



Long-term (10-25 years) outcomes of knee osteochondral autologous transplantation in soccer players

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ABSTRACT

Objective: Osteochondral lesions in the knee can occur in a high percentage of soccer players. Untreated, symptomatic osteochondral lesions can lead to reduced athletic performance, early career-ending, and the premature onset of knee osteoarthritis. One of the treatment options is osteochondral autologous transplantation with the mosaicplasty technique. The study aims to investigate the long-term outcomes of the procedure in the athletic population.

Design: In a single-center retrospective study, the long-term outcomes of knee mosaicplasty procedures in soccer players between 1992 and 2011 were investigated. Using International Knee Documentation Committee and Bandi score to evaluate the knee function, Tegner score to measure activity, and MOCART 2.0 score to describe cartilage surface. Players' skill level was divided into professional, competitive, and recreational groups.

Results: Fifty-five out of 73 soccer players were included; 25 had MRI at the last follow-up control. The average follow-up time was 17.54 years (10.32-24.91). The mean International Knee Documentation Committee score was 68.52 ± 16.01 (33-87), MOCART was 70.8 ± 18.12 (25-95), and 80% of the patient had a good Bandi score. The mean size of the defects was $2.08 \text{ cm}^2 \pm 1.19$ (1.5 cm^2) and overall return to sport time was 7.78 ± 2.96 (4-12) months.

Conclusion: The knee mosaicplasty procedure has a good long-term result, with no significant decrease in functional scores compared to other studies even after 20 years from the surgery. Therefore, osteochondral autologous transplantation is a reasonable option for soccer players with small to medium-sized osteochondral lesions in the knee.

Introduction

Osteochondral lesions in the general population can occur in 34% to 62% of knee arthroscopies, and full-thickness defects are seen in 4.2% to 6.2% of the cases.¹ Regarding soccer players, knee cartilage injury prevalence is much higher. It can occur 36% in asymptomatic players and 98% in symptomatic.²⁻⁵ Due to the game's risk profile, this high prevalence correlates with the high prevalence of other knee injuries, such as anterior cruciate ligament (ACL) and meniscal lesions.^{2,3,6} Untreated, symptomatic osteochondral lesions can lead to reduced athletic performance, early career-ending, and the premature onset of knee osteoarthritis.⁷⁻⁹

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The management of symptomatic articular cartilage lesions is complex, and there are several conservative and operative treatment options.¹⁰⁻¹³

Regarding the destructive effect of high-impact loading, articular cartilage surface restoration should withstand the mechanical joint stresses of up to 20 times bodyweight generated during high-impact, pivoting sports.¹⁴ However, surgical techniques do not provide an utterly normal hyaline surface. Therefore, several studies implicate it is desirable to choose a full-thickness osteochondral restoration procedure to achieve an almost physiological cartilage surface.¹⁵⁻¹⁷ One of these techniques is osteochondral autologous transplantation (OAT) with the mosaicplasty technique. This widely used procedure was described by Hangody et al. in 1992 and has been used for knee lesions since 1992. The exact surgical methodology and indications are detailed in the cited articles.¹⁸⁻²² According to several studies, mosaicplasty has good or excellent clinical results in football players in more than 80% of the cases.^{15,23,24} The advantage lies in the technique itself because hyaline cartilage transplanted with the mosaicplasty procedure has better histological structure and survival, therefore restoring cartilage surface with sufficient mechanical properties.²⁵ Furthermore, OAT is subject to bone healing and thus guarantees shorter rehab times and a much faster return-to-play. However, other cartilage regenerative procedures require patients to abstain from full-contact sports for more than 12 months, which is a significant disadvantage for high-level professional athletes.

Based on a recent study, despite significant developments in recent years, optimal management of cartilage injuries in the athletic population remains highly challenging and controversial and has yet to be determined.⁹ Therefore our single-center, retrospective study investigates the long-term results of mosaicplasty procedures in our department. Our findings support our hypothesis; namely, mosaicplasty is applicable with good efficiency for full-thickness osteochondral lesions and maintains the level of activity and henceforward indicated to use in the athlete population.

Methods

This single-center retrospective study investigated 73 soccer players treated with OAT using the mosaicplasty technique in our department between 1992 and 2011. Only those patients whose follow-up period was at least 10 years or longer were included. Patients with unstable knees and malalignment were excluded from the study. Our players' skill levels were divided into professional, competitive, and recreational groups. Professional players participate in the national league, competitive in a lower division, and recreational ones play soccer regularly as a hobby. The activity was measured with Tegner score. At the last follow-up control, all the included patients had an IKDC (International Knee Documentation Committee)²⁶ score, evaluated by an independent physician, and a Bandi score²⁷ to measure femoropatellar complaints as well as possible donor site disturbances. The available T3 MR images were graded by a blinded radiologist using the MOCART 2.0 score (Magnetic Resonance Observation of Cartilage Repair Tissue).²⁸

Statistical analysis

The statistical calculations and the data visualization were performed using R version 4.0.3 and STATA version 17.0. All parametric data (eg, IKDC score) are presented as mean \pm standard deviation, non-parametric data (eg, Lesion location) are presented as frequency in the given category, and binary variables (eg, Gender) are given as ratios. We calculated paired *t* tests and reported i) the mean difference; ii) the 2-tailed *P*-values; iii) and the *t*-statistics. The number of stars corresponds to the significance of the *P*-value ($***P < .001$, $**P < .01$, $*P < .05$).

Figure 1 demonstrates the association between the predicted probability of having a good Bandi-score at the given IKDC score $\hat{p} = Pr(y_i = 1 | IKDC_i)$. We also run the same estimation with the Linear Probability Model as a robustness check. Although it shows weaker significance, it still strengthens the positive association between IKDC and good Bandi-score.

Results

Between 1992 and 2011, 73 soccer players were operated with knee OAT using the mosaicplasty technique in our department. Fifty-five patients had an IKDC score, and 27 had available MRI at the last follow-up control examination. Therefore we had an overall 55 included patients. The average follow-up time was 17,54 years (10,32-24,91). The mean IKDC score was 68.52 ± 16.01 (33-87), MOCART was 70.8 ± 18.12 (25-95), and 80% of the patient had a good Bandi score (Table 1).

The following regions were involved in 55 knee cases: 50 femoral condylar (37 medial, 13 lateral) and 7 femoropatellar (6 patellar and 1 trochlear) (Table 2). The mean size of the defects was 2.03 ± 1.19 (1-5 cm²). The number and diameter of grafts are shown in Table 3. Nineteen procedures were arthroscopic, and 36 were done with arthrotomy. Twenty-nine percent of our patients had injury-related operations before the surgery, such as debridement, LCA reconstruction, partial meniscal resection, microfracture, high tibial osteotomy, and femoropatellar realignment procedure. Fifty-six percent of the players had additional surgical intervention during the mosaicplasty due to co-injuries or malalignment in the knee. Fourteen percent of the patients had debridement or lateral patellar retinacular release because of recurrent pain and limitation in motion (Table 2).

Seven patients were professional soccer players, 23 were competitive, and 25 were recreational. Overall return to sport time was $7,78 \pm 2,96$ (4-12) months. Eighty-five percent of professional, 34% of competitive, and 88% of recreational players could go back to the same level of sport after surgery. There was a 1,85 points decrease in Tegner score from an overall mean of 8,10 to 6,25 (Table 4).

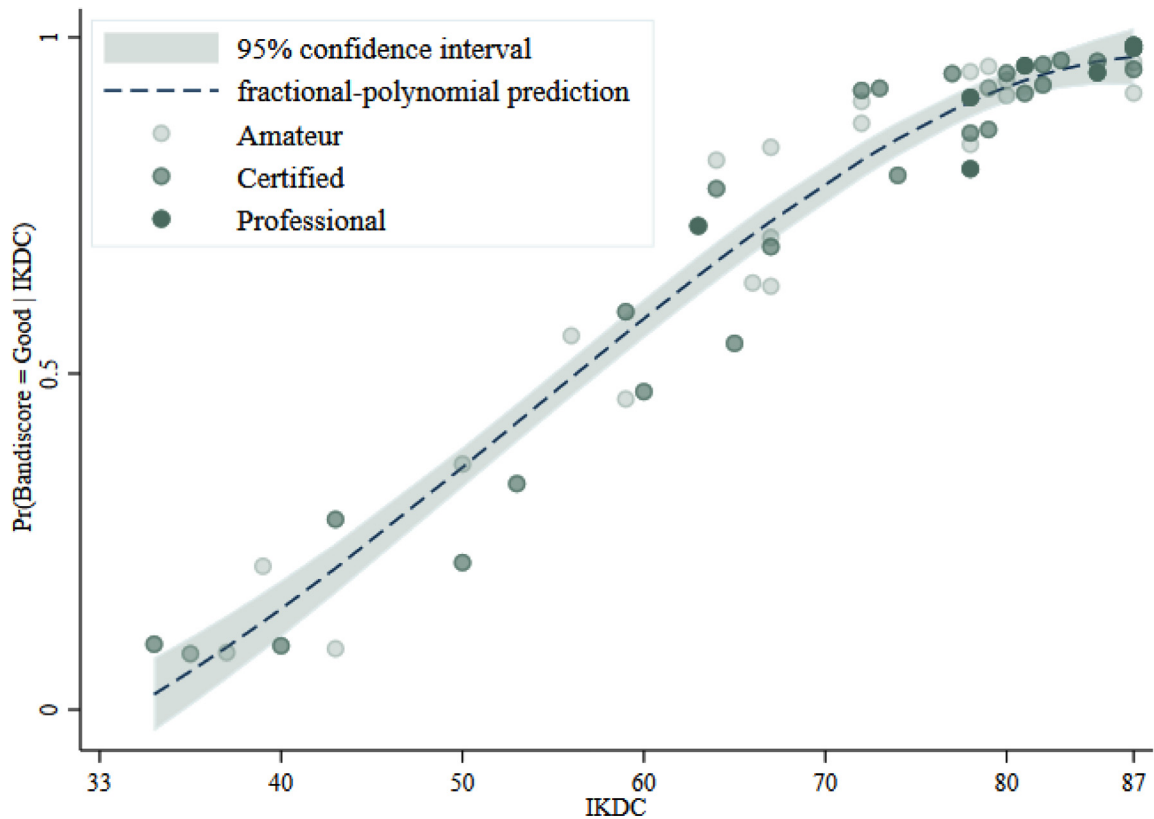


Fig. 1. Predicted probabilities of Logit model.

Table 1
Demographic distribution, functional, and MRI scores.

	All	Recreational	Competitive	Professional
Observations	55	25	23	7
Male: Female ratio	40 (72%): 15(28%)	18 (72%): 7(28%)	17(74%): 6(26%)	5(71%): 2(29%)
Age at the time of the operation	29.2 ± 8.11 (14-45)	29.24 ± 8.50 (15-45)	29.95 ± 7.33 (17-42)	26.57 ± 9.77 (14-45)
Follow up time (in years)	17.54 ± 3.82 (10.32-24.91)	17.13 ± 3.2 (11.12-22.11)	17.43 ± 4.52 (10.32-24.91)	19.34 ± 3.36 (15.11-24.34)
IKDC (0-87)	68.52 ± 16.01 (33-87)	65.72 ± 17.09 (35-87)	68.13 ± 15.53 (33-87)	79.85 ± 8.37 (63-87)
MOCART* (0-100)	70.8 ± 18.12 (25-95)	69.09 ± 23.21 (25-95)	73.18 ± 15.04 (50-95)	68.33 ± 7.63 (60-75)
Bandi-score good: poor ratio	44 (80%): 11 (20%)	18 (72%): 7(28%)	19 (82.6%): 4(17.4%)	7 (100%): 0 (0%)

Abbreviation: IKDC, International Knee Documentation Committee.

* Note that exact data was available for only 25 players out of 55.

Discussion

We hypothesized that athletes' osteochondral lesions treated with OAT using the mosaicplasty technique allow players shorter return to sport time and maintain the level of activity in a long-term follow-up. We used clinical functional and MRI scores to objectify the procedure results. Our study's substantial advantage is the high follow-up time with an average of 17,54 years and using the MOCART score. However, we could not measure the correlation between MOCART and IKDC score because of the low MRI number, but presumably, there is a positive one. Only one study uses the MOCART score to evaluate cartilage restoration after mosaicplasty in the knee.²⁹ Furthermore, it is worth underlining that 17 of our patients had OAT with mosaicplasty more than 20 years ago, which means 31% of our population. Despite such a long time since surgeries, a functional knee score with a mean 68.52 ± 16.01 (33-87) is still similar to publication in mid-and long-term follow-up studies.³⁰⁻³³ Solheim et al. (2018) found a Lysholm

Table 2
Distribution of lesion size and additional procedures.

	All	Recreational	Competitive	Professional
Defect size *	55	25	23	7
(cm ²)	2.03 ± 1.19 (1-5)	2.28 ± 1.28 (1-4)	2.03 ± 1.16 (1-5)	1.1 ± 0.22 (0.5-1.5)
Lesion location				
CLF	13	9	2	2
CMF	35	12	19	4
Patella	6	3	2	1
Trochlea	1	1	0	0
Additional (and previous) surgeries †				
HTO	7 (+1)	2	4 (+1)	1
LCA	16 (+1)	6 (+1)	7 (+2)	3
LMMG	3 (+2)	3 (+1)	(+1)	0
LMLG	3	2	1	0
Lateral release	2	1	1	0
Microfracture	2 (+1)	1	1 (+1)	0
Ventromedialisation	3 (+1)	1 (+1)	2	0
Debridement	(+9)	(+3)	(+5)	(+1)
Procedure				
Open	35 (64.8%)	17 (30.1%)	14 (25.4%)	5 (9.1%)
Arthroscopic	19 (35.2%)	8 (14.5%)	9 (16.3%)	2 (3.6%)
Complication				
Swelling	1	1	0	0
Limitation in motion	3	0	2	1
Pain	3	2	1	0
Lock	1	0	1	0

Abbreviation: CLF: condyle lateral femur, CMF: condyle medial femur, HTO: high tibial osteotomy, LCA: ligament cruciate anterior, LMMG: laesio meniscus medialis genus, LMLG: laesio meniscus lateralis genus.

* Note that, exact data was available for only 42 players out of 55.

† Previous surgeries in parenthesis.

Table 3
Graft donor sites.

	Graft 8,5	Graft 6,5	Graft 4,5	Bandi-score good: poor ratio
Donor site				
All	31	19	4	44:11
(mosaics number)				
CMF	2.25 ± 1.34	2.57 ± 1.70	9 ± 7.78	0.80 ± 0.40
(mosaics number)	23	16	4	37:7
CLF	1.95 ± 1.22 (1-5)	2.81 ± 1.75 (1-6)	9 ± 7.78 (2-18)	0.84 ± 0.36
(mosaics number)	8	3	0	7:3
	3.12 ± 1.35 (2-5)	1.33 ± 0.57 (1-2)	–	0.7 ± 0.48

score mean value of 77 (SD 17) in patients with more than 15 years of follow-up.³⁴ Although they used a different functional score to evaluate the knee, our mean score is 78% and Solheim's 77% if the scores are calculated in percentage from the maximal point.

However, according to femoropatellar complaints, as potential donor site disturbances, we had a higher ratio of poor outcomes than previously published by our institute (20%). Several studies implicate that osteoarthritis prevalence can change between 60% and 80% in former professional soccer players.³⁵⁻³⁷ Therefore, this study's higher rate of patellofemoral complaint can be explained as an early sign of knee osteoarthritis. Complaint caused by arthritis is probably high in our population because 35 out of 55 patients were more than 45 years old at the last follow-up control. The correlation between Bandi, IKDC, and age is well-represented in Figure 1. It shows that functional scores have a negative correlation with age. In addition, 7 patients had mosaicplasty in the patellofemoral joint, and 4 had poor Bandi scores. However, we got 15% of poor Bandi score outcomes if we ruled out these patients. Our study's disadvantage is that we did not objectify osteoarthritic changes with the Kellgren-Lawrence score, and we investigated only the implanted grafts with the MOCART score. Therefore, donor site morbidity should be contemplated carefully. Some outcomes of our study also need to be considered thoroughly. The investigated time interval includes the early phase of mosaicplasty. The patellofemoral region and lesion size over 4 cm² got out from mosaicplasty indication, and the usage of bigger graft sizes increased throughout the years. Therefore the number of arthrotomies is decreased.

Table 4

Patients division, return to sport and Tegner score distribution.

	All	Return to sport same level	Return to sport lower level	No sport
Observations	55	36	14	5
Return to sport (in years)	0.64 ± 0.25 (0.25-1) [†]	0.61 ± 0.25 (0.25-1)	0.71 ± 0.25 (0.5-1)	–
Sport level before				
Amateur	25	22	0	3
Certified	23	8	13	2
Professional	7	6	1	0
Tegner before	8.10 ± 1.18 (7-10)	7.63 ± 0.99 (7-10)	8.65 ± 0.92 (7-10)	7.80 ± 1.09 (7-9)
Tegner now	6.25 ± 2.49 (2- 10)	6.97 ± 2.31 (3-10)	5.64 ± 2.02 (2-7)	2.80 ± 1.78 (2-6)
Tegner Δ	1.85***	0.97**	3.01***	5.00***
	Pr (T > t) = 0.000	Pr (T>t) = 0.014	Pr (T>t) = 0.000	Pr (T>t) = 0.000
	t = 4.98	t = 2.22	t = 5.04	t = 5.33
	Logit model (1)		Linear probability model (3)	
IKDC	0.1085***	0.1099** (0.035)	0.0177* (0.002)	
Age		–0.0654*** (0.011)	–0.0067 (0.092)	
Gender (Male)		0.2737 (1.059)	–0.0206 (0.092)	
Constant	–6.1937** (1.7845)	–4.4916 (3.402)	–0.2973 (0.402)	
Clustered SE	Yes	Yes	Yes	
(Pseudo) R ²	0.35	0.37	0.42	
Observation	55	55	55	

Abbreviation: IKDC, International Knee Documentation Committee.

Standard errors in parentheses. (***) $P < .001$, (**) $P < .01$, (*) $P < .05$.[†] Those 5 people, who did not return to the sport were treated as missing data.

A total of 63% lesion were found in the CMF region, which correlates with Leonie et al.'s and Hanna et al.'s study. They investigated the at-risk regions for pre- osteoarthritis at the tibiofemoral joint with MRI. Both articles concluded that the medial cartilage regions, especially the medial posterior zones, are at risk.^{38,39} Considering Tegner score as a measure of return to sport, we found that 90% of our patients could continue soccer, and 65% of this at the same level as before surgery. Miethoefer et al. (2012) had the same result in a study including 1469 patients.⁴⁰ Our players' mean return to sport time was $7,78 \pm 2,96$ (4-12) months, which is slightly behind the mean values, as Krych et al. (2017) found in a meta-analysis that includes more than 2000 patients. Their mean return to sport time was $5,2 \pm 1,8$ months.⁴¹

All of the procedures were done on stable knees with normal axial anatomy. If pre- or intraoperative findings were different, a realignment procedure with high tibial osteotomy or LCA reconstruction was done parallel with the OAT; overall, 42% of our cases. This is similar to Noyes et al. study's finding, namely acute and chronic anterior cruciate ligament (ACL) injuries were 40% to 70% associated with articular cartilage injuries.⁴²

In conclusion, our study's findings show that OAT using the mosaicplasty technique allows players a shorter return to sport time and maintains the activity level with a good joint function. Furthermore, there is no significant decrease in functional scores compared to other studies even after 20 years from the surgery. Eighty-five percent of our professional players could continue their careers after the surgery and still have a good functional score. Therefore, mosaicplasty is a reasonable option for soccer players with small to medium-sized (1-3 cm²) osteochondral lesions in the knee with good long-term outcomes.

Consent statement

Complete informed consent was obtained from the patient for the publication of this study and accompanying images.

Institutional review board approval

Review board name: Regional Researchethical Review Board
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Declaration of competing interest

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Author Contributions

Miklós Keszég: Writing - original draft, data collection. László Hangody: Writing - review & editing. Zsófia Egyed: MRI scoring. Gergő Tóth: Data processing, Statistic. Gergely Pánics: Writing - review & editing, Supervision.

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