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Sports Activity After Reconstruction of Osteochondral Lesions of the Talus With Autologous Spongiosa Grafts and Autologous Matrix-Induced Chondrogenesis

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Background: For the treatment of osteochondral lesions of the talus (OCLTs), autologous matrix-induced chondrogenesis (AMIC) is a safe 1-step procedure with good clinical and radiological results. However, data regarding postoperative sports activity after AMIC are limited.

Purpose: To identify significant factors influencing the rate of postoperative sports and recreational activities.

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

Methods: The sports and recreational activities of 60 patients (mean age, 34.9 ± 11.5 years) undergoing the AMIC procedure were retrospectively analyzed at a mean of 46.9 ± 17.8 months (range, 24.5-87.0 months) postoperatively. The visual analog scale (VAS) for pain score, Tegner activity scale score, activity rating scale (ARS) score, and satisfaction with surgery outcomes were assessed.

Results: Corrective calcaneal osteotomy was performed in 38 of 60 (63.3%) patients. Ligament repair was performed in 41 of 60 (68.3%) patients. The mean VAS score improved significantly from 6.9 ± 1.6 points (range, 5-10 points) preoperatively to 2.3 ± 1.9 points (range, 0-6 points) at latest follow-up ($P < .001$). No significant change in the mean Tegner activity scale score (3.3 ± 2.0 preoperatively to 3.4 ± 2.2 postoperatively; $P = .526$) and the mean ARS score (2.6 ± 4.3 preoperatively to 2.3 ± 3.4 postoperatively; $P = .874$) was noted. The percentage of patients involved in sports activity before the onset of symptoms became significantly lower at the time of surgery (from 95.0% to 53.3%; $P < .001$); no significant difference was noted postoperatively (from 53.3% to 58.3%; $P = .663$). No significant difference of the weekly sports frequency and the duration of sports activity was found postoperatively.

Conclusion: Patients undergoing AMIC repair of an OCLT participate at a similar low postoperative sports and recreational activity level compared with the preoperative level.

Keywords: osteochondral lesion; talus; AMIC; sports activity

Posttraumatic osteochondral lesions of the talus (OCLTs) are common entities in young adults who are active in sports.[9,21] Most OCLTs require operative treatment because of failed nonoperative treatments consisting of anti-inflammatory medication, viscosupplementation, physical therapy, and orthotics.[5,11,23] The most common operative methods include debridement with/without microfracturing,[8] autologous osteochondral transplantation (AOT),[13] autologous chondrocyte implantation,[10] matrix-induced autologous chondrocyte transplantation (MACT),[1] or bulk osteochondral allograft transplantation.[25] Autologous matrix-induced chondrogenesis (AMIC) aided repair of OCLTs has been introduced more recently.[35] This 1-step procedure combines debridement of the OCLT, filling of the bone defect with autologous spongiosa, and sealing of the graft with a collagen matrix.[30] Previous studies have demonstrated that the AMIC procedure is a safe treatment method for OCLTs with overall good clinical[31] and magnetic resonance imaging results.[15,36]

Many patients with OCLTs desire to return to sports activity and participate at the same level before their original onset of symptoms. Although the frequency and intensity of sports activity after a cartilage repair procedure in the knee are well documented,[19] data capable of describing postoperative sports and recreational activities after the operative treatment of OCLTs are limited.[22,31] The objective of the present study was to evaluate the sports and recreational activities of patients who underwent AMIC repair for OCLTs.

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METHODS

Patients

Between October 2007 and March 2012, 80 consecutive patients received operative treatment for a symptomatic OCLT with the AMIC procedure.[30] Patients with a first-time OCLT diagnosis or failure of previous operative OCLT treatment were included. OCLTs of all sizes were included. Patients were not considered for surgery if they had an age of greater than 55 years, an unfused distal tibial physis, or involvement of the tibial side of the ankle (kissing lesion).

The follow-up examination was performed by the first author (M.W.) at the institution's outpatient clinic between April 2014 and January 2015. The clinical assessment was performed with the American Orthopaedic Foot & Ankle Society (AOFAS) ankle score.[14] All patients rated their pain on a visual analog scale (VAS) from 0 points (no pain) to 10 points (maximal pain).[6] Patients were asked to rate their satisfaction with the surgical outcome using the modified Coughlin scale (1 = very satisfied, 2 = satisfied, 3 = satisfied with reservation, 4 = not satisfied).[7]

The Tegner activity scale[28] (Table 1) and activity rating scale (ARS)[18] determined sports and activity levels before surgery and at the time of follow-up. The intensity of pain (VAS) and the use of pain medication during sports activity were also documented (regularly, occasionally, never).

Hindfoot alignment was assessed by measuring the moment arm of the calcaneus using a weightbearing hindfoot alignment view as described by Saltzman and el-Khoury.[27] Positive values were defined as valgus alignment.

This study was conducted in accordance with the Declaration of Helsinki and the Guidelines for Good Clinical Practice. The protocol was approved by the ethics committee of the University of Basel. All patients provided informed written consent before surgery and participation.

Operative Technique

All surgical procedures were performed by the senior author (V.V.). The defective cartilage and necrotic/fibrotic bone underneath were debrided and microdrilled. Autologous spongiosa bone was harvested from the iliac crest and was impacted into the talar bony defect.[4] A collagen I/III matrix (Chondro-Gide; Geistlich Pharma AG) was cut to match the size of the defect and fixed over the spongiosa bone graft with fibrin glue (Tissucol; Baxter). If the preoperative examination and radiographs showed malalignment of the hindfoot (defined as $\geq 10^\circ$ of hindfoot valgus and $>0^\circ$ of varus), corrective calcaneal osteotomy was performed: Dwyer osteotomy was selected in patients with a varus deformity, and lateral lengthening osteotomy of the calcaneus was selected in patients with a valgus deformity.[29] If ankle joint instability was noted during the clinical examination (positive anterior drawer and inversion test result) that was later confirmed by ankle arthroscopic surgery, the ligament was repaired using a modified Broström-Gould procedure.[12]

Postoperative Care

Postoperative rehabilitation was standardized for all patients. Postoperatively, the ankle joint was immobilized in a walking brace (Aircast Walker; DJO Global) for 8 weeks. Of those 8 weeks, partial weightbearing was allowed for 6 weeks, followed by 2 weeks of a gradual increase of weightbearing, until full weightbearing was achieved. The rehabilitation phase including strengthening of the ankle joint stabilizing lower leg muscles and proprioception training started at 6 weeks after surgery. After 12 weeks, light exercise (eg, swimming, cycling) was allowed. A return to competitive sports was allowed after 5 to 6 months. Postoperative care was identical for patients with additional procedures such as corrective osteotomy and/or ligament reconstruction.

Statistical Analysis

A Kolmogorov-Smirnov normality test was performed to determine if data were normally distributed. The Wilcoxon signed-rank test and Mann-Whitney rank-sum test were used for the comparison of paired and unpaired nonnormally distributed data. The McNemar test and Fisher exact test were used for the comparison of paired and unpaired binomial data. Analysis of variance and the chi-square test were used for the comparison of continuous variables and binomial data in more than 2 groups, respectively. A P value of $\leq .05$ was considered significant. Statistical analysis was performed using SPSS v20.0 software (SPSS Inc) and SigmaPlot 12.5 (Systat Software Inc).

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TABLE 1
Sports and Work Activities According to the Tegner Activity Scale[28]

Level	Activities
10	Competitive sports: soccer, football, rugby (national elite)
9	Competitive sports: soccer, football, rugby (lower divisions), ice hockey, wrestling, gymnastics, basketball
8	Competitive sports: racquetball or bandy, squash or badminton, track and field athletics (jumping, etc), downhill skiing
7	Competitive sports: tennis, running, motorcars speedway, handball Recreational sports: soccer, football, rugby, bandy, ice hockey, basketball, squash, racquetball, running
6	Recreational sports: tennis and badminton, handball, racquetball, downhill skiing, jogging at least 5 times per week
5	Work: heavy labor (construction, etc) Competitive sports: cycling, cross country skiing Recreational sports: jogging on uneven ground at least twice weekly
4	Work: moderately heavy labor (eg, truck driving, etc)
3	Work: light labor (nursing, etc)
2	Work: light labor Recreational sports: walking on uneven ground possible but impossible to backpack or hike
1	Work: sedentary (secretarial, etc)
0	Sick leave or disability pension because of knee problems

RESULTS

Demographics

A total of 60 patients were available for evaluation (24 female, 36 male; mean age, 34.9 ± 11.5 years; range, 15.4-57.9 years). The mean body mass index (BMI) was 27.6 ± 5.5 kg/m^2 (range, 19.0-45.2 kg/m^2). Twenty patients (of an initial 80 patients; 25.0%) were lost to follow-up because of relocation or a change of contact details. The mean postoperative follow-up was 46.9 ± 17.8 months (range, 24.5-87.0 months). Forty-six defects were located on the medial side (76.6%) and 14 on the lateral talar edge (23.3%). Twenty-one patients smoked at the time of surgery (35.0%). Medial malleolar osteotomy was performed in all but 2 cases of medial OCLTs (44/46; 95.6%). In 2 cases of lateral OCLTs, lateral malleolar osteotomy (2/14; 14.2%) was performed. Corrective calcaneal osteotomy was performed in 38 of 60 (63.3%) patients. Of those, lateral lengthening osteotomy was performed in 36 (94.7%) patients and Dwyer osteotomy in 2 (5.3%) patients. Ligament repair was performed in 41 of 60 (68.3%) patients. Of those, 8 underwent lateral (19.5%), 5 underwent medial (12.2%), and 28 underwent combined medial-lateral ligament repairs (68.3%).

Clinical and Radiographic Outcomes

Of all the patients, 65% were very satisfied or satisfied, 22% were partially satisfied, and 13% were not satisfied with the surgery outcome. Regarding the use of pain medication during sports and recreational activities, 86.7% of the patients did not require pain medication, 11.7% (n = 14; 2 tramadol, 10 ibuprofen, 2 mefenamic acid) required occasional pain medication, and 1.7% (1 tramadol) required regular pain medication. The mean preoperative VAS score decreased significantly ($P < .001$) from 6.9 ± 1.6 points (range, 5-10 points) to 2.3 ± 1.9 points (range, 0-6 points) at latest follow-up. The mean AOFAS score improved significantly from 43 ± 14 points preoperatively (range, 16-71 points) to 76 ± 17 points (range, 28-100 points) postoperatively ($P < .001$). All patients undergoing malleolar osteotomy showed osseous consolidation on postoperative radiographs at 3 months. The mean preoperative and postoperative moment arms of the calcaneus were 0.8 ± 7.7 mm (range, 12.6 to 18.9 mm) and 1.1 ± 4.9 (range, 9.3 to 7.4 mm), respectively ($P = .144$).

Before the onset of symptoms, 95.0% of the patients were involved in sports activity and participated, on average, in 2.8 different sports disciplines (Table 2). The percentage of patients involved in sports activity decreased significantly at the time of surgery (from 95.0% to 53.3%; mean number of sports disciplines, from 2.8 to 1.0; $P < .001$); no significant difference was noted postoperatively (from 53.3% to 58.3%, $P = .663$; mean number of sports disciplines, from 1.0 to 1.2, $P = .209$).

There was no significant difference in the mean postoperative weekly sports frequency and duration of sports activity compared with preoperative values at 1.6 ± 1.9 versus 1.1 ± 1.6 sessions per week ($P = .127$), respectively, and 2.1 ± 2.5 versus 1.8 ± 2.7 hours ($P = .396$), respectively.

The top 10 cited sports activities did not change for the preinjury, preoperative, and postoperative periods, but the ranking was altered (Table 3). There were no significant changes in the Tegner activity scale score and ARS score from the preoperative to postoperative state (Table 4). Specifically, the mean Tegner activity scale score was 3.3 ± 2.0 and 3.4 ± 2.2 points for the preoperative and postoperative periods ($P = .526$), respectively, and the mean ARS score was 2.6 ± 4.3 and 2.3 ± 3.4 points for the preoperative and postoperative states ($P = .874$), respectively.

The demographic and surgical data were comparable in both the sports-active and sports-inactive (no sports activity at all) patients (Table 5). Sports-inactive patients had a significantly higher pain level ($P = .001$) and a significantly lower functional score ($P = .009$) (Table 5). Regarding the influence of additional procedures accompanying cartilage repair, no significant differences in the pain level, functional score, and sports activity score were found (Table 6). Patients with medial OCLTs had a significantly lower AOFAS score compared with patients with lateral OCLTs

TABLE 2
Sports Activity Before and After Operative Treatment[a]

	Before Symptom Onset	Before Surgery	Postoperatively	*P* Value[b]
Sports activity, %	95.0	53.3	58.3	<.001/.663/<.001[c]
No. of sports disciplines	2.8 ± 1.6 (0 7)	1.0 ± 1.3 (0 5)	1.2 ± 1.4 (0 4)	<.001/.209/<.001[d]
Competition, %	40.0	8.3	5.0	<.001/.683/<.001[c]
No. of sports sessions per week		1.1 ± 1.6 (0 7)	1.6 ± 1.9 (0 7)	/.127[d]/
Duration of sports activity, h		1.8 ± 2.7 (0 12)	2.1 ± 2.5 (0 10)	/.396[d]/

[a]Values are shown as mean ± SD (range) unless otherwise specified.
[b]Before symptom onset versus before surgery/before surgery versus postoperatively/before symptom onset versus postoperatively.
[c]Using the McNemar test.
[d]Using the Wilcoxon signed rank test.

TABLE 3
Top 10 Sports Activities According to Patient Participation Before and After Operative Treatment

Sports Activity	Before Symptom Onset, %	Preoperatively, %	Postoperatively, %
Cycling	42	25	35
Soccer	38	8	8
Running	27	10	15
Swimming	20	8	17
Hiking	20	10	18
Skiing	20	5	8
Fitness	18	13	27
Tennis	15	5	2
Dancing	7	3	3
Gymnastics	7	3	2

at follow-up (P = .047) (Table 7). Patients with previous OCLT repair attempts had a significantly lower AOFAS score compared with patients with first-time surgery at follow-up (P = .019) (Table 8).

DISCUSSION

This study focused on measuring the sports and recreational activities of patients who underwent AMIC-aided reconstruction of OCLTs combined with autologous bone grafting. This was a severely affected cohort, with a large fraction of patients (26/60; 43.3%) undergoing revision surgery after a previously failed attempt of surgical OCLT treatment. Additionally, in the majority of the patients (50/60; 83.3%), osteochondral reconstruction had to be complemented by a stabilizing and/or realigning procedure to address pre-existing hindfoot instability and/or malalignment. A significant improvement regarding the AOFAS score and VAS for pain score was demonstrated, which is comparable with previously published data on AMIC-aided OCLT repair.[31,33-35] Regarding sports and recreational activities, no significant difference comparing preoperative and postoperative activity scores (ARS, Tegner) was noted. Also, no significant difference was found in regards to the weekly sports frequency and duration of sports activity.

Two previous studies briefly addressed sports activity after the treatment of OCLTs with AMIC repair.[16,31]

TABLE 4
Activity Scores[a]

	Preoperative	Postoperative	*P* Value
Tegner activity scale score, points	3.3 ± 2.0 (0 9)	3.4 ± 2.2 (0 9)	.526[b]
Activity rating scale score, points	2.6 ± 4.3 (0 16)	2.3 ± 3.4 (0 13)	.874[b]

[a]Values are shown as mean ± SD (range).
[b]Using the Wilcoxon signed rank test.

Valderrabano et al[31] treated 26 patients with AMIC repair for large cystic OCLTs (average follow-up time, 31 months). Similar to our study, a substantial proportion of those patients had undergone previous surgery (n = 14; 54%), and concomitant procedures (ligament repair, corrective calcaneal osteotomy) were performed in 17 of 26 (65%) of the patients. Nineteen patients (73%) participated in sports before the onset of symptoms compared with 3 (12%) at the time of surgery. The number increased to 16 patients (62%) at postoperative follow-up. This improvement was stronger than in our study; however, the patients were eventually likewise not able to achieve the same sports activity level as before the onset of symptoms.

Kubosch et al[16] followed 17 patients 39.5 months after the same procedure. Of those, 6 (35%) underwent revision. The activity level of the patients before surgery was not noted, but 12 patients (71%) participated in sports at the follow-up examination. This might also explain the higher satisfaction rate (76.5% of the patients satisfied or very satisfied). The reason for the superior results over those of our study may be the fact that these patients did not require additional surgical procedures in any case.

Other surgical treatment techniques for OCLTs have been evaluated regarding sports and recreational activities. Paul et al[22] assessed a cohort of 131 patients who underwent AOT at an average follow-up time of 60 months. We used similar outcome parameters; therefore, the results of this study are highly comparable with the results from our investigation. As in our study, the ARS score and Tegner score did not improve (5.9 preoperatively to 5.0 postoperatively and 8.9 preoperatively to 6.8 postoperatively, respectively). Likewise, no return to the same sports and

TABLE 5
Demographics, Surgical Details, and Postoperative Outcomes in Sports-Active and Sports-Inactive Patients[a]

	Sports Active Patients	Sports Inactive Patients	*P* Value
Patients/ankles, n	35/35	25/25	
Age, y	34.9 ± 11.5 (15.4 56.4)	34.7 ± 11.7 (17.7 57.9)	.810[b]
Sex, male:female, n	19:16	17:8	.411[c]
BMI, kg/m^2	26.8 ± 5.3 (19.4 42.4)	28.7 ± 5.8 (19.0 45.2)	.122[b]
Smoking, yes:no, n	12:23	9:16	.661[c]
Osteochondral lesion, medial:lateral, n	26:9	20:5	.760[c]
Malleolar osteotomy, medial:lateral, n	28:7	19:6	.758[c]
Ligament repair, yes:no, n	25:10	16:9	.630[c]
Calcaneal osteotomy, yes:no, n	19:16	19:6	.995[c]
Follow up, mo	48.8 ± 18.3 (24.9 87.0)	44.3 ± 17.2 (24.5 79.6)	.290[b]
VAS score, points	1.8 ± 1.7 (0 6)	3.1 ± 1.9 (0 6)	.009[b]
AOFAS score, points	81.5 ± 14.5 (36 100)	67.4 ± 17.4 (28 88)	.001[b]

[a]Values are shown as mean ± SD (range) unless otherwise specified. AOFAS, American Orthopaedic Foot & Ankle Society; BMI, body mass index; VAS, visual analog scale.
[b]Using the Mann Whitney rank sum test.
[c]Using the Fisher exact test.

TABLE 6
Demographics, Surgical Details, and Postoperative Outcomes in Patients With Concomitant Surgical Procedures[a]

	AMIC	AMIC + Calcaneal Osteotomy	AMIC + Ligament Repair	AMIC + Calcaneal Osteotomy + Ligament Repair	*P* Value
Patients/ankles, n	10/10	9/9	12/12	29/29	—
Age, y	38.7 ± 13.4 (17.9-56.0)	32.4 ± 8.9 (17.7-46.0)	31.5 ± 10.5 (15.4-48.9)	35.6 ± 12.0 (21.2-57.9)	.547[b]
Sex, male:female, n	8:2	7:2	6:6	15:14	.243[c]
BMI, kg/m^2	32.6 ± 6.6 (23.5-42.4)	28.2 ± 7.5 (19.0-45.2)	25.8 ± 5.1 (19.4-34.0)	26.5 ± 3.6 (19.4-33.9)	.062[b]
Smoking, yes:no, n	8:2	4:5	5:7	4:25	.002[c]
Osteochondral lesion, medial:lateral, n	8:2	8:1	6:6	24:5	.103[c]
Follow-up, mo	54.4 ± 23.6 (25.4-87.0)	52.5 ± 20.0 (24.8-79.6)	52.2 ± 19.6 (29.6-81.1)	40.5 ± 11.9 (24.5-70.7)	.211[b]
Preoperative VAS score, points	7.5 ± 1.4 (5-10)	6.8 ± 1.6 (5-10)	6.9 ± 1.5 (5-10)	6.7 ± 1.7 (5-10)	.462[b]
Postoperative VAS score, points	2.0 ± 2.0 (0-6)	2.3 ± 2.0 (0-6)	1.8 ± 1.9 (0-5)	2.6 ± 1.9 (0-6)	.580[b]
AOFAS score, points	74.4 ± 18.6 (31-90)	74.8 ± 16.5 (36-88)	83.3 ± 15.3 (54-100)	73.2 ± 17.5 (28-100)	.231[b]
Sports activity, yes:no, n	6:4	4:5	10:2	15:14	.228[c]
No. of sports sessions per week	0.9 ± 1.0 (0-2)	1.7 ± 2.7 (0-7)	1.1 ± 1.2 (0-4)	1.1 ± 1.2 (0-4)	.914[b]
Duration of sports activity, h	1.7 ± 2.1 (0-6)	2.6 ± 4.4 (0-12)	2.2 ± 3.6 (0-12)	1.5 ± 1.7 (0-6)	.957[b]
Preoperative Tegner score, points	3.6 ± 1.6 (1-7)	3.2 ± 2.7 (0-9)	3.3 ± 2.3 (1-9)	3.2 ± 1.9 (0-7)	.774[b]
Postoperative Tegner score, points	3.9 ± 1.7 (1-7)	2.4 ± 1.2 (1-5)	4.3 ± 2.5 (0-9)	3.1 ± 2.3 (0-9)	.135[b]
Preoperative ARS score, points	2.6 ± 4.2 (0-12)	2.3 ± 5.3 (0-16)	2.9 ± 4.9 (0-16)	2.5 ± 3.9 (0-15)	.898[b]
Postoperative ARS score, points	2.4 ± 3.9 (0-12)	0.9 ± 1.8 (0-4)	3.5 ± 4.1 (0-12)	2.2 ± 3.3 (0-13)	.407[b]

[a]Values are shown as mean ± SD (range) unless otherwise specified. AMIC, autologous matrix-induced chondrogenesis; AOFAS, American Orthopaedic Foot & Ankle Society; ARS, activity rating scale; BMI, body mass index; VAS, visual analog scale.
[b]Using analysis of variance.
[c]Using the chi-square test.

recreational activity level as before the onset of symptoms could be demonstrated at the time of follow-up: regarding sports activity, 96.9% of the patients were engaged in sports before the onset of symptoms compared with 83.8% the year before surgery and 89.3% at the time of survey. The weekly sports frequency and duration of sports activity did not significantly change postoperatively when compared with preoperatively, with 1.7 to 2.2 sessions per week and 4.2 to 5.1 hours (P = .052), respectively.

Although the study by Paul et al[22] and our study are methodically similar, the patient group in our investigation seems to have been more limited in their activities before surgery, which is demonstrated by the lower preoperative scores on the ARS and Tegner activity scale and a lower percentage in participation in sports. Analogous to our study, Paul et al[22] noticed that patients modify their postoperative sports activities and noted a reduction of participation in high-impact and contact sports. They concluded that a potential reason for this behavior may be that patients were concerned with overloading their ankle joint, thereby risking recurrent trauma. This could lead to the self-limiting of intense activities and the observed noted shift in sports. This also may explain why even though an improvement of overall functional outcomes (improved AOFAS score) and a general reduction of pain were achieved, a substantial fraction of our patients

TABLE 7
Demographics, Surgical Details, and Postoperative Outcomes in Patients With Medial Versus Lateral Osteochondral Lesions[a]

	Medial Osteochondral Lesions	Lateral Osteochondral Lesions	*P* Value
Patients/ankles	46/46	14/14	
Age, y	35.4 ± 11.5 (17.7 57.9)	33.1 ± 11.8 (15.4 56.0)	.558[b]
Sex, male:female, n	27:19	9:5	.765[c]
BMI, kg/m^2	28.3 ± 5.8 (19.0 45.2)	25.4 ± 4.1 (19.4 33.3)	.122[b]
Smoking, yes:no, n	13:33	8:6	.061[b]
Malleolar osteotomy, yes:no, n	44:2	2:12	<.001[b]
Ligament repair, yes:no, n	30:16	11:3	.515[b]
Calcaneal osteotomy, yes:no, n	32:14	6:8	.112[b]
Follow up, mo	47.5 ± 18.0 (24.5 87.0)	45.0 ± 17.8 (24.6 80.8)	.662[b]
Preoperative VAS score, points	6.9 ± 1.6 (5 10)	6.9 ± 1.5 (5 10)	.979[b]
Postoperative VAS score, points	2.5 ± 1.9 (0 6)	1.8 ± 1.9 (0 6)	.198[b]
AOFAS score, points	73.8 ± 15.9 (31 100)	81.7 ± 20.2 (28 100)	.047[b]
Sports activity, yes:no, n	26:20	9:5	.760[b]
No. of sports sessions per week	1.3 ± 1.7 (0 7)	0.8 ± 0.9 (0 2)	.673[b]
Duration of sports activity, h	2.0 ± 3.0 (0 12)	1.1 ± 1.4 (0 4)	.678[b]
Preoperative Tegner score, points	3.4 ± 2.1 (0 9)	2.9 ± 1.8 (0 6)	.552[b]
Postoperative Tegner score, points	3.3 ± 1.9 (0 9)	3.7 ± 2.3 (0 9)	.397[b]
Preoperative ARS score, points	2.6 ± 4.6 (0 16)	2.4 ± 3.1 (0 8)	.924[b]
Postoperative ARS score, points	2.5 ± 3.7 (0 13)	1.7 ± 2.5 (0 8)	.692[b]

[a]Values are shown as mean ± SD (range) unless otherwise specified. AOFAS, American Orthopaedic Foot & Ankle Society; ARS, activity rating scale; BMI, body mass index; VAS, visual analog scale.
[b]Using the Mann Whitney rank sum test.
[c]Using the Fisher exact test.

TABLE 8
Demographics, Surgical Details, and Postoperative Outcomes in Patients With Versus Without Previous Surgery[a]

	With Previous Surgery	Without Previous Surgery	*P* Value
Patients/ankles	26/26	34/34	
Age, y	36.6 ± 12.5 (15.4 57.5)	33.5 ± 10.8 (17.7 57.9)	.355[b]
Sex, male:female, n	15:11	21:13	.795[c]
BMI, kg/m^2	28.0 ± 4.9 (19.4 42.4)	27.3 ± 6.0 (19.0 45.2)	.395[b]
Smoking, yes:no, n	13:13	8:26	.055[c]
Osteochondral lesion, medial:lateral, n	23:3	23:11	.072[c]
Malleolar osteotomy, yes:no, n	25:1	21:13	.002[c]
Ligament repair, yes:no, n	16:10	25:9	.405[c]
Calcaneal osteotomy, yes:no, n	19:7	19:15	.190[c]
Follow up, mo	53.1 ± 17.6 (24.9 87.0)	42.2 ± 16.7 (24.5 81.8)	.009[b]
Preoperative VAS score, points	6.6 ± 1.4 (5 10)	7.1 ± 1.7 (5 10)	.283[b]
Postoperative VAS score, points	2.7 ± 2.1 (0 6)	2.1 ± 1.7 (0 6)	.339[b]
AOFAS score, points	69.9 ± 18.8 (28 98)	80.1 ± 14.5 (36 100)	.019[b]
Sports activity, yes:no, n	14:12	21:13	.603[c]
No. of sports sessions per week	1.2 ± 1.5 (0 5)	1.1 ± 1.7 (0 7)	.511[b]
Duration of sports activity, h	1.9 ± 2.3 (0 8)	1.8 ± 3.0 (0 12)	.465[b]
Preoperative Tegner score, points	3.2 ± 2.0 (0 7)	3.3 ± 2.1 (0 9)	.958[b]
Postoperative Tegner score, points	2.9 ± 2.4 (0 9)	3.8 ± 2.0 (0 9)	.080[b]
Preoperative ARS score, points	2.4 ± 4.4 (0 15)	2.7 ± 4.3 (0 16)	.653[b]
Postoperative ARS score, points	2.0 ± 3.8 (0 13)	2.6 ± 3.1 (0 12)	.151[b]

[a]Values are shown as mean ± SD (range) unless otherwise specified. AOFAS, American Orthopaedic Foot & Ankle Society; ARS, activity rating scale; BMI, body mass index; VAS, visual analog scale.
[b]Using the Mann Whitney rank sum test.
[c]Using the Fisher exact test.

were only partially satisfied (22%) or not satisfied (13%) with the outcome of the procedure. This might be especially true for high-demand or competitive athletes. When comparing the pain levels and functional scores after surgery, we found a significant difference for the sports-inactive population in comparison with the sports-active

patients (Table 5). While the influence of sports activity indirectly changes the AOFAS score (subcategory function; subitem activity limitations, support; maximum, 10 points[14]), it does not affect the total score as much as a decrease in pain (subcategory pain; maximum, 40 points). Therefore, the low AOFAS scores are more likely caused by high pain levels (significantly higher VAS scores).

Higher rates for return to sports after surgery have been reported for other techniques. Aurich et al[1] reviewed 18 patients undergoing MACT. The lesions in this cohort were less than 6 mm deep and did not require bone plasty, and no additional procedure had to be performed. In 11 patients (61%), bone stimulation had been performed before the MACT procedure. Sixteen (89%) were participating in sports before the onset of symptoms. Thirteen of 18 (72%) patients returned to the same sports level after surgery. In a case series published by Ferkel et al,[8] all 60 patients treated arthroscopically by bone marrow stimulation (debridement, microdrilling) indicated that they could return to their previous sport of choice. In this study, all revision surgical procedures were excluded. Fifteen (25%) patients had a significant associated injury requiring additional procedures of the ankle.

The reason for the inferior results in our study may lie in the characteristics of our study cohort with a high rate of revision cases and the need for additional procedures. One would expect the subgroup of patients undergoing AMIC repair as the sole surgical procedure to have scored higher on postoperative scores. Interestingly, we could not show a significant difference regarding functional outcomes, pain, and sports and recreational activities when comparing the group of patients without additional procedures (10 patients; 17%) with patients undergoing ligament repair and/or calcaneal osteotomy (50 patients; 83%) (Table 6). The patient group undergoing AMIC repair only had a higher mean BMI than the group undergoing AMIC repair with additional procedures. This factor, although statistically not significant, might have canceled out the potential positive benefit of not being negatively affected by malalignment or instability. Another reason might be that the number of patients in the group treated by AMIC repair only was not sufficient enough to show a statistically significant difference. It is also not possible to dissect out the effect on the outcomes of AMIC repair itself from the influence of the accompanying procedures. Although this issue introduces a bias for analysis, we think that it is important to address ankle joint instability or hindfoot malalignment. Data from biomechanical studies support the idea that lateral ankle instability leads to increased stress distribution in the medial half of the ankle joint.[2,20] A recent study by Lee et al[17] observed increased failure rates and inferior performance in sports and recreational activities in patients with lateral ankle instability, while average clinical outcomes were similar in both groups. Biomechanical experiments demonstrated that in varus and supination, the maximum pressure is located on the medial border of the talus, while in valgus and pronation, the maximum pressure is located on the lateral talar border.[3] If physiological biomechanical joint properties are not restored, increased pathological stress on the repair tissue may negatively influence healing of the defect and eventually lead to graft failure and the recurrence of pain.[31]

Patients undergoing revision surgery after previous surgical treatment attempts showed a significantly lower functional score than patients undergoing first-time surgery (Table 8). Pain levels and sports activity scores were not significantly different. Contrary to our findings, Valderrabano et al[31] did not find a significant difference for the postoperative AOFAS score when comparing patients with first-time surgery and revision surgery. One reason for this might be that our mean follow-up time was longer, and these differences do not become significant until the midterm follow-up.

The majority of our patients (77%) were treated for medial OCLTs. Medial OCLTs are more common than lateral OCLTs, with incidence rates of 58% to 63%.[26,32] It is also known that medial OCLT domes have a significantly larger surface area and are deeper than lateral lesions.[26] This might be the reason why patients undergoing surgery for medial OCLTs had a significantly lower functional score than patients with lateral OCLTs (Table 7). These findings are supported by a recent study by Polat et al.[24] In a cohort of 82 patients undergoing arthroscopic bone marrow stimulation, the subgroup analysis of the lesion location demonstrated that lateral lesions had significantly better functional results.

This study's main limitation is its retrospective nature. Patients were asked for clinical information and sports activity that, in most of the cases, dated back several years. In addition, the retrieval rate was 75% (60/80 patients), which might introduce a selection bias and lead to misinterpretation of the results. Also, we described a severely affected group, which might not represent the regular population. The particular collagen matrix used for this study is not currently approved by the United States Food and Drug Administration for use in North America.

CONCLUSION

Severely affected patients who undergo AMIC repair for reconstruction of OCLTs in combination with joint realigning and stabilizing procedures show a satisfying postoperative functional outcome and a reduction in postoperative pain at midterm follow-up. Patients' postoperative sports and recreational activity levels remain stable when compared with preoperative levels. However, patients are not able to return to the same sports activity level as before the onset of symptoms. Patients also modify their sports activity and participate more in low-impact sports.

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