Polyurethane Meniscal Scaffold: Does Preoperative Remnant Meniscal Extrusion Have an Influence on Postoperative Extrusion and Knee Function?

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Abstract

Meniscal extrusion (ME) has been identified as a risk factor in the development of knee osteoarthritis. The relevance of this finding when a meniscal scaffold is used has not been extensively studied. The objective of this study was to determine whether preoperative meniscal remnant extrusion (MRE) was correlated with postoperative scaffold extrusion (SE) or with functional outcomes at the 2-year follow-up. Retrospective study included all polyurethane scaffolds implanted with a minimum 2-year follow-up. A magnetic resonance imaging (MRI) was performed preoperatively and postoperatively at 2 years. Extrusion was measured in millimeters in a coronal view. Patients were assigned to either group 1 or 2 depending on the preoperative MRE being either <3 mm (minor extrusion) or 3 mm (major extrusion). Functional outcomes were analyzed by means of the Western Ontario Meniscal Evaluation Tool (WOMET), International Knee Documentation Committee, Kujala and Tegner scores, as well as visual analog scale. Satisfaction was also documented. Sixty-two out of 98 patients were available to undergo an MRI at final follow-up. The mean age was 41.3 years (range, 17–58) and the mean follow-up was 45 months (range, 25–69). The mean preoperative MRE was 2.8 mm (standard deviation [SD] 1.2) and the mean postoperative SE was 3.8 mm (SD 1.8) ($p < 0.01$). All functional scores improved during the study period. When the correlation (Spearman's rho) between the difference in extrusion between the pre 26 and postoperative periods and their correlation with the different scores was assessed, correlation was only observed in the WOMET (rho 0.61, $p = 0.02$). The preoperative MRE in Group 1 was 1.85 mm (SD 0.83) and 3.7 mm (SD 2.2) in Group 2 ($p < 0.01$). At final follow-up, SE was 3.86 mm (SD 0.7) in Group 1, whereas it was 3.98 mm (SD 1) in Group 2 ($p = 0.81$). No differences were observed in the scores used for these two groups. The SE observed at the 2-year follow-up after the implantation of a polyurethane scaffold did not depend on preoperative MRE (major or minor extrusion). The WOMET score, which was the only meniscal-specific functional scored used, showed some inferior results in the most extruded meniscal scaffolds. This is a retrospective case series. Level of evidence is 4.

Keywords
- polyurethane scaffold
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The current trend in meniscal tear management is to preserve as much meniscal tissue as possible. However, this is not always possible. When pain appears in the meniscectomized compartment, restitution of the lost tissue is an option.[1] Meniscal scaffolds prove to be a valid alternative when there is a considerable loss of meniscal tissue but still there is some tissue remnant, specifically its peripheral rim.[2]

To date, two different meniscal scaffolds have been marketed for partial meniscal defects. One is the Collagen Meniscal Implant (ReGen Biologics; Franklin Lakes, NJ) and the other is the Actifit polyurethane scaffold (Orteq Ltd., UK). While good clinical results have been observed at the mid- and long-term follow-ups,[3–7] magnetic resonance imaging (MRI) assessment showed abnormal findings such as diminished morphology, signal intensity alteration, or cartilage degeneration progression.

Meniscal extrusion (ME) has been identified as a risk factor in the development of knee osteoarthritis. The lack of cartilage coverage by meniscal tissue affects load distribution capacities. This leads to the loss of cartilage and to subsequent knee osteoarthritis. De Coninck et al and Faivre et al[8,9] studied the impact of preoperative meniscal remnant extrusion (MRE) on the clinical outcomes of polyurethane scaffold implantation and on postoperative scaffold extrusion (SE). They viewed that preoperative and postoperative ME were not correlated with functional outcomes at the 2-year follow-up. Furthermore, they also observed that extrusion increased from the preoperative period to the postoperative follow-up. Both studies included a limited number of patients.

The main objective of this study was to evaluate whether the preoperative MRE was correlated with the postoperative SE in a large group of patients. The secondary aim was to assess whether SE has an influence on the clinical outcomes at the 2-year follow-up. The main hypothesis of this study was that preoperative extrusion of the peripheral rim would not correlate with postoperative SE. It was also hypothesized that the degree of extrusion would have no relationship to the functional outcomes.

Materials and Methods

A retrospective study was conducted to assess all the patients who had had a medial polyurethane scaffold implanted for a postmeniscectomy syndrome. The study was approved by the clinical research ethics committee of the institution.

A minimum follow-up of 2 years was required. All patients were operated on by the same surgical team (four surgeons). The same technique and similar postoperative protocols were used. Those patients with a malalignment of >5 degrees as well as patients with untreated knee instability were excluded. If the malalignment or the instability was corrected in the same surgical procedure, it was not considered exclusion criteria. Rheumatic diseases, polyurethane allergies, and pregnancy were other exclusion criteria.

Surgical Technique

The whole procedure was performed arthroscopically. A release of the medial collateral ligament was performed with a pie-crusting technique when necessary. The meniscus defect was trimmed to fit the scaffold. The polyurethane scaffold was prepared with an extra length of 5 to 10 mm of the measured defect to compensate for the effect of the horizontal sutures, which partially shrinks the polyurethane scaffold. Once in place, it was fixed to the posterior horn of the meniscal remnant using all-inside sutures. For the meniscal body or those corresponding to the anterior horn, an outside-in repair technique was used.

Radiological and Functional Measurements

An MRI was performed preoperatively and 2 years postoperatively and extrusion was then compared. All examinations were performed in the study hospitals, but measurements were made by the same experienced musculoskeletal radiologist who was blinded for the study purposes.

Extrusion (in mm) of the meniscal remnant was calculated in a coronal view, preoperatively (►**Fig. 1**). At the last follow-up MRI, the same measurements were performed to calculate SE. The chosen coronal view used to make measurements was defined as the single slice presenting the greatest area of the medial spine. If this was difficult to differentiate, the image which showed the greatest width of the tibia plateau was chosen. The medial–lateral meniscal coronal width and meniscal body extrusion to the closest 0.1 mm were measured. Regarding the definition of major and minor extrusion,[10,11] those patients with preoperative extrusion of <3 mm were included in Group 1, whereas those patients with a preoperative extrusion equal to or greater than 3 mm were included in Group 2.

Functional outcomes were analyzed by means of the Western Ontario Meniscal Evaluation Tool (WOMET), International Knee Documentation Committee, the Kujala and Tegner scores, as well as visual analog scale. They were assessed preoperatively and at the last follow-up visit. Satisfaction was assessed at the last follow-up. Patients were asked to rate their satisfaction with the end result of the surgery on a scale ranging from 0 to 4 (with 4 being the best score).

Statistical Analysis

Categorical variables were presented as frequencies and percentages. The mean and standard deviation (SD) were calculated for each continuous variable. The comparison between MRE and SE was assessed using the paired *t*-test.

The chi-square and the Wilcoxon's tests, depending on the case, were used to compare the pre and postoperative results of the different knee tests. Correlation coefficients between extrusion and the different scores and the differences between the post and preoperative periods were calculated using Spearman's rank correlation coefficient. The statistical analysis was performed using the SPSS 19 (SPSS Inc.; Chicago, IL) statistical package. The significance level was set at $p < 0.05$.

Results

During the period under review, a total of 98 polyurethane scaffolds were implanted. Four of them were not implanted in a postmeniscectomy syndrome and were thus excluded.

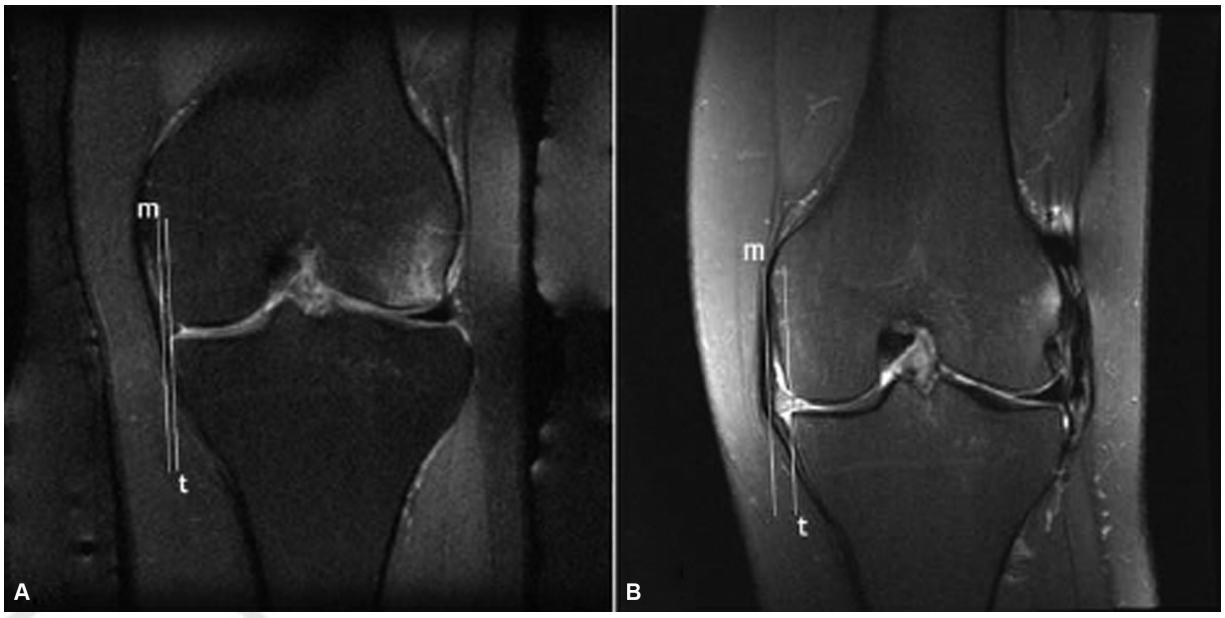

Fig. 1 MRI of a left knee. (**A**) Preoperatively, meniscal remnant extrusion was 2 mm (minor extrusion) in this case. (**B**) The postoperative MRI used to calculate scaffold extrusion showed that the scaffold was 5 mm (major extrusion) beyond the tibial margin. m, meniscal remnant or scaffold border; MRI, magnetic resonance imaging; t, tibial margin.

Table 1 Mean and standard deviation of the different scores in the pre and postoperative periods

	Preoperative	Postoperative	*p*-Value
WOMET	37.9 (SD 11.2)	67.6 (SD 20.4)	<0.01
IKDC	34.1 (SD 17)	70.4 (SD 16.8)	<0.01
Tegner	5.1 (SD 1.8)	4 (SD 1.8)	<0.01
Kujala	48.4 (SD 14.4)	83.3 (SD 16)	<0.01
VAS	7.22 (SD 1.2)	2.67 (SD 2.1)	<0.01

Abbreviations: IKDC, International Knee Documentation Committee; SD, standard deviation; VAS, visual analog scale; WOMET, Western Ontario Meniscal Evaluation Tool.

Table 2 Correlation (Spearman's rho) between the ME differences from the postoperative and preoperative periods when compared with the same differences in the functional scores

	ME difference	*p*-Value
WOMET differences	0.61	0.02
IKDC differences	0.08	0.79
Tegner differences	−0.1	0.72
Kujala differences	−0.06	0.84
VAS differences	−0.19	0.53

Abbreviations: IKDC, International Knee Documentation Committee; ME, meniscal extrusion; VAS, visual analog scale; WOMET, Western Ontario Meniscal Evaluation Tool.

Three patients with untreated concurrent knee instability were also excluded. In 29 patients, postoperative MRI was not available.

A total of 62 patients (46 men and 16 women) were then included. The median follow-up was 45 months (range, 25–69). The patients had a median age of 41.3 years (range, 17–58 years). Four patients who had been previously operated with a high tibial osteotomy underwent a plate removal procedure in the follow-up period. None of these patients needed a new surgery to remove the scaffold during this period.

The mean preoperative MRE was 2.8 mm ± 1.2 and the mean postoperative SE was 3.8 mm ± 1.8 ($p = 0.00$). All functional scores improved postoperatively (►**Table 1**). ►**Table 2** shows the correlation (Spearman's rho) between the differences in extrusion between the pre- and postoperative periods and their correlation with the different scores studied. An important correlation was observed in the WOMET (rho 0.61, $p = 0.02$).

Regarding the differences between the two groups, preoperative MRE in Group 1 was 1.85 mm (SD 0.83), whereas Group 2 had a mean preoperative MRE of 3.7 mm (SD 2.2) ($p < 0.01$). Patients from Group 1 had an SE at 2 years postoperatively of 3.86 mm (SD 0.7), whereas it was 3.98 mm (SD 1) in Group 2 ($p = 0.8$). No differences in the evaluated functional outcomes in either group in both periods under study (►**Table 3**) were found. Similarly, no differences were observed when the preoperative MRE (Group 1 vs. Group 2) was compared with the differences in the assessed scores.

Discussion

The main finding of this study was that, independently of the preoperative MRE, all the patients had major SE at 2-year follow-up. Secondly, the WOMET score showed a high correlation with the increment of the SE observed over the studied period.

When it comes to comparing preoperative and postoperative extrusion after a polyurethane scaffold implantation, De Cornick et al[8] observed preoperative MRE of 2.17 mm (SD

Table 3 Values for different scores assessed for Groups 1 and 2

	Group 1			Group 2		
	Preop	Postop	Rho/*p*-Value	Preop	Postop	Rho/*p*-Value
WOMET	40.55 (11.9)	67.6 (15)	−0.37/0.46	32.4 (13.8)	56 (25.5)	0.57/0.18
IKDC	35 (20.8)	68.7 (13.7)	−0.44/0.38	28.7 (16.8)	61.3 (20.9)	0.67/0.09
Tegner	5.7 (1.7)	4 (1.7)	0.64/0.16	5.3 (1.7)	3.7 (1.9)	−0.03/0.9
Kujala	48.7 (15.6)	81.75 (14.8)	−0.54/0.26	43 (14.6)	76.2 (20)	0.39/0.38
VAS	7.3 (0.8)	3.5 (1.9)	0.52/0.28	7 (0.7)	3.3 (1.7)	−067/0.09
Ahlbäck	1.5 (0.8)	1.5 (0.8)	−0.13/0.8	1.8 (0.9)	1.6 (0.9)	0.00/1.0
Satisfaction		2.9 (0.8)	−059/0.21		2.4 (1.1)	0.41/0.35

Abbreviations: IKDC, International Knee Documentation Committee; Preop, preoperative; Postop, postoperative; VAS, visual analog scale; WOMET, Western Ontario Meniscal Evaluation Tool.
Note: Mean and standard deviation. The *p*-value studied the correlation between the differences in the meniscal extrusion and the differences for each score studied.

0.84) in a series of 26 patients. This extrusion increased to 4.45 mm (SD 0.89) at 3 months postoperatively and remained steady afterward. Similarly, Faivre et al[9] observed preoperative MRE of 2.7 mm that increased to 4 mm at the 1-year follow-up and it decreased to 3.4 mm at the 2-year follow-up. Conversely, in the current investigation with a considerably higher number of cases, that finding is not confirmed. In the series presented here, postoperative ME does not depend on preoperative MRE. Surprisingly, those patients with minor MRE in the preoperative period achieve SE similar to those patients with major preoperative MRE. It is possible that once the extrusion process has been initiated, it only settles down when it reaches around 4 mm. Again, this was not only observed in the current study but also in the series by Faivre et al and De Cornick et al.[8,9] These results are like those observed with meniscal allograft transplantation (MAT) at short follow-up.[10] Abat et al[10] observed around 30% of ME at 3-year follow-up after MAT. However, the indications for meniscal scaffolds and meniscal allografts are different. While a polyurethane scaffold can only be implanted in a meniscal tissue remnant, the MAT procedure is done in a previous complete meniscectomized compartment. Thus, an assessment of prior MRE in patients with performed MATs is not possible.

From the clinical standpoint, all the patients showed a similar improvement in terms of the functional scores evaluated at the 2-year follow-up. This is also in agreement with those previously reported series.[8–14] In series with a longer follow-up,[6,7] functional improvements were also observed. However, as the MRI aspect worsened and the size considerably decreased, its potential chondroprotective effect was questioned. In the current series, it was observed that the mean WOMET score and the degree of extrusion had a positive correlation between the pre- and postoperative evaluations. The WOMET score is a meniscus-specific evaluation tool that was not used in those two referenced studies[8,9] in the same way as in other more generic knee scores were used.

ME is a risk factor for cartilage loss and knee osteoarthritis.[15–17] For this reason, it is a challenge for surgeons to prevent or diminish graft or implant extrusion in patients undergoing meniscal substitutions. Different methods have been described to prevent extrusion in MAT. A small reduction in the size of the allograft,[18] osteophyte excision,[19] or a concomitant caspulodesis[20] has been shown to decrease allograft extrusion. However, no technical recommendation has yet been described to control SE.

Although this is the largest series reporting on extrusion of meniscal scaffolds, it has some weaknesses. The patients were studied retrospectively and followed up for only 2 years. While the later can be obviously questioned from a functional point of view, the extrusion process is known to end a few months after the meniscal substitution.[8,21] The fact that the extrusion was only studied in MRI coronal views with a single slice extrusion assessment performed in the supine position can also be questioned. Other authors have described alternative methods to study the extrusion on the sagittal and axial planes.[22] However, a recent study concluded that the method used in the current investigation correlates most closely with the true perpendicular extrusion measurements obtained from manually segmented models.[22] In this study, cartilage pathology or osteoarthritis progression was not checked since the follow-up was too short to analyze these parameters. However, it would be interesting to follow these patients longer to check the possible effect SE has on the progression of cartilage degeneration.

In conclusion, the SE observed at the 2-year follow-up after the implantation of a polyurethane scaffold did not depend on preoperative MRE (major or minor extrusion). The WOMET score, which was the only meniscal-specific functional scored used, detected some inferior results in the most extruded meniscal scaffolds. This is basically a radiological study that has attempted to analyze the effect previous MRE may have on postoperative SC. The clinical differences observed at the 2-year follow-up that were assessed with a specific-meniscus score should be taken with caution and might be analyzed again with a longer follow-up study to confirm that the SE could be implied with the final clinical outcomes.

Conflict of Interest
None declared.

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