics

<table>
<thead>
<tr>
<th>Sex</th>
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<tr>
<td>Male, no. (%)</td>
<td>39 (75%)</td>
<td>Mean±SD 30.8±9.4</td>
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<tr>
<td>Female, no. (%)</td>
<td>13 (25%)</td>
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Longitudinal length of meniscus defect after surgical debridement

<table>
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<th>Prior meniscal surgeries (involved meniscus)</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>1, no. (%)</td>
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<tr>
<td>2, no. (%)</td>
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<tr>
<td>Unknown, no. (%)</td>
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### RESULTS

Between March 2007 and April 2008, 62 patients were screened for inclusion into the study. Of these, 2 patients were lost before surgery (patients canceled intervention), and a further 8 patients were ineligible or were withdrawn from the study during surgery, because of either repairable meniscus, grade ≥3 cartilage degeneration, unstable knee, or extremely tight lateral joint compartment. The remaining 52 patients (34 medial and 18 lateral lesions) underwent treatment with the polyurethane meniscus scaffold. Two participants were lost to follow-up, and 1 reportedly moved to Australia. In addition, 2 patients discontinued because of a serious adverse event (SAE). One patient incurred a post-operative infection and the scaffold was removed as part of the treatment, and 1 participant with severe grade 4 cartilage damage already at study entry underwent a total knee arthroplasty at 4 months after index surgery. Valid DCE-MRI scans at 3 months after implantation were available for 43 patients (82.7%). At 12 months, 44 patients (84.6%) who agreed underwent second-look arthroscopy, which included biopsy, and histologic analyses were carried out on the biopsy specimens. Magnetic resonance imaging data were available for 47 patients at 12 months.

### Scaffold Status

No loosening of sutures or tears of the scaffold were found on the MRI performed at 1 week (51/51). Furthermore, all scaffolds displayed a normal position of the posterior horn (Figure 1), indicating ease of the required implantation technique.
On 3-month MRI, no loosening of sutures or the device was observed, and during second-look arthroscopy at 12 months, integration of the scaffold with the native meniscus was observed in all but 1 of the patients (43 of 44 [97.7%]).

Tissue Ingrowth

**Tissue Ingrowth at 3 Months as Assessed by DCE-MRI.** A primary objective of this proof-of-principle study was to evaluate tissue ingrowth at 3 months after implantation using DCE-MRI. At 3 months after implantation, the DCE-MRI demonstrated this in 35 of 43 (81.4%) patients with significant signal enhancement (ie, proliferation of blood vessels, and hence evidence of tissue ingrowth into the peripheral half of the scaffold) (Figure 2).

Histologic Results From 12-Month Biopsy Specimens

In total, 44 patients consented to the second-look arthroscopy (Figure 3), including taking a biopsy specimen for histologic analysis.

All biopsy samples contained fully vital material, with no signs of necrosis or cell death (ie, presence of cell pods, ghost cells, cells with defragmented nuclei) or serious adverse reaction to the scaffold material or its degradation products (presence of granulocytes in large numbers). Interestingly, in this regenerated tissue, a fibrous capsule and 3 distinct layers were observed, each with its own unique histologic characteristics, including presence or absence of vessel structures, and the composition of ECM (Figure 4).

Layer 1, located inferior to a fibrous capsule, was observed in 11 of 44 (36.4%) specimens. It was a vascularized, hypercellular layer mainly consisting of fibroblasts and some oval fusiform fibrochondroblast-like cells, with a surrounding ECM. Layer 2, observed in 41 of 44 (93.2%) specimens, was a hypercellular, avascular, loosely organized layer, containing mainly type I collagen with a mixture of fibroblasts as well as oval and rounded-type fibrochondroblast-like cells. Layer 3, a hypocellular, avascular, and fibrin-rich layer consisting of rounded fibrochondroblast-like cells, was observed in all 44 specimens (Figure 5).

Monitoring of Cartilage Status on MRI

At 12 months after implantation, standard MRI was carried out to monitor any adverse changes to the scaffold. In addition, the articular cartilage was assessed at each MRI follow-up using the ICRS cartilage scoring system, which gives a measure of the cartilage status and lesion depth.2,12
Cartilage grades on anatomic MRI were available at 12 months after surgery for 47 of 52 (90.4%) patients (30 patients with medial lesions and 17 patients with lateral meniscal lesions, of whom 1 medial patient did not have a 1-week MRI available). Of the 46 patients with both 1-week and 12-month MRI scans available, the majority (35 of 46 [76.1%]) demonstrated stable articular cartilage grades in the index compartment between the 1-week and the 12-month follow-up (see the Appendix, available online at http://ajs.sagepub.com/supplemental/). Worsened cartilage grades in the index compartment were reported for 4 patients. Of these, 3 had generalized deterioration of the

![Figure 3. Image taken during 12-month second-look arthroscopy, showing 100% refill of the meniscus defect and successful integration of the implant with the native meniscus. (Photograph courtesy of Professor Bellemans, Leuven, Belgium.)](image)

![Figure 4. Sirius red stain (40×) illustrating an overlying vascularized fibrous capsule (C) and the 3 distinct layers observed in the biopsy specimens. Going from the superficial area toward the center of the specimen: layer 1 consists of vascularized fibrous tissue (1), layer 2 consists of nonvascularized, hypercellular, loose collagenous tissue (2), and layer 3 consists of immature cells in a nonvascularized immature and fibrinous tissue (3). In this staining, mature collagen is deep red, and a decrease in deep red colorization is noted when moving from the capsule toward layer 3, suggesting the increase in mature collagen toward the superficial part of the tissue.](image)

![Figure 5. Capsule and layer 1: CD34 immunohistochemistry (200×) showing the presence of vessel "sprouts" (arrows) in layer 1, characteristic of neoangiogenesis. The young vessels are located toward the center and the older, thick-walled vessels are located toward and in the fibrous capsule. This is a strong indication of vessel ingrowth, and hence for tissue ingrowth taking place from the capsule toward the center of the biopsy. Layer 2: Sirius red stain (400×) illustrating a loose extracellular matrix (ECM). A mixture of fusiform fibroblast-like cells (short arrows) and more polygonal fibrochondroblast-like cells (long arrows) was observed. Layer 3: hematoxylin and eosin (400×) showing chondroblast-like cells in layer 3. These cells are surrounded by a small pericellular rim of more basophilic amorphous substance (short arrows). The ECM in between (asterisk) is eosinophilic and amorphous. These latter features are also observed in cartilage.](image)
knee and 1 had developed a focal defect in an area not in direct contact with the scaffold. Interestingly, an improved cartilage grading was observed in the index compartment in 7 subjects (see online Appendix), of whom 1 patient (Figure 6) underwent an ACL repair at 3 months after index surgery and 1 a treatment of osteochondritis dissecans with a chondral plug at 9 months after index surgery (Figure 7).

**Other Safety Data**

Before the 12-month follow-up visit, a postoperative infection was reported approximately 1 week after index surgery, a myocardial infarction was reported approximately 4 months after index surgery, and a total knee arthroplasty was carried out approximately 4 months after index surgery in a patient with severe osteoarthritis already on study inclusion (ICRS grade 3-4); all were considered unrelated to the scaffold. At the 12-month follow-up visit, 1 SAE with an unknown relationship to the scaffold (a nonintegration of the scaffold with the native meniscus) was reported. However, no SAEs with a causality related to the scaffold were reported.

**DISCUSSION**

A solution that is both easy to use and effective has yet to be found for the treatment of pain and dysfunction after
partial meniscectomy and for the associated long-term sequelae of partial meniscectomy. To meet this need, a novel, biodegradable, polyurethane meniscal implant (Actifit) has been developed. An objective of this proof-of-principle study was to evaluate the potential of the novel polyurethane scaffold to support new tissue ingrowth of viable tissue after partial meniscectomy in the case of an irreparable partial meniscus lesion.

The DCE-MRI data at 3 months after implantation showed significant signal enhancement and therefore early evidence of tissue ingrowth in the peripheral half of the scaffold in a high percentage (81.4% [35 of 43]) of patients. This is because signal enhancement in the first 20 to 60 seconds after intravenous contrast administration can only be explained by the proliferation of blood vessels into the porous scaffold matrix. In the first 60 seconds, hardly any contrast agent has left the blood vessels, so diffusion of gadolinium into the scaffold from the synovium or the meniscocapsular junction is not yet possible.

Further evidence of tissue ingrowth was obtained at 12 months after implantation by histologic analyses of biopsy specimens taken from the center of the inner free edge of the implanted polyurethane scaffold. All 44 biopsies showed fully vital material, with no signs of inflammatory reaction, necrosis, or cell death, illustrating that the scaffold is biocompatible and supports successful new tissue ingrowth. Moreover, a distinct organization of tissue was observed, with 3 layers based on the presence or absence of vessel structures, cellular morphologic characteristics, and ECM composition. This particular organization with vascular and avascular tissue with a collagenous matrix resembles that of native human meniscus tissue. When comparing the biopsy findings of the inner free edge of the scaffold meniscus with the native meniscus tissue, layer 1 resembles the peripheral red, vascularized zone typically rich in meniscus cells of the fusiform (fibroblast-like) cell type and thus rich in type I collagen. Layer 2 resembles the middle red-white zone of the native human meniscus containing a mixture of oval and polygonal fibrochondroblast-like cells and fibroblast-like cells while being completely avascular. Layer 3 resembles the white or inner third zone with fibrochondroblast-like cells, characterized by its avascularity; nevertheless, the observed ECM is still immature. This characteristic organization suggests that ingrowth is started superficially and that a maturation process occurs in an inbound direction.

The layered histologic structure observed at 12 months was consistent in all 44 biopsy samples, having meniscus tissue–like characteristics specifically in relation to cellular structure and ECM. It should be noted, however, that fully mature meniscus-like tissue was not expected nor observed at the 12-month timepoint. Nevertheless, to our knowledge, this is the first clinical study to report ingrowth of tissue, with a structured organization, after implantation of an acellular synthetic scaffold after partial meniscectomy.

These clinical results are supportive of data previously reported in animal studies, describing an active fibrovascular ingrowth derived from the synovium after total meniscal replacement with the polyurethane meniscus implant. Over time, this fibrovascular front slowly retracted, leaving behind tissue that resembled fibrocartilage within the scaffold.

Importantly, in this clinical study, no indication of cartilage damage caused by the scaffold was observed during second-look arthroscopy or on MRI. Moreover, the cartilage grades were stable at 1 year after index surgery, and it is of particular interest to note that 7 of the patients displayed improved cartilage grades in the index compartment from 1 week to 12 months. Further research and long-term follow-up is required, however, to show possible chondroprotective effects.

This proof-of-principle study had a number of limitations, the main limitation being the lack of a partial meniscectomy control arm. However, going back 50 years, we are unaware of published clinical evidence of significant tissue regeneration after partial meniscectomy. In the absence of such evidence, we consider that any new tissue generation observed in this study can be attributed to implantation of the polyurethane meniscus scaffold. More extensive biopsy samples being taken and at additional time points would have provided more robust qualitative data. This was not done, however, for fear of increasing the overall burden to study participants, in particular of additional invasive procedures and therefore increased risk to the patient, as well as for fear of compromising the integrity of the scaffold and subsequent patient outcomes.

It is hypothesized that repair of the meniscus rather than excision will help to provide further stabilization of the joint capsule in the case of ACL disruption. Future research is required to evaluate the role of the polyurethane scaffold in the repair of meniscus lesions in cases with concomitant ACL disruption.

CONCLUSION

In this proof-of-principle study, DCE-MRI illustrated successful tissue ingrowth into the polyurethane scaffold at 3 months, and MRI and histology findings showed further ingrowth continuing up to 12 months after index surgery. Moreover, these data demonstrate the biocompatibility of the polyurethane scaffold and its potential to support tissue ingrowth with meniscus-like characteristics after partial meniscectomy.

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REFERENCES


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