Good clinical results after combined arthroscopic meniscal allograft transplantation and autologous chondrocyte implantation

Prof. Dr. med. Rainer Siebold[1,2], Johannes Pawelczyk[1]

[1] International Center for Orthopedics, ATOS Clinic, Heidelberg, Germany
[2] Institute for Anatomy and Cell Biology, Ruprecht-Karls-University, Heidelberg, Germany
[3] Artificial Intelligence in Chronic Pain Foundation (AICP), Heidelberg, Germany

Disclosures

The authors do not have any financial or non-financial conflicts of interest to declare at this time.

Introduction

ATOS KLINIK HEIDELBERG

- Meniscal injury is a highly prevalent diagnosis at 61 cases per 100.000 people, with an incidence of 12 – 14%, and is often associated with cartilage damage[1,2].
- Despite recent advancements in surgical meniscal restoration, many meniscal lesions are still not repairable, leading to meniscectomy, with subsequent functional meniscal insufficiency, rapid joint degeneration, and development of osteoarthritis[3-6].
- Isolated meniscal allograft transplantation (MAT) and autologous chondrocyte implantation (ACI) have become well established therapeutic procedures for meniscal insufficiency and cartilage damage, respectively[7-12].
- However, research on *combined* MAT and ACI is limited and the optimal treatment approach for patients with meniscal insufficiency and coexisting full-thickness chondral defects remains unclear.
- We therefore designed and conducted a single-center longitudinal study with the purpose of evaluating the viability, safety, and efficacy of this novel combined surgical approach in patients with meniscal insufficiency and coexisting full-thickness chondral defects.

Methods

- After obtaining approval from our local ethics committee, we performed a longitudinal evaluation of patients who received combined all-arthroscopic MAT and ACI at our institution between 2001 and 2021. Eligibility criteria are detailed in **Table 1**. Written informed consent was obtained from all participants.
- We assessed multiple internationally standardized and validated questionnaires[13-17], as well as failure rates, reoperation rates, and postoperative magnetic resonance imaging using the MOCART score[18].
- Arithmetic mean, standard deviation (SD), median, and range were calculated for complete datasets. Wilcoxon signed rank tests were applied to determine whether differences between pre- and postoperative outcome measures were significant. No alpha adjustment was used. All tests were two-sided and p value of ≤ 0.05 was considered significant.

Inclusion Criteria	Exclusion Criteria
Total or subtotal loss of medial or lateral meniscus and concomitant chondromalacia (Outerbridge 3-4°) affecting the ipsicompartmental femoral condyle and/or tibial plateau	Relevant complex trauma to the affected knee joint
Surgical treatment with combined MAT and ACI	Rheumatoid comorbidity
Age at index surgery 14-60 years	Follow-up duration less than 12 months
Normal lower extremity alignment	Relevant ligamentous instability

Table 1. Study inclusion and exclusion criteria.

Surgical Technique – Graft Preparation (Meniscus)

Figure 1. Meniscal allograft with bone-bridge just prior to implantation into the knee joint.

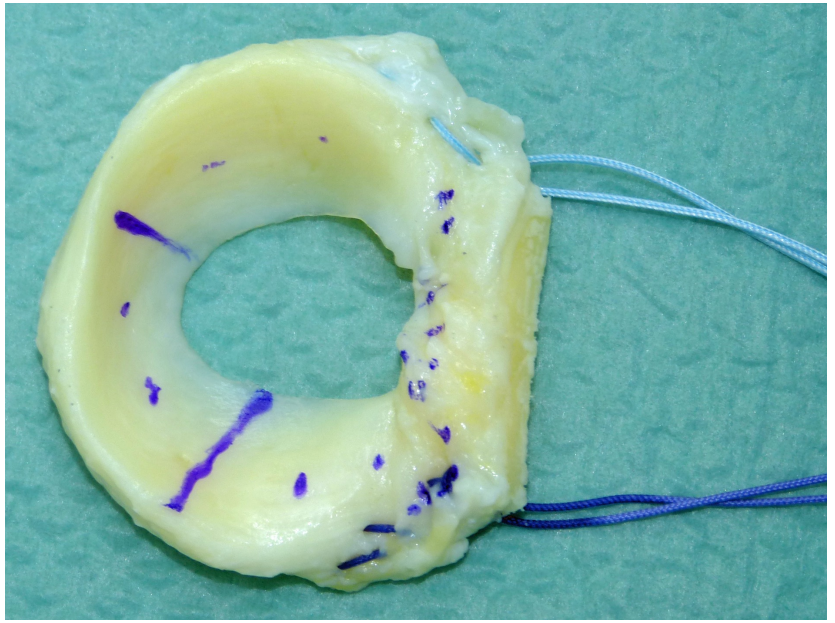

Figure 2. Close-up view of meniscal allograft with visible markings for intraarticular orientation and fixation sutures.

Surgical Technique – Graft Implantation (Meniscus)

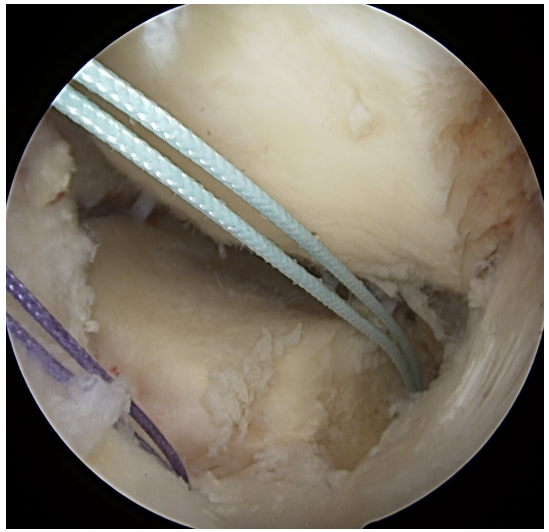

Figure 3. Intraarticular view prior to meniscal allograft implantation with visible tibial bone trough and shuttle sutures.

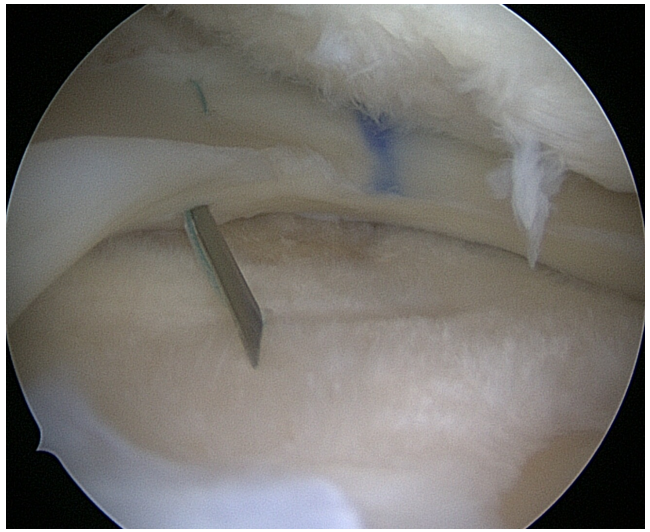

Figure 4. Intraarticular view during outside-in fixation of pars intermedia of the implanted meniscal allograft.

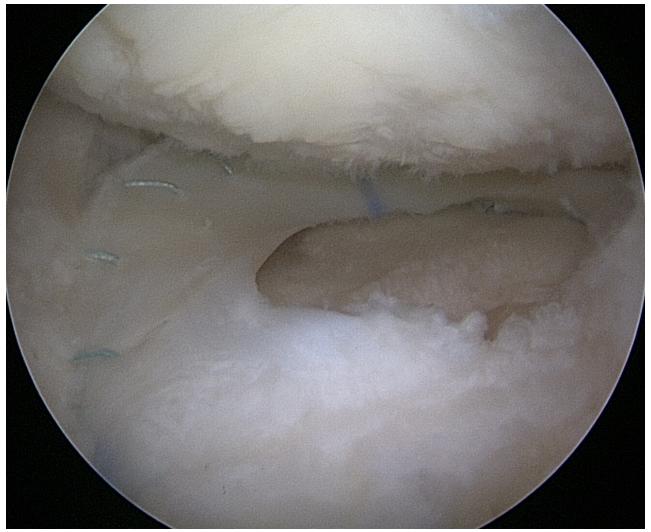

Figure 5. Fully fixated meniscal allograft in its final position.

Surgical Technique – Autologous chondrocyte implantation

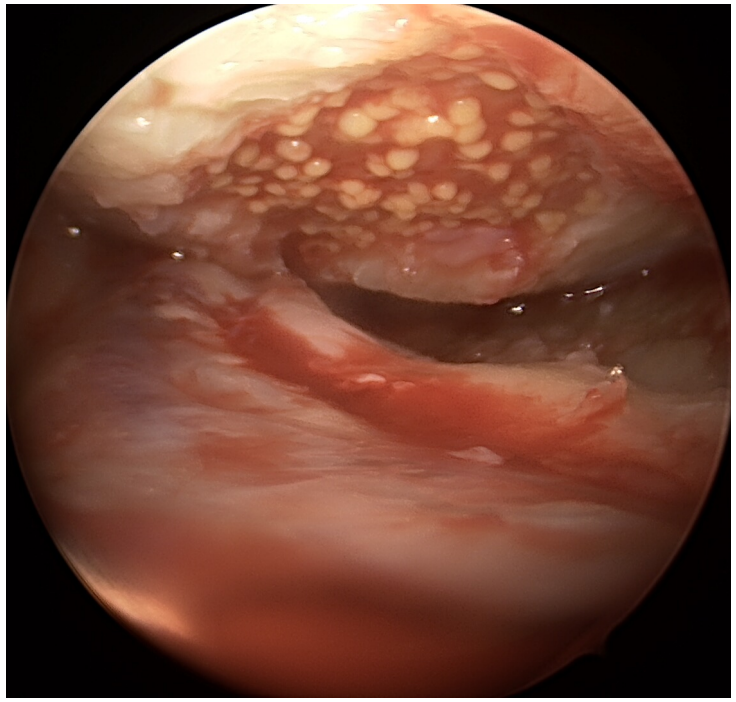

Figure 6. Intraarticular view just after implantation of autologous chondrocytes (spheroids) into femoral defect.

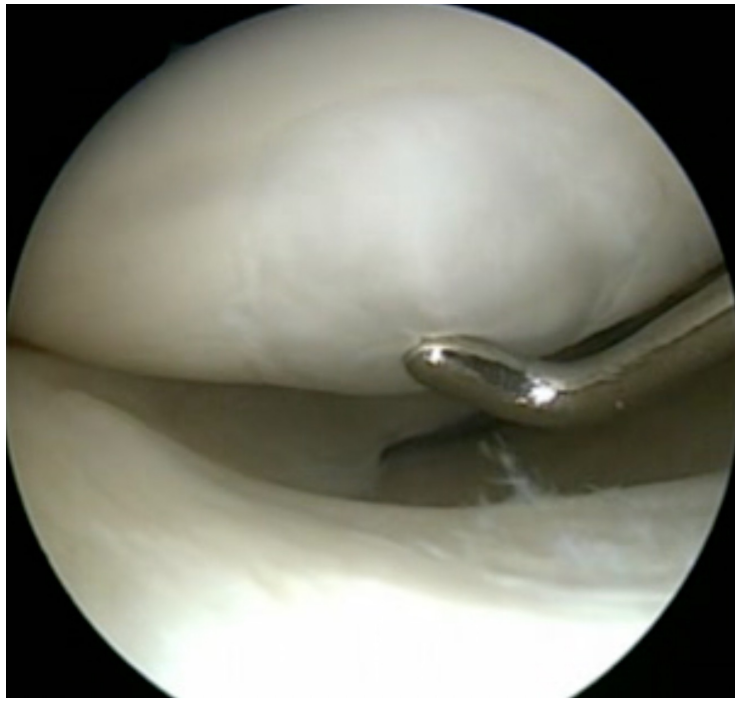

Figure 7. Intraarticular view during 2nd look arthroscopy 1 year after autologous chondrocyte implantation.

Results

- We observed marked improvements across all longitudinal outcome measures, comparing pre- and postoperative scores. Differences between pre- and postoperative scores were statistically significant in all cases, except for KOOS symptoms and VAS for patient satisfaction with the affected knee joint.
- A univariate analysis of longitudinal outcome measures by time point (pre- vs. postoperative), is summarised in **Figures 8 – 10** .
- The mean MOCART score for chondral graft integration was 68.9 ± 16.8 at an average follow-up time of 40.4 ± 20.1 months.
- The rate of MAT failure (requiring revision MAT, total resection, or conversion to arthroplasty) was 10%.
- No ACI failures (requiring revision ACI or similar cartilage restoration procedure/conversion to arthroplasty) were observed.
- The reoperation rate was 40%, with an average number of subsequent procedures of 0.75 ± 1.07.

Characteristics	Unit/coding	Range or count (n)	Mean ± SD or proportion
Age at index surgery	years	15 – 47	31.9 ± 9.7
Sex	male	13	65%
	female	7	35%
BMI	kg/m^2	18.9 – 27.8	24.1 ± 2.3
Index side	left	6	30%
	right	14	70%
Affected compartment	lateral	15	75%
	medial	5	25%
Defect size	cm^2	0.8 – 14.5	4.6 ± 3.6
Presence of kissing lesion	no	13	65%
	yes	7	35%
Duration between MAT and ACI surgery	weeks (negative values indicate ACI prior to MAT)	-35 – 25	5.4 ± 10.8
Number of prior surgeries		0 – 4	1.6 ± 1.0
Follow-up	months	12 – 135	72.6 ± 34.4

Table 2. Baseline patient and defect characteristics.

Results – IKDC, Lysholm, Tegner & VAS

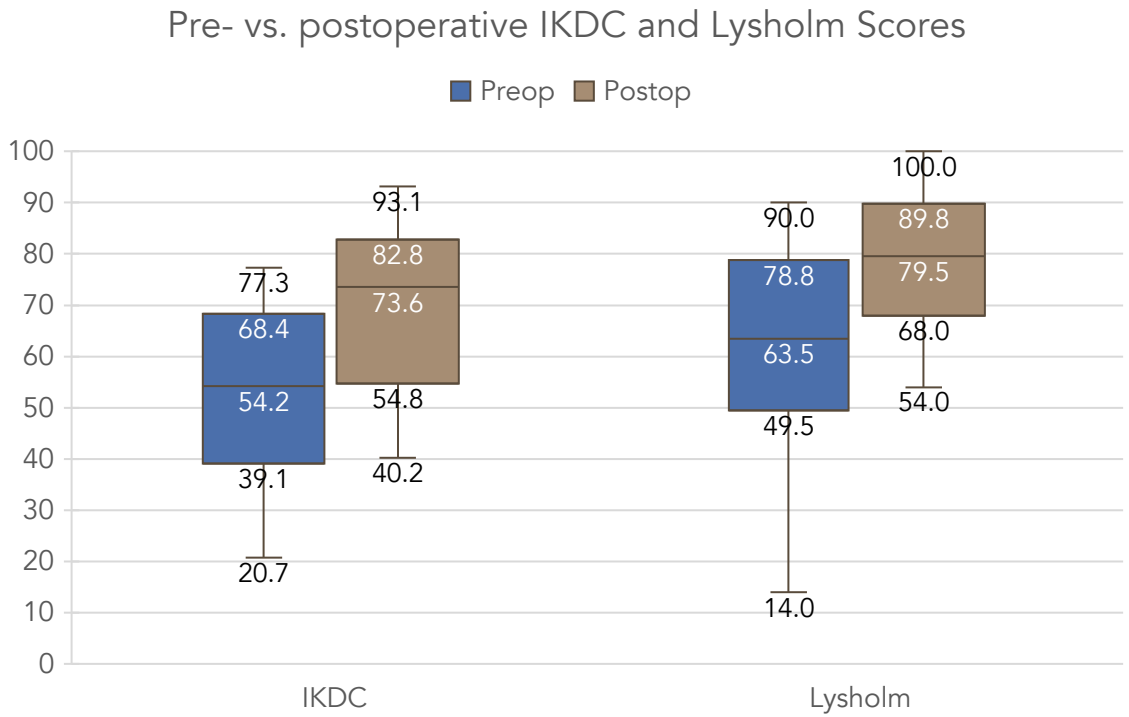

Figure 8. Pre- vs. postoperative IKDC and Lysholm scores. Both differences are statistically significant ($p < 0.05$). *Abbreviations: IKDC, International Knee Documentation Committee Subjective Knee Form.*

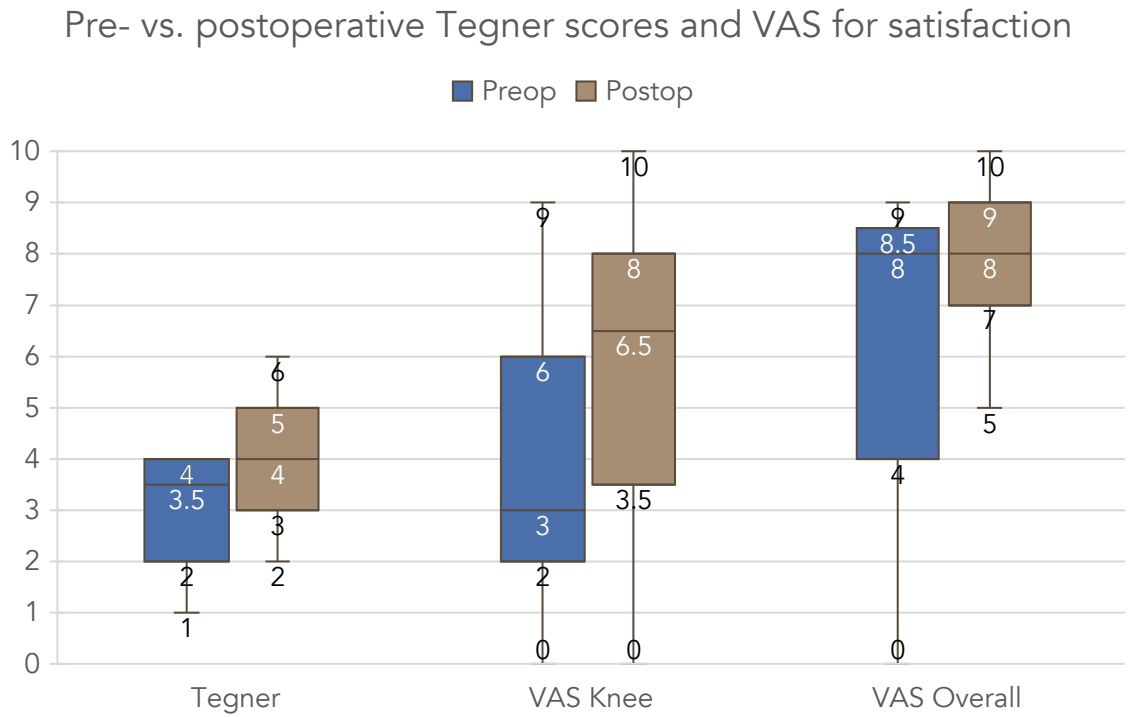

Figure 9. Pre- vs. postoperative Tegner activity scale and visual analog scale for patient satisfaction with the affected knee joint and overall. All differences are statistically significant ($p < 0.05$), except for VAS Knee.

Results

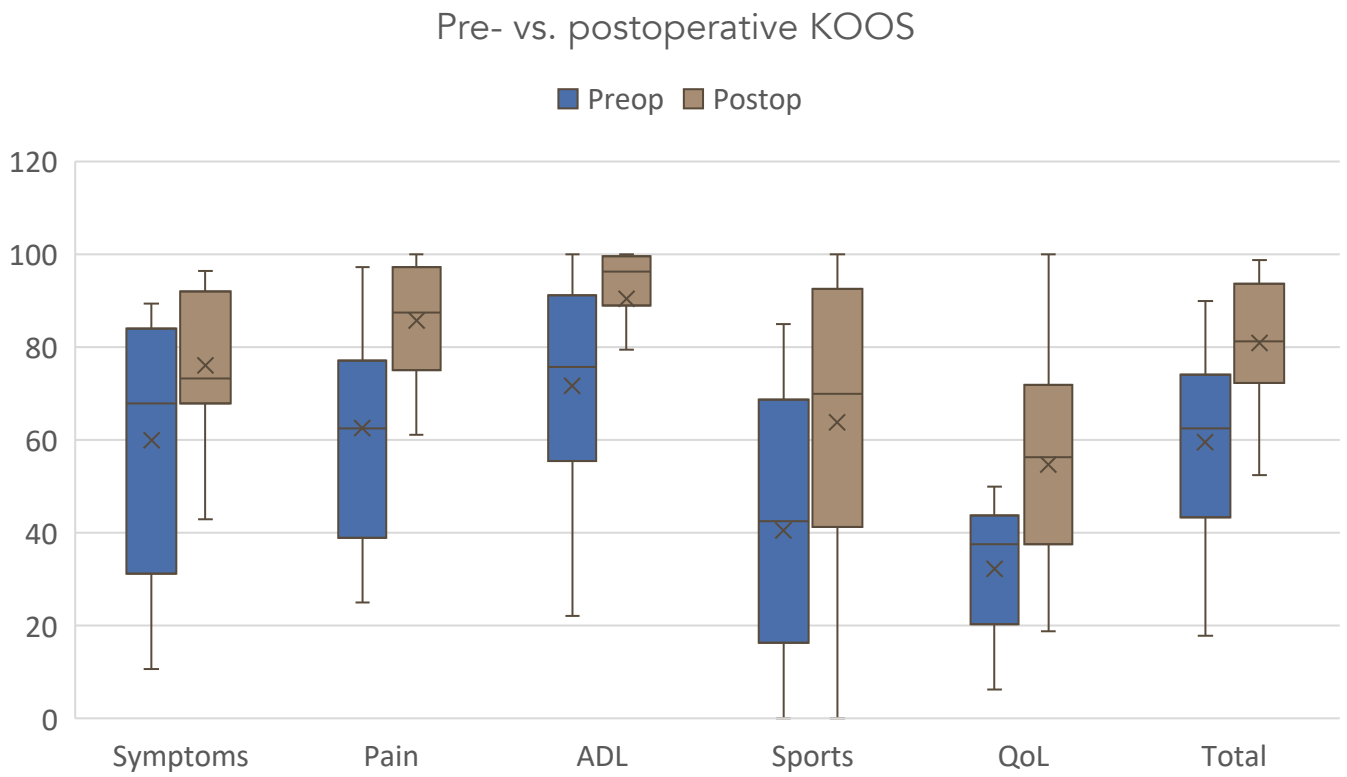

Figure 10. Pre- vs. postoperative KOOS. All differences are statistically significant ($p < 0.05$), except for KOOS symptoms. *Abbreviations: KOOS, Knee Injury and Osteoarthritis Outcome Score; ADL, activities of daily living; QoL, quality of life.*

	Scale	Mean ± SD (preop)	Mean ± SD (postop)	Delta
Symptoms	0 – 100	60.0 ± 26.4	76.1 ± 15.2	16.1 ± 30.5
Pain	0 – 100	62.5 ± 22.5	85.7 ± 12.7	23.2 ± 26.8
ADL	0 – 100	71.6 ± 23.3	90.4 ± 12.6	18.7 ± 25.3
Sports	0 – 100	40.5 ± 29.2	63.8 ± 29.8	23.3 ± 38.6
QoL	0 – 100	32.2 ± 14.5	54.7 ± 24.1	22.5 ± 25.4
Total	0 – 100	59.5 ± 21.4	80.9 ± 13.5	21.4 ± 25.5

Table 3. Pre- and postoperative KOOS, as well as deltas. All differences are statistically significant ($p < 0.05$), except for KOOS symptoms. *Abbreviations: KOOS, Knee Injury and Osteoarthritis Outcome Score; ADL, activities of daily living; QoL, quality of life.*

Discussion

- Key findings: (i) marked improvements were observed across all longitudinal outcome measures; (ii) postoperative magnetic resonance imaging revealed satisfactory integration of chondral graft tissue; (iii) the procedure demonstrated a low failure rate of 10%; (iv) a high reoperation rate of 40% was recorded.
- Our results provide a relatively long average follow-up period of 6 years. Importantly, comparison studies[19-23] align well with our findings, indicating a consensus that combined MAT and ACI is effective, with the noted significant improvements in a variety of clinical outcome measures across multiple studies providing strong evidence for the efficacy of this combined approach.
- Regarding improvements in IKDC scores (our primary outcome measure), our findings align with the results reported by Yoon et al.[19]. These authors observed a 10.2-point average improvement from pre- to postoperative IKDC scores, while our cohort saw an improvement of 16.3 ± 23.9 points. It's worth noting that the minimal clinically important difference for this metric is 9.8 points[24], indicating that on average, combined MAT and ACI was able to provide clinically meaningful improvements in our primary outcome measure.
- Our study observed a reoperation rate of 40%, which is consistent with previously published data from four comparison studies. The average reoperation rate across these studies was 41.35%[19,20,22,23]. Although the reoperation rate in our cohort was significant, we consider it to be generally acceptable, particularly given the lack of alternative treatment options to combined MAT and ACI, besides arthroplasty. This is corroborated in the current literature. Importantly, it is crucial to communicate this expected reoperation rate to prospective patients.
- Our cohort showed a 10% failure rate, compared to rates of 52.6% reported by Yoon et al.[19], 33.3% by Ogura et al.[20], 13.8% by Farr et al.[22], and 5.3% by Gersoff et al.[23]. Importantly, all failures in our cohort were attributed to the MAT component, highlighting its role as a limiting factor in the success of combined MAT and ACI. The need for a uniform and standardised approach to assess and report MAT failure has been emphasized by De Bruycker et al.[7] and Álvarez-Lozano et al.[25].

Conclusion

- Our findings, in the context of the existing literature, indicate that combined all-arthroscopic meniscal allograft transplantation and autologous chondrocyte implantation using chondrospheres is a viable, safe, and effective treatment approach for patients with meniscal insufficiency and coexisting full-thickness cartilage lesions.
- This combined surgical procedure achieved meaningful improvements in clinical outcome measures and patient satisfaction at acceptable failure and reoperation rates.

References

1. Logerstedt DS, Snyder-Mackler L, Ritter RC, Axe MJ. Knee pain and mobility impairments: meniscal and articular cartilage lesions. *J Orthop Sports Phys Ther*. Jun 2010;40(6):A1-a35. doi:10.2519/jospt.2010.0304
2. Schneider O, Scharf HP, Stein T, Knapstein S, Hermann C, Flechtenmacher J. [Incidence of knee injuries : Numbers for outpatient and inpatient care in Germany]. *Orthopade*. Dec 2016;45(12):1015-1026. Inzidenz von Kniegelenkverletzungen : Zahlen fur die ambulante und stationare Versorgung in Deutschland. doi:10.1007/s00132-016-3301-6
3. Bryceland JK, Powell AJ, Nunn T. Knee Menisci. *Cartilage*. Apr 2017;8(2):99-104. doi:10.1177/1947603516654945
4. Fairbank TJ. Knee Joint Changes After Meniscectomy. *The Journal of Bone and Joint Surgery British volume*. 1948;30-B(4):664-670. doi:10.1302/0301-620x.30b4.664
5. U J, S S-H, F L, A R. Long-term follow-up of meniscectomy in athletes. A prospective longitudinal study. *The Journal of Bone and Joint Surgery British volume*. 1987;69-B(1):80-83. doi:10.1302/0301-620x.69b1.3818740
6. Christoforakis J, Pradhan R, Sanchez-Ballester J, Hunt N, Strachan RK. Is there an association between articular cartilage changes and degenerative meniscus tears? *Arthroscopy*. Nov 2005;21(11):1366-9. doi:10.1016/j.arthro.2005.08.031
7. De Bruycker M, Verdonk PCM, Verdonk RC. Meniscal allograft transplantation: a meta-analysis. *Sicot j*. 2017;3:33. doi:10.1051/sicotj/2017016
8. Elattar M, Dhollander A, Verdonk R, Almqvist KF, Verdonk P. Twenty-six years of meniscal allograft transplantation: is it still experimental? A meta-analysis of 44 trials. *Knee Surg Sports Traumatol Arthrosc*. Feb 2011;19(2):147-57. doi:10.1007/s00167-010-1351-6
9. Bin SI, Nha KW, Cheong JY, Shin YS. Midterm and Long-term Results of Medial Versus Lateral Meniscal Allograft Transplantation: A Meta-analysis. *Am J Sports Med*. Apr 2018;46(5):1243-1250. doi:10.1177/0363546517709777
10. Dhillon J, Decilveo AP, Kraeutler MJ, Belk JW, McCulloch PC, Scillia AJ. Third-Generation Autologous Chondrocyte Implantation (Cells Cultured Within Collagen Membrane) Is Superior to Microfracture for Focal Chondral Defects of the Knee Joint: Systematic Review and Meta-analysis. *Arthroscopy*. Aug 2022;38(8):2579-2586. doi:10.1016/j.arthro.2022.02.011
11. Gou GH, Tseng FJ, Wang SH, et al. Autologous Chondrocyte Implantation Versus Microfracture in the Knee: A Meta-analysis and Systematic Review. *Arthroscopy*. Jan 2020;36(1):289-303. doi:10.1016/j.arthro.2019.06.033
12. Colombini A, Libonati F, Lopa S, Peretti GM, Moretti M, de Girolamo L. Autologous chondrocyte implantation provides good long-term clinical results in the treatment of knee osteoarthritis: a systematic review. *Knee Surg Sports Traumatol Arthrosc*. Jun 18 2022;doi:10.1007/s00167-022-07030-2
13. Irrgang JJ, Anderson AF, Boland AL, et al. Development and validation of the international knee documentation committee subjective knee form. *Am J Sports Med*. Sep-Oct 2001;29(5):600-13. doi:10.1177/03635465010290051301
14. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)--development of a self-administered outcome measure. *J Orthop Sports Phys Ther*. Aug 1998;28(2):88-96. doi:10.2519/jospt.1998.28.2.88
15. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res*. Sep 1985;(198):43-9.
16. Mitsou A, Vallianatos P, Piskopakis N, Maheras S. Anterior cruciate ligament reconstruction by over-the-top repair combined with popliteus tendon plasty. *J Bone Joint Surg Br*. May 1990;72(3):398-404. doi:10.1302/0301-620x.72b3.2341436
17. Flandry F, Hunt JP, Terry GC, Hughston JC. Analysis of subjective knee complaints using visual analog scales. *Am J Sports Med*. Mar-Apr 1991;19(2):112-8. doi:10.1177/036354659101900204
18. Marlovits S, Singer P, Zeller P, Mandl I, Haller J, Trattnig S. Magnetic resonance observation of cartilage repair tissue (MOCART) for the evaluation of autologous chondrocyte transplantation: determination of interobserver variability and correlation to clinical outcome after 2 years. *Eur J Radiol*. Jan 2006;57(1):16-23. doi:10.1016/j.ejrad.2005.08.007
19. Yoon KH, Kang SG, Kwon YB, Kim EJ, Kim SG. Clinical outcomes and survival rate of autologous chondrocyte implantation with and without concomitant meniscus allograft transplantation: 10- to 15-year follow-up study. *Arch Orthop Trauma Surg*. Aug 2019;139(8):1117-1123. doi:10.1007/s00402-019-03148-0
20. Ogura T, Bryant T, Minas T. Biological Knee Reconstruction With Concomitant Autologous Chondrocyte Implantation and Meniscal Allograft Transplantation: Mid- to Long-term Outcomes. *Orthop J Sports Med*. Oct 2016;4(10):2325967116668490. doi:10.1177/2325967116668490
21. Bhosale AM, Myint P, Roberts S, et al. Combined autologous chondrocyte implantation and allogenic meniscus transplantation: a biological knee replacement. *Knee*. Oct 2007;14(5):361-8. doi:10.1016/j.knee.2007.07.002
22. Farr J, Rawal A, Marberry KM. Concomitant meniscal allograft transplantation and autologous chondrocyte implantation: minimum 2-year follow-up. *Am J Sports Med*. Sep 2007;35(9):1459-66. doi:10.1177/0363546507301257
23. Gersoff WK. Combined meniscal allografttransplantation and autologous chiondrocyte implantation. *Operative Techniques in Sports Medicine*. 2002/07/01/ 2002;10(3):165-167. doi:https://doi.org/10.1053/otsm.2002.36440
24. Ogura T, Ackermann J, Mestriner AB, Merkely G, Gomoll AH. The Minimal Clinically Important Difference and Substantial Clinical Benefit in the Patient-Reported Outcome Measures of Patients Undergoing Osteochondral Allograft Transplantation in the Knee. *Cartilage*. Jan 2021;12(1):42-50. doi:10.1177/1947603518812552
25. Álvarez-Lozano E, Luna-Pizarro D, Meraz-Lares G, Quintanilla-Loredo R, Cerdá-García MV, Forriol F. Two-stage bone and meniscus allograft and autologous chondrocytes implant for unicompartmental osteoarthritis: midterm results. *Musculoskelet Surg*. Jun 2022;106(2):133-143. doi:10.1007/s12306-020-00680-w