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Research Article

Treatment of Meniscal and Tendon Lesions With Tisseel Fibrin Glue and Orthokine ACS Injections Under MRI Control - 8 Years Follow-Up of 502 Patients by Interviews

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Introduction - Critical Analysis of Meniscus-Oriented Osteoarthritis Prevention

Exposure to knee joint Pathologies and Endoprosthetics

Knee joint pathologies are among the most common causes of loss of mobility and pain in the musculoskeletal system worldwide. The growing incidence of gonarthrosis is reflected in the steadily increasing number of endoprosthetic procedures. According to the latest data from the EPRD Annual Report [1] primary knee endoprostheses were implanted in Germany in the calendar year 2023. The report further points out that knee arthroplasty patients tend to be younger and have a higher body mass index than those with hip arthroplasty. In the analysis of the revisions, 15.931 total knee endoprostheses were recorded. The most common reasons for revisions were relaxations (21.6%) and infections (15.0%). These figures make it clear that endoprosthetics is not a definitive solution, but often leads to a chain of further interventions.

The demographic development and the high revision rate give joint-preserving strategies great relevance to health economics. The goal of modern orthopedics is therefore to stabilize degenerative joint changes at an early stage, before progressive destructive processes lead to the prosthesis indication.

Meniscus Lesions as a key factor in Osteoarthritis Development

The meniscus acts as a shock absorber and force distributor in the knee. Untreated or incompletely healed ruptures alter the biomechanics, increase the pressure load locally and initiate degenerative cartilage changes. The S2k guideline 033/006 [2] "Meniscus diseases" of the working group of the Scientific medical professional society (AWMF) and the S2k guideline of the German Society for Orthopaedics and Trauma Surgery (DGOU) [3] points out that complex tear shapes and extrusions of the meniscus are a risk factor for the development of osteoarthritis. The guideline emphasizes that a significantly stronger osteoarthritis progression occurs after a meniscus resection than after a meniscus suture (88% vs. 40%) and therefore calls for a meniscus suture to be aimed for primarily.

A meta-analysis by *Poulsen* [4] et al. 2019 examined over one million patients with cruciate ligament, meniscus or combined injuries. The authors found an odds ratio of 6.3 (95% CI 3.8-10.5) for the development of knee osteoarthritis after isolated meniscus injury and 6.4 (95% CI 4.9-8.3) after combined cruciate ligament and meniscus injury. Although the risk is significantly increased, the authors point to the high heterogeneity ($I^2 > 90\%$) and the lack of high-quality prospective studies, so these results should only be taken as an indication. The clinical problem is therefore not only pain treatment, but above all the prevention of osteoarthritis-associated late effects.

Guidelines and Consensus on Meniscus Treatment

Current guidelines and consensus papers emphasize the im-

portance of meniscus preservation. The 2016 ESSKA Meniscus Consensus [5] recommends that surgery be performed as early as possible in the case of repairable tears; meniscus repair should be considered first-line therapy because long-term clinical and radiological outcomes are worse after partial meniscectomy. The consensus clarifies that numerous cracks that were once considered irreparable should be repaired today. He also states that there is no evidence that biological enhancement methods such as needling or platelet-rich plasma (PRP) improve healing. This underlines that biological augmentation is of great interest, but has so far been insufficiently supported by high-quality data.

The DGOU guideline [3] emphasizes that meniscus tears pose a potential risk for osteoarthritis development and that osteoarthritis progression is significantly higher after resection than after meniscus suturing. In addition, meniscus resection increases the femorotibial load by at least 200%. These biomechanical and clinical findings support the paradigm shift towards reconstructive procedures.

Biological Augmentation - Evidence

In addition to mechanical repair techniques, biological augmentation strategies such as PRP, mesenchymal stem cells or growth factors are discussed to improve healing. A narrative review by *Poggi*, [6] *et al*. 2022 notes that while mechanostimulation and fibral clot augmentations were among the first techniques used, they produced limited and unconvincing results. Previous systematic reviews show that PRP augmentation may reduce the risk of meniscus refixation failure, but robust randomized comparisons are lacking. Data on fibrin glue application come mainly from animal experiments and small case series; controlled clinical trials hardly exist. The latest review of biological augmentation (2025) [7] emphasizes that although fibrin and other biomaterials may be theoretically beneficial, the existing studies have methodological weaknesses and variable quality.

Autologous conditioned serum (ACS) is a cell-free blood product that contains high concentrations of growth factors and interleukin-1 receptor antagonists. Intra-articular ACS injections are already being used to treat osteoarthritis; randomized controlled trials [8] showed a short-term reduction in pain, but the evidence-based data is heterogeneous. A 2022 narrative review [9] evaluates ACS as a potentially safe therapy for joint disease, but highlights the lack of high-quality human studies, especially in soft tissue injuries. Only small case series report improvements in meniscus-associated pain; the authors emphasize that further investigations are necessary due to the small number of cases.

Minimally Invasive MRI-Guided Refixation with Tisseel and ACS - Evidence and Critical Assessment

Against the background of this lack of evidence, a minimally invasive, MRI-guided refixation procedure was developed, in which meniscus margins are adapted using the two-component adhesive Tisseel and ACS is then applied. The fibrin glue forms a temporary scaffold, while ACS is intended to provide biological stimulation. The 4-year follow-up analysis published so far [10] (n = 170) documented a significant improvement in the overall WOMAC score from 34.6 ± 18.5 to 13.2 ± 9.5 points and a low surgical conversion rate (8/170); in the vast majority of patients, surgery could be avoided. However, this is a retrospective archival study without a control group and with heterogeneous patient selection, so that statements on effectiveness and safety are only possible to a limited extent. The authors themselves call for controlled studies for validation. A narrative review of ACS also emphasizes that most studies represent small case series and that further investigation is urgently needed.

Objective of the Present Work

In view of the high prevalence of knee joint pathologies, the growing number of knee endoprostheses and the evident role of the meniscus in the development of osteoarthritis, there is an urgent need for biologically oriented, joint-preserving therapies. At the same time, the insufficient evidence on biological augmentation strategies and the contradictory data situation make a critical evaluation necessary. The present study is therefore intended to test the results of MRI-guided meniscus refixation with Tisseel and ACS in the long term and to evaluate them in the context of the current evidence-based literature. The aim is to work out the potential advantages, limitations and clinical implications of this procedure and thus contribute to the differentiated use of regenerative therapy concepts in meniscus treatment.

Materials and Methods

Study Design and Ethical Approval

This study was planned as a retrospective, single-centre archive analysis. Patients treated at a single orthopedic practice between August 2016 and May 2023 were identified from procedural logs. They were invited to participate in a structured telephone interview during the summer of 2024. Because there was no randomisation, no blinding and no control group, causal inference is not possible; observed improvements could reflect the natural course of the lesions or placebo effects. Treatment protocols were not standardised across patients, and follow-up schedules depended on clinical availability. These design choices reduce internal validity and make it difficult to separate treatment effects from confounding factors. The study was approved by the local ethics committee (No. 276/2021; U1111-1268-5097), and all participants provided written informed consent for the anonymised use of their data in accordance with the Declaration of Helsinki.

Patient Population and Eligibility

Inclusion Criteria

Patients were eligible if they were adults with MRI-confirmed

structural pathology in one of the following tissues: knee meniscus, supraspinatus tendon, plantar fascia, medial or lateral collateral ligament of the elbow, scapholunate ligament, or acetabular labrum. Candidates had to experience pain, functional impairment and local effusion, and they needed to have a documented surgical recommendation that they declined in favour of a tissue-preserving alternative. Eligible patients had been treated with the combination of fibrin-glue refixation and subsequent autologous conditioned serum (ACS) injections.

Exclusion Criteria

Patients were excluded if they lacked MRI evidence of structural pathology, had systemic inflammatory disease, active infection or coagulation disorders that contraindicated needle intervention, or if they refused telephone follow-up. Cases with incomplete documentation were also excluded. Bilateral treatments were analysed as separate cases.

Cohort Size and Potential Biases

During the study period, 502 patients fulfilled the documentation requirements and were included in the database. For the 2024 survey, only those whose procedure had occurred at least one year earlier were contacted. This approach introduces selection bias, because patients lost to follow-up or interviewed very early after treatment were excluded. Moreover, the cohort encompassed a wide range of joints and pathologies; heterogeneity of this magnitude precludes meaningful subgroup analysis and limits the generalisability of the findings. Patients who refused surgery but sought this intervention may have different expectations and disease severity than the general population, potentially biasing subjective outcomes.

Intervention and Biological Rationale Fibrin-Glue Refixation

The mechanical component of the procedure involved MRI-guided injection of a two-component fibrin sealant into the lesion. Fibrin sealants, such as Tisseel, comprise a solution of fibrinogen (and stabilisers such as aprotinin) and a separate solution containing thrombin and calcium. When mixed at the needle tip, the components form a fibrin clot that adheres tissue within minutes. Systematic reviews of fibrin glue [10] in meniscal repair have reported improved healing rates but also note that the available evidence is limited and heterogenous. The 2016 ESSKA meniscus consensus [5] concluded that biological augmentation, including fibrin adhesives, has not yet been shown to improve clinical outcomes after meniscal repair and should be considered experimental.

Autologous Conditioned Serum (ACS ®)

The biological component consisted of a series of ACS injections. Venous blood was drawn into specialised syringes containing medical-grade glass beads. The blood was incubated at 37°C for approximately six hours, during which monocytes and platelets are stimulated to release anti-inflammatory and regenerative mediators, including interleukin-1 receptor antagonist (IL-1Ra), interleukin-10, interleukin-4, platelet-derived growth factor (PDGF), vascular-endothelial growth factor (VEGF), insulin-like growth factor (IGF), transforming growth factor-β (TGF-β), fibroblast growth factor (FGF), lipid mediators and exosomes. After centrifugation, the cell-free serum was collected and injected intra-articularly; four injections at weekly intervals constituted the standard protocol. Unlike platelet-rich plasma (PRP), ACS contains minimal platelets and is prepared without exogenous activators. However, evidence for ACS remains sparse [9]: narrative reviews highlight that only small case series and uncontrolled studies are available, and there is a lack of high-quality randomised trials. Thus, the biological plausibility of ACS does not equate to proven clinical efficacy, and its use in musculoskeletal lesions should be considered investigational.

Combined Mechanobiological Approach

The rationale for combining fibrin glue with ACS was to provide both mechanical stabilisation of the lesion and a local milieu rich in anti-inflammatory and regenerative mediators. While this concept is theoretically attractive, the paucity of robust clinical evidence for either component means that the combination must be interpreted with caution. Previous observational studies [8] of similar interventions reported promising improvements but were subject to substantial bias, underscoring the need for controlled trials.

MRI-Guided Procedure

All interventions were performed under real-time MRI guidance using an open magnet system and interventional access coils. MRI allows high-resolution visualisation of soft tissues and needle trajectory without ionising radiation. Image guidance is believed to enhance the accuracy of intra-articular injections compared with blind approaches. However, recent systematic reviews have found [11] that while image-guided injections achieve better placement, the clinical benefits over landmark-guided injections are modest and the cost-effectiveness is uncertain. Thus, the added value of MRI guidance in this context remains to be established.

After sterile preparation and local anaesthesia, an MRI-compatible needle (22 G, 50-100 mm) was advanced into the lesion under multiplanar imaging. Correct placement was confirmed by injecting 0.5-1.0 mL of gadolinium-based contrast agent. The fibrin sealant was then injected while the patient was repositioned supine. Passive motion of the joint (e.g., 0-60° knee flexion) was carried out to distribute the adhesive and minimise unwanted adhesion. Patients were allowed full weight-bearing immediately after the procedure and were advised to avoid strenuous activities until the six-week follow-up MRI.

Follow-up and Outcome Assessment

Clinical documentation included age, sex, lesion location and

classification, Kellgren-Lawrence grade for knee cases, previous surgeries and laterality. Follow-up MRI examinations were typically performed six weeks post-intervention to assess the integrity of the repair, although the adhesive itself is not MRI-visible. The 2024 telephone survey comprised five simple questions about residual symptoms, additional surgery, willingness to repeat the procedure, perceived symptom change and recommendation to others. These items are not validated outcome measures; they offer only a crude estimate of patient satisfaction and may be subject to recall and interviewer bias. Standardised instruments such as the WOMAC were collected before and 6 weeks after the procedure, but were not included in this study, limiting comparability with other studies. Moreover, patient-reported outcomes can be influenced by expectations and the absence of blinding.

Critical Appraisal

This methods section highlights multiple sources of potential bias. The study relies on patient self-selection (individuals who declined surgery and sought an alternative intervention), lacks a control group, and uses non-standardised outcome measures assessed retrospectively by telephone. The combination of fibrin-glue refixation and ACS is biologically plausible but remains experimental. Existing consensus statements caution that biological augmentation of meniscus repair has not demonstrated clear benefits, and narrative reviews note the dearth of high-quality trials evaluating ACS. Previous case series have reported favourable outcomes but were limited by retrospective design and uncontrolled confounding. Therefore, the present study should be interpreted as preliminary, and future prospective, randomised, controlled trials are essential to determine whether the intervention offers superior clinical or structural outcomes compared with standard care.

Results and Critical Interpretation

Here are some examples of MRI images of a medial meniscus rupture before (Figure 1) and 6 weeks after refixation (Figure 2) using the technique described above:

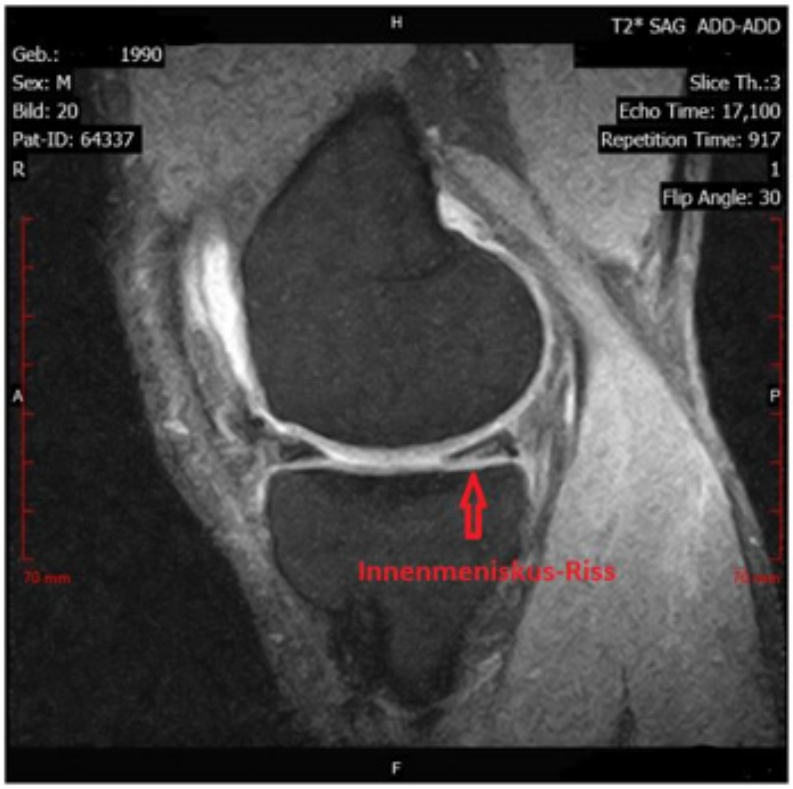

Figure 1: MRI images of a medial meniscus.

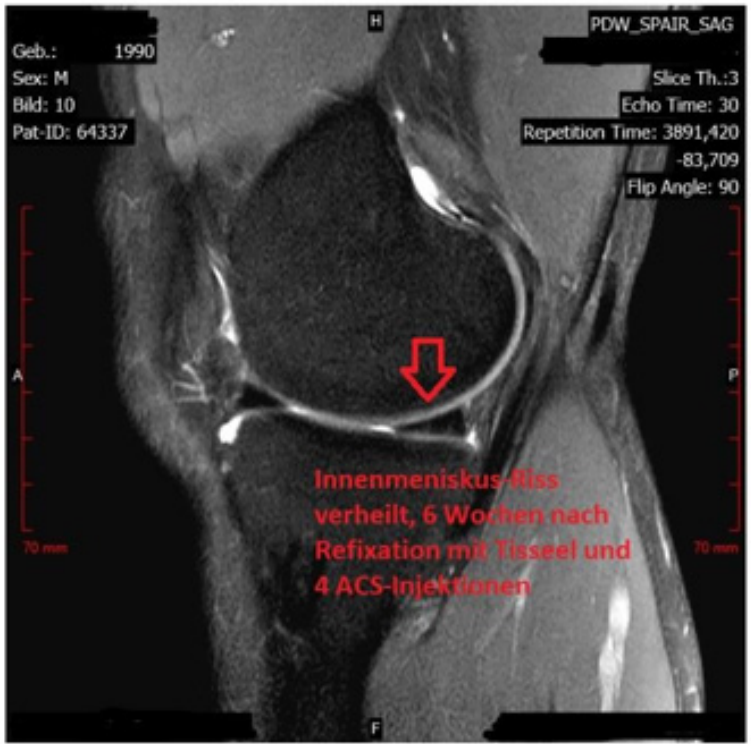

Figure 2: 6 weeks after refixation.

Cohort Characteristics and Follow-Up

A total of 502 patients who underwent MRI-guided fibrin-glue refixation combined with Autologous Conditioned Serum (ACS) injections between 2016 and 2023 were included in the retrospective analysis. All participants had MRI-confirmed lesions of the meniscus, tendon or ligament and had declined a recommended surgical procedure in favour of this minimally invasive approach. Follow-up was conducted by structured telephone interviews in the summer of 2024 for cases whose intervention dated back at least 12 months. Consequently, the observation period ranged from 1 to 8 years. Telephone follow-up introduces recall bias, and patient self-reports cannot substitute for standardised clinical scores or objective imaging. Furthermore, individuals who consented to remote follow-up may have been more satisfied than those lost to follow-up, inflating positive responses.

Patient-Reported Outcomes

Interview - Questions

1. Residual Symptoms. Do you still have discomfort in the treated joint? 1.1 ( ) No If so, how strong: 1.2 ( ) Mild, 1.3 ( ) Moderate, 1.4 ( ) Severe?

2. Reoperation Rate. Have you undergone surgery on the treated joint in the meantime?

a. ( ) No 2.2 ( ) Yes

3. Willingness to repeat the procedure. Would you have the treatment done again?

a. ( ) No 3.2 ( ) Yes

4. Would you say that you feel better in the treated joint after the procedure than before?

a. () Yes. 4.2 () No, complaints are equal to 4.3. () No, complaints are worse

5. Would you recommend the treatment method to other patients? 5.1 () Yes 5.2 () No The total of 502 treatments were then divided into annual groups from 2016 to 2023 and compared over the course of the year.

Residual Symptoms

Of the 502 cases, 319 patients (63.5 %) reported no residual symptoms, 91 (18.1 %)

reported mild symptoms, 61 (12.1 %) moderate symptoms and 31 (6.2 %) severe symptoms. Thus, 81.7 % of respondents reported none or only mild complaints up to eight years after the procedure. Because no validated outcome measures (e.g., WOMAC or KOOS) were used and results were self-reported by telephone, these figures should be interpreted cautiously. Patient satisfaction may be influenced by expectations or by relief at having avoided surgery. There is no imaging evidence that the treated tissues healed or that the intervention prevented degenerative progression (Table 1).

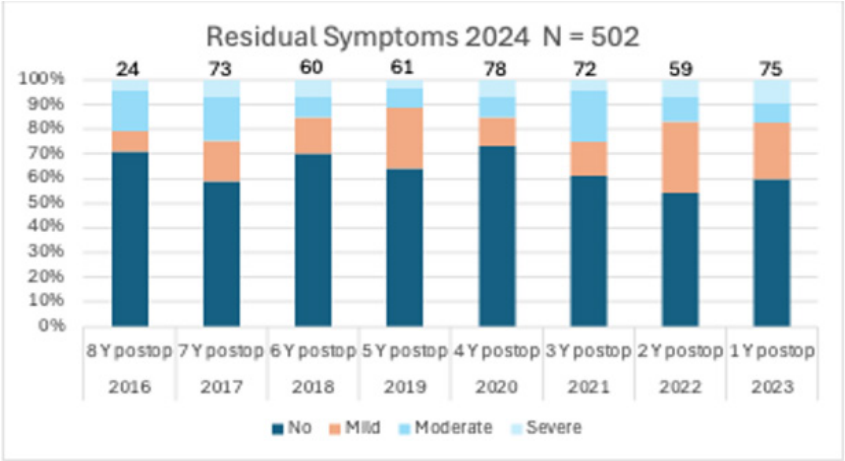

Diagram 1: shows the figures in Table 1 as a diagram.

Table 1: Answers to question 1 – Residual Symptoms.

Residual Symptoms 2024 = N = 502									
No	%	70,83	58,90	70,00	63,93	73,08	61,11	54,24	60,00
Mild	%	8,33	16,44	15,00	24,59	11,54	13,89	28,81	22,67
Moderate	%	16,67	17,81	8,33	8,20	8,97	20,83	10,17	8,00
Severe	%	4,17	6,85	6,67	3,28	6,41	4,17	6,78	9,33
Treatments		24	73	60	61	78	72	59	75
		2016	2017	2018	2019	2020	2021	2022	2023
		8 Y postop	7 Y postop	6 Y postop	5 Y postop	4 Y postop	3 Y postop	2 Y postop	1 Y postop

Reoperation Rate

In the second interview question, patients were asked whether surgery had been performed in the treated joint in the meantime. The results are shown in (Table 2 and Diagram 2).

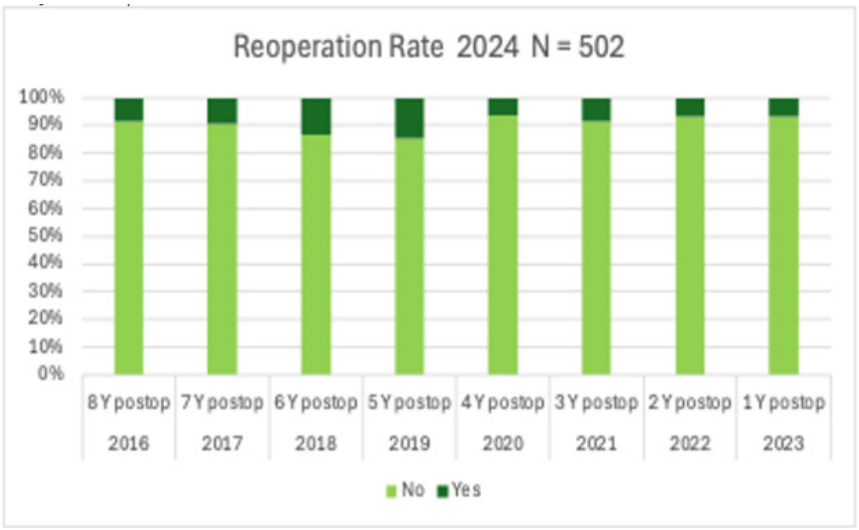

Diagram 2: for Table 2 Question 2.

Table 2: Answers to question 2 Reoperation Rate.

Reoperation Rate 2024 N = 502									
No	%	91,67	90,41	86,67	85,25	93,59	91,67	93,22	92,00
Yes	%	8,33	9,59	13,33	14,75	6,41	8,33	6,78	6,67
Treatments		24	73	60	61	78	72	59	75
		2016	2017	2018	2019	2020	2021	2022	2023
		8 Y postop	7 Y postop	6 Y postop	5 Y postop	4 Y postop	3 Y postop	2 Y postop	1 Y postop

In the vast majority = 455 or 90.1% of the treatments, no further surgical intervention has been required to date. Even when answering this question, the relatively small fluctuation range remains constant over the years, the differences between the years are not statistically significant.

Only 47 cases (9.9 %) underwent subsequent surgery at the treated joint during the follow-up period. While a reoperation rate below 10 % appears encouraging, it must be considered in the context of patient selection. All included patients had declined surgery originally; their reluctance to undergo invasive procedures may have persisted, irrespective of symptoms. In addition, the retrospective design does not allow determination of whether avoidance of surgery was due to genuine structural healing or to patient preference. Previous case series of similar interventions have reported high rates of surgery avoidance but were limited by lack of controls and retrospective design.

Willingness to Repeat the Procedure

When asked if they would elect to have the same treatment again, 83.5 % of respondents answered yes. The results are shown in (Table 3 or in the diagram in Table 3).

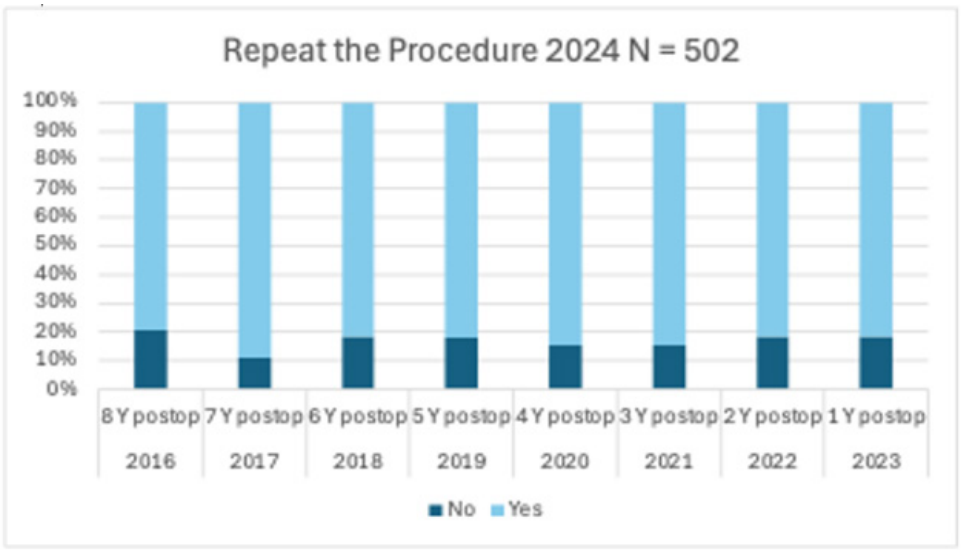

Diagram 3: Diagram for question 3.

Table 3: for Answers Question 3.

Repeat the Procedure? 2024 = N =502									
No	%	20,83	10,96	18,33	18,03	15,38	15,28	18,64	18,67
Yes	%	79,17	89,04	81,67	81,97	84,62	84,72	81,36	81,33

Treatments		24	73	60	61	78	72	59	75
		2016	2017	2018	2019	2020	2021	2022	2023
		8 Y postop	7 Y postop	6 Y postop	5 Y postop	4 Y postop	3 Y postop	2 Y postop	1 Y postop

This diagram also shows that the results have remained constant over the years. The differences between the individual years are not statistically significant, so the question of whether they would have this treatment carried out again is answered by an average of more than 83.5% of all patients with yes.

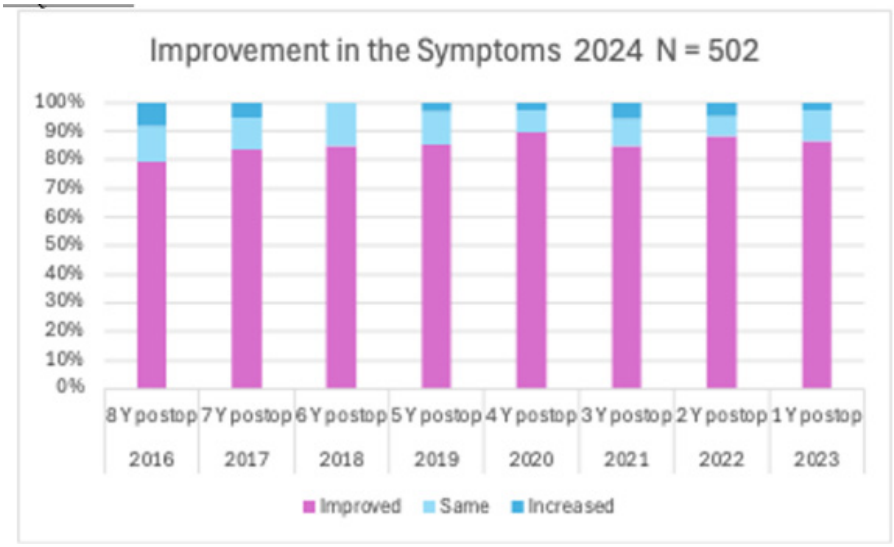

Diagram 4: Answers Question 4.

Table 4: Answers Question 4.

Improvement in the Symptoms 2024 N = 502									
Improved	%	79,17	83,56	85,00	85,25	89,74	84,72	88,14	86,67
Same	%	12,50	10,96	15,00	11,48	11,48	9,72	6,78	10,67
Increased	%	8,33	5,48	0,00	3,28	3,28	5,56	5,08	2,67
Treatments		24	73	60	61	78	72	59	75
		2016	2017	2018	2019	2020	2021	2022	2023
		8 Y postop	7 Y postop	6 Y postop	5 Y postop	4 Y postop	3 Y postop	2 Y postop	1 Y postop

Improvement in the Symptoms?

Finally, the patients were asked whether there had been an improvement in the symptoms after the treatment. The patients were able to choose from 3 possibilities: 1.: the symptoms have improved, 2.: the complaints have remained the same, 3.: the complaints have increased. The result of this survey is shown in (Table 4 and in Diagram 4).

This diagram also shows that the symptoms have improved in a total of well over 85.9% of all patients, and that the improvement has remained constant over the years up to the eighth year after the procedure. Again, the differences between the years were not significant.

Recommendation to Others

The proportion of patients who would recommend the com-

bined fibrin-glue and ACS treatment to others was 91.6 %. Recommendation rates remained stable across all follow-up durations. Such figures reflect subjective satisfaction rather than objective efficacy and should be interpreted cautiously. The absence of systematic follow-up imaging or validated functional scores prevents determination of whether the intervention provides durable structural repair or merely temporary symptom relief. The answers to this question are shown in (Table 5 and Diagram 5).

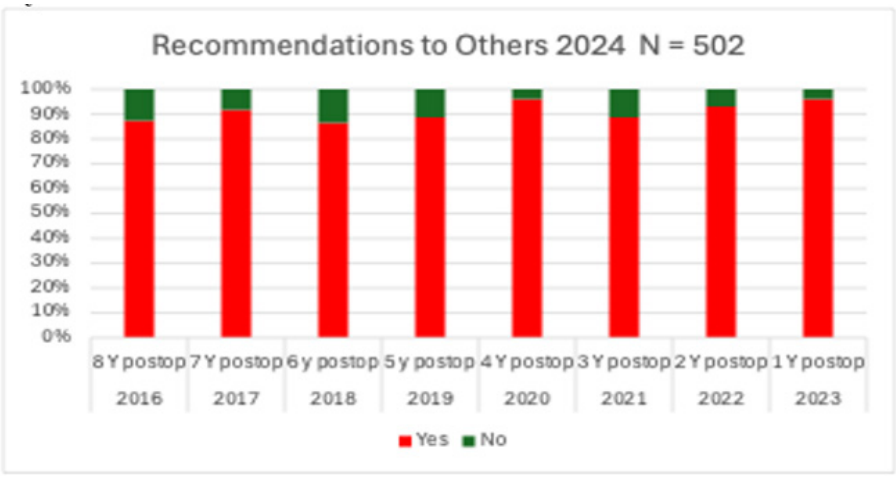

Diagram 5: Answers Question 5.

Table 5: Answers Question 5.

Recommendation to Others 2024 N = 502									
Yes	%	87,50	91,78	86,67	88,52	96,15	88,89	93,22	96,00
No	%	12,50	8,22	13,33	11,48	3,85	11,11	6,78	4,00
Treatments		24	73	60	61	78	72	59	75
		2016	2017	2018	2019	2020	2021	2022	2023
		8 Y postop	7 Y postop	6 Y postop	5 Y postop	4 Y postop	3 Y postop	2 Y postop	1 Y postop

The chart shows that, on average, 91.6% of patients would recommend this treatment method to other patients based on their experience. The differences between the individual years are not statistically significant.

Although these high satisfaction rates suggest perceived benefit, they must be interpreted within the context of non-blinded self-assessment. Without a control group or blinding, placebo effects and patient expectations can have a substantial impact on perceived outcomes. Narrative reviews on ACS highlight that most published reports are small, uncontrolled case series with inherently high risk of bias.

Distribution of Treated Joints

Most of the joints treated are knee joints and specifically meniscus lesions (83.9%). The second most common treatment of shoulder joints was with supraspinatus tendon lesions (11.2%), followed by lesions on the foot, mostly partial ruptures of the plantar fascia, and some partial lesions of the Achilles tendon (3.8%). Finally, 2 lesions of the joint tendon insertions at the elbow joint (0.4%), as well as 3 lesions of the scapholunar ligament at the wrist (0.6%) and a labrum lesion at the hip joint (0.2%). This distribution reflects the higher prevalence of degenerative meniscal tears in middle age, but it limits extrapolation of results to tendinous or labral lesions, which were under-represented. The heterogeneity of treated tissues and pathologies precludes meaningful subgroup analysis and complicates interpretation (Table 6, Diagram 6).

Demographic Profile

The cohort's median age was 55 years (range 14-84 years), with the largest group aged 50-60 years, corresponding to the peak incidence of degenerative meniscal lesions. Men accounted for 62.4 % of cases and women for 37.6 %. These demographics align with

epidemiological data on knee degeneration but may not represent younger athletic populations or individuals with high-energy traumatic tears. Selection of patients who declined surgery may further skew the demographic profile (Table 7, Diagram 7).

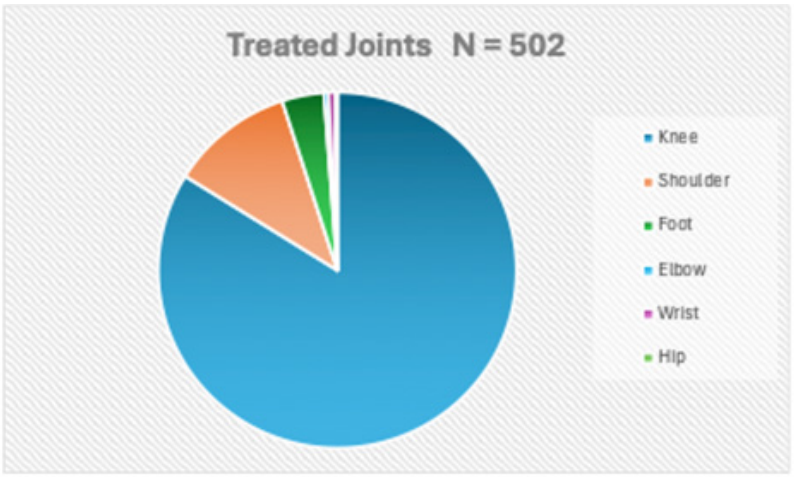

Diagram 6: Distribution of treated joints.

Table 6: Distribution of treated joints.

Distribution of treated joints N = 502			
		treatments	%
Knee		421	83,9
Shoulder		56	11,2
Foot		19	3,8
Elbow		2	0,4
Wrist		3	0,6
Hip		1	0,2

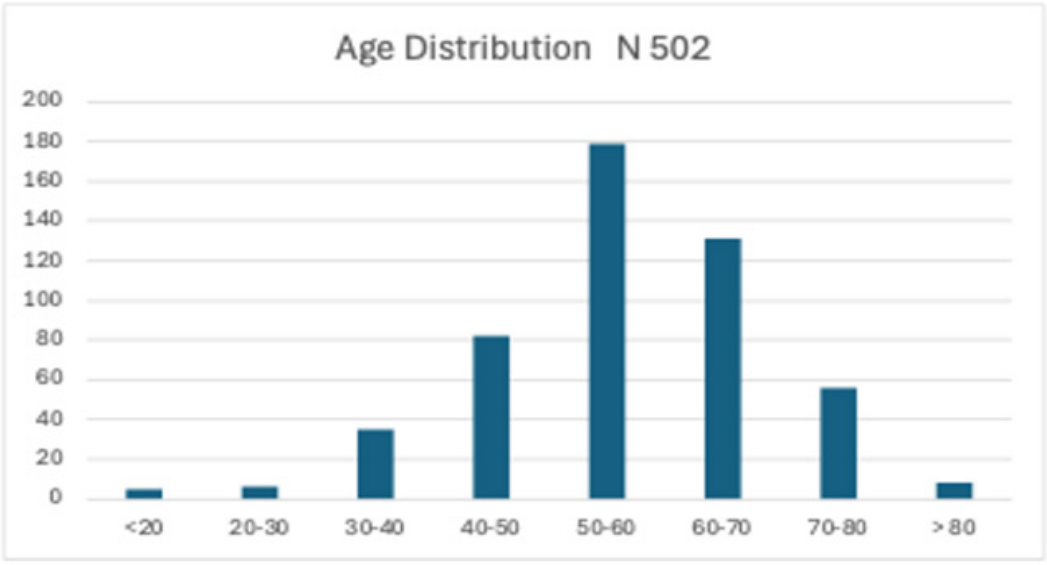

Diagram 7: Age Distribution Chart.

Table 7: Age – Distribution.

Age Distribution N = 502								
Age	<20	20-30	30-40	40-50	50-60	60-70	70-80	>80
Number	5	6	35	82	179	131	56	8
%	1,0	1,2	7,0	16,3	35,7	26,1	11,2	1,6

Gender Distribution

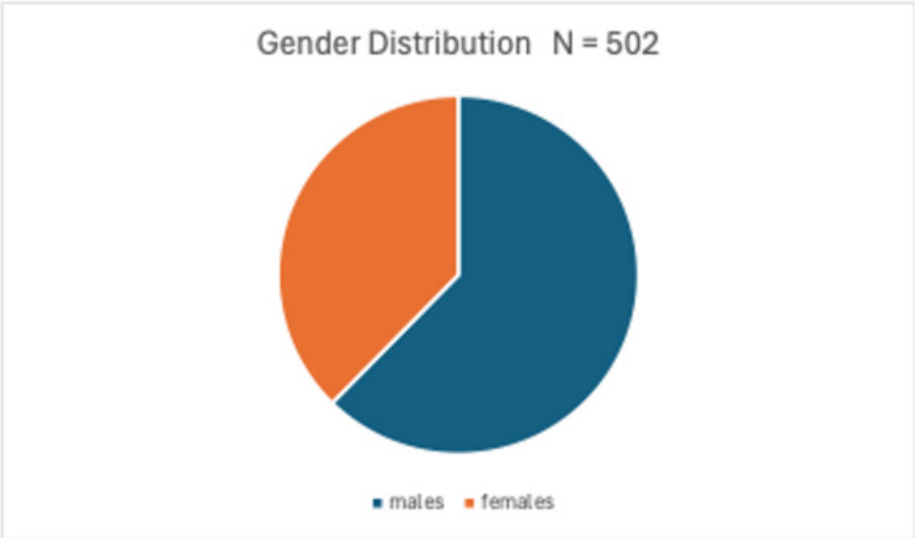

Diagram 8: Gender Distribution Chart.

Table 8: Gender distribution.

Gender Distribution N = 502		
	Number	%
Males	313	62,4
Females	189	37,6

The vast majority of patients treated, about 2/3 (62.4%) were males and only about 1/3 (37.6%) were females (Table 8, Diagram 8).

Statistical Analysis and Robustness

Data were analysed descriptively. Means, standard deviations and proportions were computed, and effect sizes were calculated where appropriate. A Bayesian exploratory approach was used to assess whether outcomes differed by treatment year; no significant differences were found. However, the lack of a control group and the heterogeneity of lesions mean that statistical comparisons provide little insight into efficacy. Bayesian analyses are sensitive to prior assumptions and may not overcome the fundamental limitations of non-randomised retrospective data.

Summary of key results and cautionary interpretation Interpretation and need for high-quality evidence

The retrospective data suggest that most patients who underwent the combined fibrin-glue and ACS procedure report sustained symptom relief and would recommend the treatment. However, the methodological limitations-including the absence of a control group, reliance on unvalidated telephone surveys, heterogeneity of indications and the potential for selection and recall bias-preclude definitive conclusions about efficacy. Existing consensus statements caution that biological augmentation of meniscus repair has not demonstrated clear benefits over standard repair, and narrative reviews emphasise the scarcity of high-quality trials evaluating ACS. Previous observational case series have reported similarly favourable outcomes but highlight the need for prospective, ran-

domised controlled studies. Until such data are available, the present results should be interpreted as hypothesis-generating rather than practice-changing.

Discussion

Summary of Principal Findings

The present study demonstrates that minimally invasive, MRI-guided meniscal refixation using Tisseel fibrin glue combined with autologous conditioned serum (ACS) can achieve stable clinical outcomes over a follow-up period of up to eight years. In 2024, 81.7 % of patients reported no or only mild residual symptoms, and 90.1 % required no subsequent surgical intervention, documenting substantial functional sustainability. High recommendation rates (91.6 %) and willingness to repeat the procedure (> 83 %) indicate pronounced patient satisfaction, serving as indirect surrogate parameters for clinical success.

Contextualisation Within Current Evidence the Shifting Paradigm in Meniscal Surgery

Meniscal lesions have traditionally been managed surgically via arthroscopic partial resection or suture repair. However, multiple randomised controlled trials have shown that degenerative meniscal tears in middle-aged patients confer no significant benefit from arthroscopic intervention compared with conservative or tissue-preserving approaches. For example, *Katz*, *et al*. found no superiority of arthroscopic partial meniscectomy over physiotherapy [12], and *Sihvonen*, *et al*. demonstrated in a sham-surgery trial that partial meniscectomy offered no additional benefit over placebo operation [13]. Against this background, biological, tissue-preserving strategies are gaining importance.

Rationale for Meniscal Preservation

Untreated meniscal lesions promote osteoarthritis development. A systematic review showed that knee osteoarthritis risk is increased four- to six-fold after knee injury [4]. The S2k guideline on meniscal diseases emphasises that arthritis progression is substantially greater following meniscectomy compared with meniscal repair (88 % versus 40 %) [3]. The ESSKA Meniscus Consensus 2019 recommends repair to preserve articular surfaces and meniscal tissue as the primary therapeutic goal [5]. Consequently, current evidence supports meniscal preservation over resection, particularly when concurrent chondral damage exists.

Biological Augmentation Strategies

Growth factor-based approaches-including platelet-rich plasma (PRP) and autologous conditioned serum (ACS)-demonstrate experimental stimulation of fibroblast proliferation, angiogenesis and matrix synthesis [6,7]. The ESSKA Instructional Course Lecture Book lists stem cells, platelet preparations, recombinant growth factors and ACS as applicable biological agents which may be combined with matrices, surgery or fibringlue [14-25]. The refixation method examined in this work addresses precisely this biological repair mechanism.

Mechanism of Action

Fibrin Glue as a Biological Scaffold

Tisseel fibrin glue mimics the final stage of natural coagulation. This two-component adhesive creates physiologic tissue adhesion and participates directly in healing processes. It has been successfully used in surgery for more than 20 years. Multiple systematic reviews support its use in meniscal repair; *Kraus*, et al. [11,14,15], *Ghezzi*, et al. [16] and *Scholz*, et al. [17] reported improved healing outcomes when fibrin glue augments meniscal repair. As Röddecker and Nagelschmidt noted, a fibrin matrix is a key prerequisite for reparative cell ingrowth [18].

Autologous Conditioned Serum (ACS)

ACS contains elevated concentrations of growth factors and the interleukin-1 receptor antagonist (IL-1Ra). Unlike PRP, ACS is produced solely through incubation and centrifugation without additives, avoiding allergic reactions. The S2k Gonarthrosis Guideline acknowledges that modified blood products, including ACS, are endorsed for knee osteoarthritis treatment [3]. Components identified in ACS include growth factors, cytokines, lipid mediators, extracellular vesicles and elements that ameliorate oxidative stress. ACS has been used for joint and soft tissue injection [19-24], pain reduction [26-31], stem-cell activation [32,33] and promotion of intra-articular homeostasis [34-37]. A hypothesised mechanism includes anabolic effects supporting healing, reduced oxidative stress and modulation of immune cell signalling-particularly a macrophage M1 → M2 shift [38].

Procedural Advantages of MRI-Guided Microtherapy Technical Considerations

The minimally invasive procedure is performed on an outpatient basis under MRI guidance with local anaesthesia. The treated knee is immediately weight bearing and functional, in contrast with arthroscopic or open surgical refixation. Key advantages include:

No wound requiring extended care No general anaesthesia

No prophylactic thrombosis treatment No drainage

No hospital stay or rehabilitation costs

Arthroscopic repair using fibrin glue is technically impossible because continuous joint irrigation during arthroscopy would wash away the adhesive. Earlier gas insufflation techniques were abandoned due to fatal gas embolism complications.

Necessity of Image Guidance

Millimetre-precise delivery of fibrin glue into closed joint spaces requires visual control. Uncontrolled adhesive application could lead to adhesion at unintended sites or life-threatening consequences if adhesive particles enter the bloodstream. MRI guidance offers three-dimensional visualisation of the needle and soft tissues without radiation exposure, providing superior accuracy compared with CT or ultrasound [39]. Studies comparing image-guided ver-

sus blind injections consistently demonstrate higher placement accuracy with image guidance [40]. Ultrasound is unsuitable for deep intra-articular injections because it cannot image behind bone or cartilage surfaces and would compromise sterility. [41,42] CT-guided injections carry substantial radiation exposure and potential long-term risk [43].

Longevity of Clinical Results

The stability of results over up to eight years is notable. While many biological therapies document short-term benefits, long-term data are often lacking. The consistently low reoperation rate (< 10 %) suggests that this procedure achieves structural stability rather than merely temporary symptom relief. Long-term investigations following arthroscopic meniscectomy show increased osteoarthritis risk [44]. A tissue-preserving approach-provided biomechanical integrity is restored-may therefore offer long-term protective effects. A four-year WOMAC score evaluation published in 2021 documented sustained efficacy (10); the present study extends these findings to six and eight years.

Patient Selection

The study cohort comprised patients with imaging-confirmed lesions and an existing surgical indication who nonetheless declined operative intervention. This group represents treatment-willing patients with structural pathology but a strong preference for joint-preserving alternatives. The predominance of knee joints (83.9 %) reflects the epidemiological dominance of meniscal lesions, and the age distribution (50-60 years) corresponds to the peak of degenerative meniscal lesions.

Limitations

Despite positive outcomes, several methodological constraints limit interpretation: Retrospective design limits causal inference.

Absence of a control group precludes direct comparison with standard treatments.

Subjective endpoints, relying on patient-reported outcomes without standardised scores (e.g. KOOS, WOMAC) in long-term follow-up.

No imaging follow-up, preventing objective verification of structural healing. Potential recall bias, given the interview format.

A randomised controlled study with standardised clinical scores and MRI follow-up is required to objectively verify structural healing. Furthermore, MRI cannot visualise fibrin adhesive directly; scar tissue after fibrin treatment appears similar to a meniscal tear signal, necessitating intra-articular contrast administration for differentiation [45].

Clinical Implications

These data suggest that minimally invasive MRI-guided refixation represents an effective alternative to surgery in selected patients. For degenerative meniscal lesions, it may serve as an intermediate step between conservative therapy and arthroscopic intervention. Given growing criticism of unnecessary arthroscopy in degenerative knees, a biologically regenerative approach gains both health-economic and tissue-preserving relevance. As *Wehling*, et al. concluded regarding intra-articular anti-cytokine therapies, the future therapeutic potential should be considered high [46].

Conclusion

Minimally invasive meniscal refixation using Tisseel fibrin glue combined with autologous conditioned serum injections demonstrates stable clinical outcomes with high patient satisfaction and low reoperation rates over up to eight years. Whether observed effects result from actual structural regeneration requires prospective, controlled studies with objectively verifiable parameters. Nonetheless, the procedure fulfills criteria for medical necessity: it corresponds to the disease, is considered promising by the specialist community, represents a recognised innovative approach and demonstrates efficacy in facilitating healing, alleviating symptoms and preventing deterioration.

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