



Return to Sport Activity After Meniscal Allograft Transplantation: At What Level and at What Cost? A Systematic Review and Meta-analysis

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Context: Meniscal injuries are common among both sport- and non-sport-related injuries, with over 1.7 million meniscal surgeries performed worldwide every year. As meniscal surgeries become more common, so does meniscal allograft transplantation (MAT). However, little is known about the outcomes of MAT in active patients who desire to go back to preinjury activities.

Objective: The purpose of this systematic review and meta-analysis was to evaluate return to sport, clinical outcome, and complications after MAT in sport-active patients.

Data Sources: A systematic search of MEDLINE, EMBASE, and CINAHL electronic databases was performed on February 25, 2018.

Study Selection: Studies of level 1 through 4 evidence looking at MAT in physically active patients with reported return to activity outcomes and at least 2-year follow-up were included.

Study Design: Systematic review and meta-analysis.

Level of Evidence: Level 4.

Data Extraction: Details of sport-related outcomes and reoperations were extracted and pooled in a meta-analysis.

Results: Nine studies were included in this systematic review. A majority (77%) of athletes and physically active patients were able to return to sport after MAT; two-thirds were able to perform at preinjury levels. Graft-related reoperations were reported in 13% of patients, while the joint replacement rate with partial or total knee prosthesis was 1.2%.

Conclusion: Physical activity after MAT appears possible, especially for low-impact sports. However, because of the limited number of studies, their low quality, and the short-term follow-up, the participation recommendation for high-impact and strenuous activities should be considered with caution until high-quality evidence of long-term safety becomes available.

Keywords: meniscal transplant; postmeniscectomy syndrome; meniscectomy; return to play; allograft; sport

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Menisci play an important role in overall knee health, with functions that include proprioception, load distribution, tibiofemoral congruity, and secondary stabilization of the knee.^{1,10,14,15,20,33} Unfortunately, meniscal injuries are common in both sport- and non-sport-related injuries.²⁹ The mean annual prevalence of meniscal injuries resulting in a meniscectomy has been estimated around 61 per 100,000 inhabitants.²⁵ A recently published analysis of 2004 through 2012 data from the American Board of Orthopaedic Surgery certification examination database showed an increased rate of surgeons performing meniscal repairs and a decreased rate of meniscal debridement. This appropriately reflects the growing concern to preserve meniscal tissue whenever possible.²⁴ Biomechanical models have indicated that peak tibiofemoral contact pressures increase significantly, some as much as 235%, after total meniscectomy.^{4,13} Recent in vivo testing confirmed increased tibiofemoral contact pressures after a meniscal injury,⁶ and there has been a strong clinical correlation between articular cartilage degradation and progression of arthritic changes within the knee compartment after meniscal debridement or total meniscectomy.^{11,16,26}

These data are particularly worrisome in the young and very active populations. It is estimated that sporting injuries account for 80% to 90% of meniscal tears in the pediatric and adolescent populations.²⁹ The results of meniscectomy in children and adolescents are guarded,^{10,18} and continued pain after subtotal or total meniscectomy in this active patient population leaves the medical provider with imperfect treatment options. Meniscal allograft transplantation (MAT) is a treatment option for patients with postmeniscectomy syndrome, but less is known about benefits in terms of return to sport and long-term health of the meniscal allograft in patients active in sport.^{2,23,27} In fact, controversy still exists⁸ on whether providers can recommend return to preinjury sport and activity levels after MAT.

Thus, the purpose of this systematic review was to evaluate return to sport, clinical outcome, and complications after MAT in sport-active patients. The hypothesis was that return to sport and preinjury level of activity was possible after MAT, with outcomes and complications similar to those of the general population.

METHODS

Study Design and Search Strategy

A systematic review and meta-analysis was performed following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.²¹ A systematic search of the MEDLINE, EMBASE, and CINAHL electronic databases was performed on February 25, 2018. The search terms were mapped to Medical Subject Headings (MeSH) terms where possible. Search terms were the following: “Menisci, Tibial”[MeSH] OR meniscus[tiab] OR meniscal[tiab] OR menisci[tiab]) AND (“Allografts”[MeSH] OR Allografts[tiab] OR allograft[tiab] OR transplant[tiab] OR transplants[tiab] OR “Transplantation”[MeSH] OR transplantation[tiab]) AND (“Sports”[MeSH] OR sport[tiab] OR

sports[tiab] OR “Athletes”[MeSH] OR athlete[tiab] OR athletes[tiab] OR “return to play”[tiab] OR “Return to Sport”[MeSH] OR “return to sport”[tiab]).

The following inclusion criteria were applied to the final yield: prospective or retrospective studies of level 1 to 4 evidence; outcomes of MAT independent of graft properties and surgical technique; mean follow-up of at least 2 years; patient populations of athletes, physically active patients, and patients willing to return to sport practice after MAT; rate of “return to sport” or “return to preinjury sport level”; and study reported in English. The following exclusion criteria were applied: studies not reporting original research, including review articles, expert opinion, or current concepts articles; posters or abstracts at annual meetings without subsequent peer-reviewed publication of an article; and incomplete data regarding sport practice and sport-related outcomes.

Article Selection and Data Extraction

To select the articles to be included in this review, 2 authors reviewed the titles and abstracts of each article identified in the literature search. When eligibility was unclear from the title and abstract, the full text of the article was obtained and evaluated for eligibility.

Regarding the population studied, the following information was obtained: number of patients treated with MAT, exclusion criteria, number of patients included in the study and number of patients evaluated at final follow-up, patient sex, mean patient age, mean follow-up, medial or lateral meniscus, and type of sport practice or physical activity. Regarding the surgical details, the following information was extracted: surgical technique, graft sizing, features and fixation, concomitant procedures, cartilage status, and rehabilitation. Regarding the outcomes, the following information was obtained: modality of evaluation (clinical, by phone, chart review), clinical scores reported in at least half of the included studies, return to sport or return to preinjury sport level, time to return to sport, and reoperations. The reoperations were evaluated in terms of total reoperation, graft-related reoperation, and partial/total joint replacement. Total reoperation was defined as the total number of reoperations sustained by the entire study population. Graft-related reoperations were defined as procedures performed to treat injuries or lesions or complications of the graft (such as meniscectomy, graft suture repair, graft removal, MAT revision, unicompartmental knee arthroplasty [UKA], or total knee arthroplasty [TKA]). Within the graft reoperations, the subgroup of partial/total joint replacement was defined as the total number of patients undergoing UKA or TKA after MAT.

Quality Assessment

The methodological quality was evaluated according to the Coleman Score modified by Magnussen et al.¹⁷ This is a quality score ranging from 0 (lowest quality) to 100 (highest quality) that evaluates patient populations, follow-up, study design, and measured outcomes. Two separate reviewers assessed study quality independently. In case of disagreement, a consensus was reached after discussion of the debated item.

Statistical Analysis

All data were tabulated on a Microsoft Excel spreadsheet. Statistical analysis was performed using OpenMeta (Analyst). Continuous data were extracted as mean and SD or range where possible. Categorical variables were extracted as total number and percentage over the total. The weighted mean and SD were calculated based on the size of the patient populations. In cases where SD was not reported, (range)/4 was used, or the value was replaced with the overall weighted mean of SDs. This was calculated only for patient age and follow-up because of the inconsistent reporting of the SD for the clinical scores.

A meta-analysis of proportions was conducted to determine the pooled rate of return to sport, return to preinjury level, total reoperations, graft-related reoperations, and total/partial knee replacement. To establish the variance of the raw proportions, a Freeman-Tukey transformation was applied. The transformed proportions were combined using the DerSimonian-Liard fixed- and random-effects models. I^2 was used to assess heterogeneity; a fixed-effects model was used in case of low heterogeneity with $I^2 < 50\%$, while a random-effects model was used in case of high heterogeneity with $I^2 > 50\%$. Statistical significance was considered with $P < 0.05$.

RESULTS

Search Results and Quality Appraisal

After duplicate removal, the titles and abstracts of 334 results were screened. A total of 17 articles regarding MAT in athletes or in physically active individuals were found. Eight articles were excluded because they did not meet the inclusion criteria. Therefore, the remaining 9 articles^{3,7,12,19,23,28,31,32,34} were included in the final systematic review and analysis (Figure 1).

Of the 9 included studies, only 3 were prospective studies^{19,23,28} while the remaining 6 were retrospective.^{3,7,12,31,32,34} No randomized controlled trials were present. The overall mean Coleman score was 56 ± 10 ; the mean scores of parts A and B were 33 ± 9 and 23 ± 3 , respectively (Table 1). Only 1 study³² had a sample size of greater than 100 patients. One study²⁸ reported sport-related outcomes of a subgroup of athletes within a broader population; therefore, information on demographic characteristics, outcomes, and complications of the athletic patients were limited because most of these data were combined with the entire cohort.

Patients and Surgical Characteristics

Overall, 467 athletes or physically active patients were included in the 9 studies,^{3,7,12,19,23,28,31,32,34} ranging from 3 to 230 in a single study. When reported, medial MAT was performed in 285 patients and lateral MAT in 167. The pooled mean age at surgery was 31.1 ± 6.2 years. Male sex was predominant in all but 2 studies.^{7,12} Overall, the pooled mean follow-up was 3.4 ± 1.2 years (Table 1). The 6 studies that described graft characteristics used fresh-frozen grafts. Six studies^{3,7,19,23,28,34} noted the graft was nonirradiated. Grafts were obtained from the authors' institution's own tissue bank or from a certified

bank (AlloSource or Cryolife). Sizing was performed with anthropometric data and radiographic measurement, while surgical technique was arthroscopic in 4 studies^{3,19,31,34} and mini-open in 4 studies.^{7,12,23,28} The remaining study³² was multicenter in nature; therefore, no homogeneous data were reported regarding graft and surgical technique. Three studies^{3,19,34} used bone-plug free grafts, 1 study³¹ used grafts with or without bone plugs, 4 studies^{7,12,23,28} used only grafts with bone plugs or bridge, and 1 did not report this information. Eight studies^{7,12,19,23,28,31,32,34} reported concomitant procedures, which were most commonly anterior cruciate ligament (ACL) reconstruction, high tibial osteotomy, or microfracture. Chondral damage at time of surgery, described in 5 studies,^{3,7,19,23,31} ranged from 57% to 100% of patients (see the Appendix, available in the online version of this article).

Clinical Outcomes

Patient evaluation was performed with clinical visits in 5 studies,^{7,19,23,28,31} by contacting the patients in 3 studies,^{3,12,34} and with chart review alone in 1 study.³² Subjective International Knee Documentation Committee (IKDC) score was reported in 5 studies,^{7,12,19,31,34} showing an improvement from a weighted mean of 50.9 preoperatively to 80.9 at final follow-up. The Tegner activity scale was reported in 5 studies^{7,12,19,31,34} and improved from a weighted mean of 2.8 preoperatively to 5.2 at final follow-up; however, it remained inferior to the preinjury weighted mean of 7.1 (Table 2).

Return to Sport

Six studies^{3,12,19,28,32,43} reported both "return to sport activity" and "return to preinjury" outcomes, 2 studies^{23,31} reported only "return to sport activity," and 1 study⁷ only "return to preinjury." Overall, 346 of 453 patients returned to any form of sport or physical activity after MAT, with a pooled rate of 77% (95% CI, 72%-83%; I^2 , 34.99%; $P = 0.15$). "Return to preinjury level" was reported in 7 studies.^{3,7,12,19,28,32,34} Overall, 264 of 379 returned to the same sport or physical activity level after MAT, with a pooled rate of 67% (95% CI, 53%-82%; I^2 , 82.43%; $P < 0.0001$) (Figure 2). The weighted mean time to return to sport, reported in 6 studies,^{3,7,12,19,28,34} was 9.2 months. At final follow-up, the sport/physical activity was reported inconsistently among studies; when the data were available, soccer, swimming, and running were the most recurrent activities (Table 2).

Reoperations

Overall, 72 reoperations were reported during the follow-up of the 448 patients, with a pooled rate of 23% (95% CI, 11%-34%; I^2 , 88.34%; $P < 0.0001$). Considering only the 54 graft-related reoperations, which were mostly graft meniscectomies, the pooled rate was 13% (95% CI, 6%-21%; I^2 , 85.69%; $P < 0.0001$), ranging from 0% to 51%. Within the graft-related reoperations, joint replacement with partial or total knee prosthesis was reported in 8 patients, with a pooled rate of 1.2% (95% CI, 0%-2%; I^2 , 0%; $P < 0.669$), ranging from 0% to 8% (Figure 3).

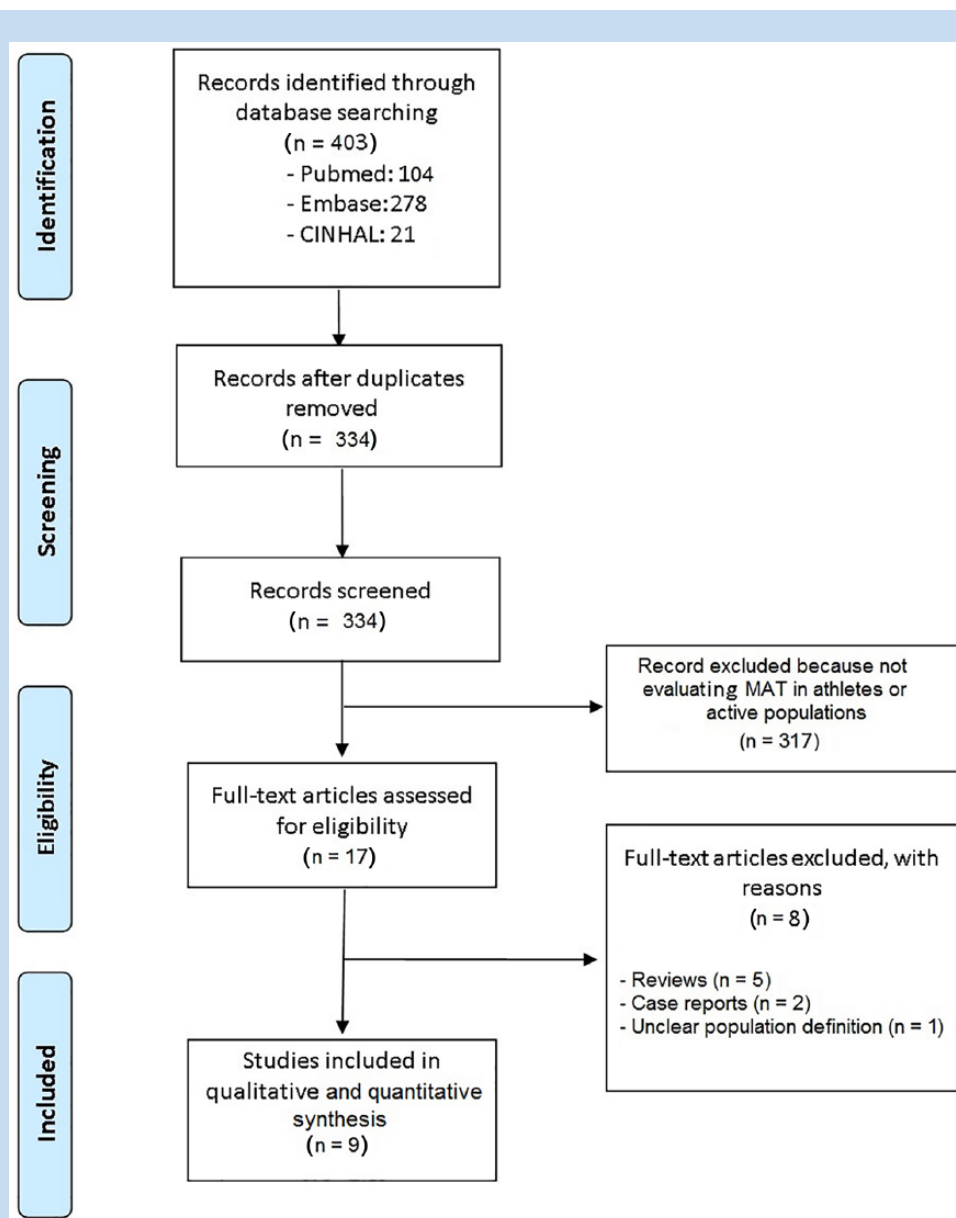


Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart for study inclusion.

DISCUSSION

The most important finding of the present systematic review, which included 9 studies^{3,7,12,19,23,28,31,32,34} and almost 500 athletes or physically active patients, was that 77% of patients were able to return to sport practice after MAT, and 67% achieved the same preinjury level. Moreover, 23% underwent a reoperation during the mean follow-up of 3.4 years, but only 13% were graft related and 1.2% involved knee replacements.

Sport activity after MAT represents a controversial topic even among knee experts. In 2016, the International Meniscus Reconstruction Expert Forum (IMREF), consisting of 21 international surgeons who are experts in MAT,⁹ crafted a

consensus statement on the practice of MAT, providing well-defined guidelines for indications, graft management, and surgical techniques. However, postoperative return to sport, which represents an important issue for many young patients requiring MAT due to postmeniscectomy syndrome, remains mostly unexplored due to the lack of high-level clinical data to evaluate the long-term results of MAT. The authors shared the IMREF opinion that, “thus far, MAT in athletes has been recommended with caution because of concerns for high failure rates and long recovery times.” Based on the results of this review, MAT in athletes and physically active patients appears to produce satisfactory outcomes from the clinical point of view after an average follow-up of 3.4 years.

Table 1. Demographic details of the included studies

Authors	Year	Design	Coleman	Patients Evaluated	Sex (Male/Female)	Age, y ^a	Follow-up, y ^a	Side (Medial/Lateral)	Population
Noyes et al ²³	2005	Prospective	66	38 (100%)	20/18	30 (14-49)	3.3 (2-5.8)	20/20 (2 bilateral)	Physically active patients
Alentorn-Geli et al ²	2010	Retrospective	42	15 (100%)	15/0	28.1 (21-45)	3 (2-4.8)	7/9	Competitive soccer players
Chalmers et al ⁷	2013	Retrospective	49	13 (93%)	4/9	19.3 (17-24)	3.3 (1.9-5.7)	10/3	High-level sports participants
Marcacci et al ¹⁹	2014	Prospective	67	12 (92%)	12/0	24.5 ± 3.6	3	6/6	Professional soccer players
Stone et al ³¹	2015	Retrospective	58	49 (100%)	36/13	45.3 (14.1-73.2)	8.6 ± 4.2 (1-15)	37/12	Physically active patients
Zaffagnini et al ³⁴	2016	Retrospective	56	89 (100%)	74/15	38.5 ± 11.2	4.26 ± 1.9	45/44	Physically active patients
Kocher et al ¹²	2016	Retrospective	56	3 (100%)	1/2	12.6 ± 2.5	2.6 ± 1.7	1/2	Sport participants
Waterman et al ³²	2016	Retrospective	41	230 (100%)	203/24	27.2 ± 5.5	2.14	159/71	Active duty military servicemembers
Saltzman et al ²⁸	2017	Prospective	66	18 (95%)	NA	NA	NA	NA	Self-identifying athletes

NA, not available.

^aAge and follow-up are presented as mean ± SD and (range), when available.

Table 2. Details of return to sport and reoperations of the included studies

Authors, Year	Sport		RTS	Return to Preinjury Level	Time to RTS, mo	Tegner			Total Reoperations	Graft-Related Reoperations	TKA/UKA
	Pre-operative	Follow-up				Pre-injury	Pre-operative	Follow-up			
Noyes et al, 2005 ²³	NA	Jumping, hard pivoting, cutting; 1 Running, twisting, turning; 4 Swimming, biking; 24	29/38 (76%)	NA	NA	NA	NA	NA	13: 1 graft reaction, 2 graft removal (tear), 3 graft suture, 2 graft meniscectomy, 1 TKA, 4 arthrolysis	9 (24%)	1 (3%)
Alentorn-Geli et al, 2010 ²	Soccer: 15	Soccer: 12	12/14 (85.7%)	12/14 (85.7%)	7.6	NA	NA	0		0 (0%)	0 (0%)
Chalmers et al, 2013 ⁷	Track and field: 2, Basketball: 5, Soccer: 2, Baseball: 2, Other: 2	NA	NA	10/13 (77%)	16.5	8 ± 2	NA	9	4: 1 graft revision, 1 graft meniscectomy, 1 graft suture, 1 plica excision	3 (23%)	0 (0%)
Marcacci et al, 2014 ¹⁹	Soccer: 12	Soccer: 11	11/12 (92%)	9/12 (75%)	7.3 (training), 10.3 (match)	10 (10-10)	8 (3-10)	10 (9-10)	4: 1 ACI, 1 loose body removal, 1 plica excision, 1 arthroscopic lavage	0 (0%)	0 (0%)
Stone et al, 2015 ³¹	NA	NA	36/49 (73.5%)	NA	NA	8	3	5	25: 16 meniscectomy/suture/revision, 5 graft removal, 3 UKA, 1 TKA	25 (51%)	4 (8%)
Zaffagnini et al, 2016 ³⁴	Soccer: 28, Tennis: 14, Skiing: 12, Running: 8, Indoor soccer: 8, Volleyball: 6, Other: 13	Soccer: 14, Tennis: 6, Skiing: 7, Running: 12, Swimming: 8, Bicycling: 7, Other: 12	66/89 (74%)	44/89 (49%)	8.6	6 (5-7)	2 (1-4)	4 (3-6)	12: 3 graft meniscectomy, 3 debridement, 1 peroneal nerve release, 1 UKA, 3 hardware removal, 1 patellar tendon repair	4 (5%)	1 (1%)

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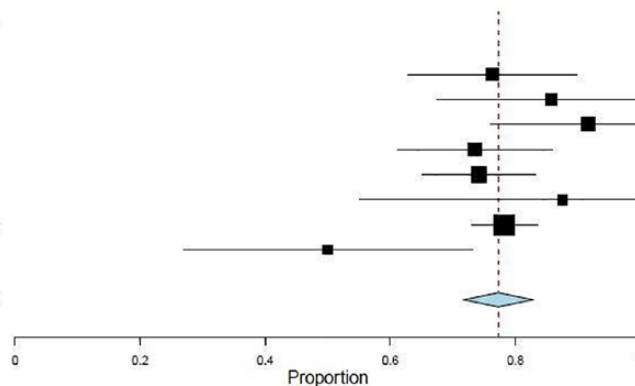
Table 2. (continued)

Authors, Year	Sport		Return to Preinjury Level	Time to RTS, mo	Tegner			Total Reoperations	Graft-Related Reoperations	TKA/UKA
	Pre-operative	Follow-up			Pre-injury	Pre-operative	Follow-up			
Kocher et al, 2016 ¹²	NA	Tegner 7 activities	2/3 (66%)	9	NA	NA	NA	7 (7-7)	0 (0%)	0 (0%)
Waterman et al, 2016 ³²	Active military service: 230	Active military service: 180	180/230 (78%)	NA	NA	NA	NA	13: 10 graft meniscectomy, 1 graft revision, 2 TKA	13 (6%)	2 (1%)
Saltzman et al, 2017 ²⁸	Soccer: 5, Football: 3, Tennis: 2, Hockey: 2, Softball: 2, Basketball: 1, Baseball: 1, Other: 3	Competitive: 5	7/18 (39%)	9.1	NA	NA	NA	NA	NA	NA

ACI, autologous chondrocyte implantation; NA, not available; RTS, return to sport; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty.

RETURN TO SPORT ACTIVITY

Proportion	Estimate (95% C.I.)	Ev/Trt
Noyes et al.	0.76 (0.63, 0.90)	29/38
Alentorn-Geli et al.	0.86 (0.67, 1.00)	12/14
Marcacci et al.	0.92 (0.76, 1.00)	11/12
Stone et al.	0.73 (0.61, 0.86)	36/49
Zaffagnini et al.	0.74 (0.65, 0.83)	66/89
Kocher et al.	0.88 (0.55, 1.00)	3/3
Waterman et al.	0.78 (0.73, 0.84)	180/230
Saltzman et al.	0.50 (0.27, 0.73)	9/18
Overall (I²=34.99 % , P=0.15)	0.77 (0.72, 0.83)	346/453



RETURN TO SAME LEVEL OF ACTIVITY

Studies	Estimate (95% C.I.)	Ev/Trt
Alentorn-Geli et al.	0.857 (0.674, 1.000)	12/14
Chalmers et al.	0.769 (0.540, 0.998)	10/13
Marcacci et al.	0.750 (0.505, 0.995)	9/12
Zaffagnini et al.	0.494 (0.391, 0.598)	44/89
Kocher et al.	0.667 (0.133, 1.000)	2/3
Waterman et al.	0.783 (0.729, 0.836)	180/230
Saltzman et al.	0.389 (0.164, 0.614)	7/18
Overall (I²=82.43 % , P< 0.001)	0.674 (0.530, 0.818)	264/379

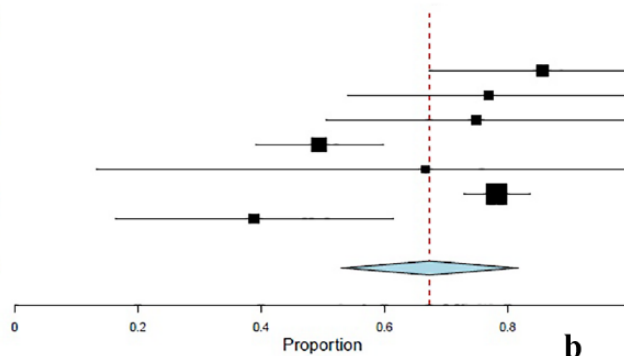


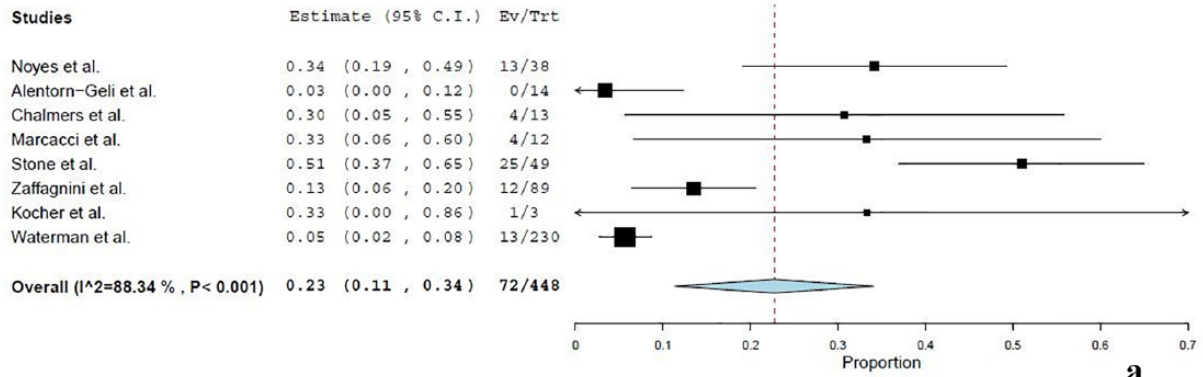
Figure 2. Proportion of patients (a) returning to sports after meniscal allograft transplantation and (b) returning to the same level of sport activity performed before meniscal injury.

Although at an overall lower level, return to sport was possible for both light and strenuous activities, including professional soccer, basketball, and baseball players.^{7,19,34} The overall subjective IKDC improvement was also satisfactory, similar to that reported in a systematic review including 35 studies and 1332 MAT procedures.³⁰ Regarding the Tegner score, only the 2 studies^{5,30} included in the present review that involved patients with a mean age at surgery of around 40 years presented similar levels of Tegner scores compared with the general population. Differently, the median values of younger athletes ranged from 7 to 10, which is superior to the value corresponding to light recreational activities (lower than 5 points) reported in the majority of general patients. Unfortunately, Tegner score was only evaluated in 5 of 9 studies^{7,12,19,31,34} and with a noticeably different sample size. To this point, Barber-Westin and Noyes⁵ recognized some limitations in the Tegner score itself. Specifically, Tegner scores are not always attributed according to frequency of sport participation or the intensity of sport according to the forces placed on the lower extremity. As an example, only national and international elite soccer players are listed as level 10, while

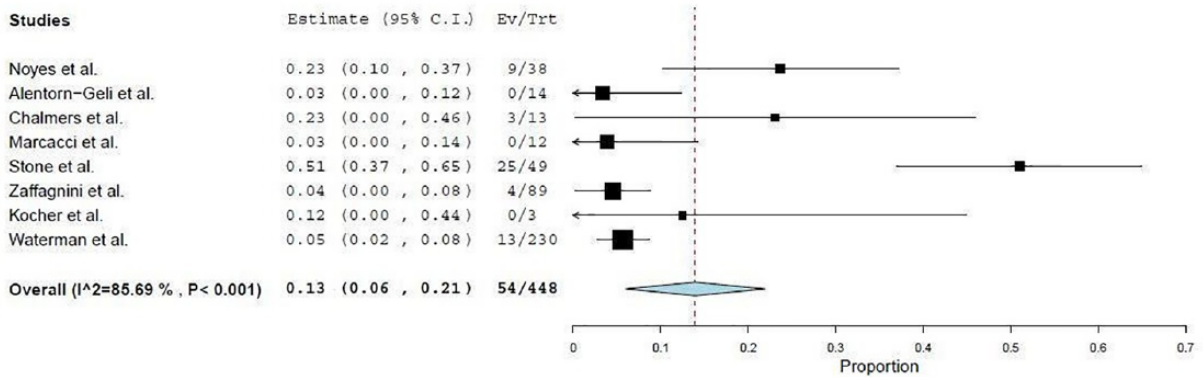
basketball players are listed as level 7. It could undoubtedly be argued that competitive collegiate or professional basketball players are asked to place similar demands on the knee joint and lower extremity as elite soccer players. This disparity is particularly relevant for the North American athletes represented in the populations described in this review. Moreover, Tegner score is usually reported as mean value, while the median value would be more appropriate, thus introducing a further source of misinterpretation.⁵ For these reasons, a more accurate assessment of a patient's sport activity could be provided by listing sports practiced and their level, especially in homogeneous and small case series of high-level athletes.

Marcacci et al¹⁹ and Alentorn-Geli et al³ reported the return to preinjury activity level at 75% and 85% of professional and competitive soccer players, respectively. A similar rate was reported by Chalmers et al⁷ for 17- to 24-year-old collegiate basketball, football, and baseball athletes. Kocher et al¹² described the results of 1 medial and 2 lateral MATs performed in 3 young athletes, younger than 14 years of age, who were able to perform demanding activities, rated as Tegner 7, 2 years

OVERALL REOPERATIONS



GRAFT-RELATED REOPERATIONS



TKA OR UKA

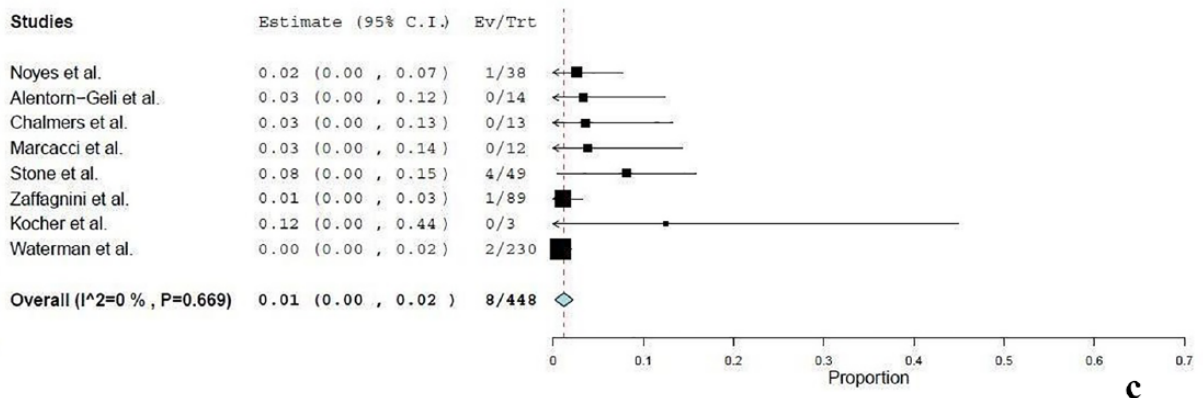


Figure 3. Proportion of patients (a) experiencing any type of reoperation, (b) a graft-related reoperation, or (c) a reoperation for total knee arthroplasty (TKA) or unicompartmental knee arthroplasty (UKA) during follow-up.

after surgery. Although not specifically referred to as athletes in their series, Waterman et al³² analyzed the outcomes of MAT performed in young military members. They reported a 78% return to active duty rate after surgery. This could be considered equivalent to sports activity because of the physical demands

required for military service. Noyes et al,²³ Stone et al,³¹ and Zaffagnini et al³⁴ studied slightly older populations with a mean age from 30 to 45 years, involving mostly light or recreational activities. They reported consistent rates of return to sport ranging from 73% to 76%. Saltzman et al²⁸ obtained the worst

results, with only 50% returning to sports; however, in their series, all athletes underwent concomitant primary or even revision ACL reconstruction, indicating more complex injuries.

Different techniques have been employed in the various series, including bone-plug or soft tissue fixation and open or arthroscopic techniques. However, overall consistent results did not allow the determination of technique superiority. Time to return to sport was also rather homogeneous, ranging from 7.3 to 9.1 months, mostly because of similar rehabilitation regimens, including protected weightbearing for 6 weeks, immediate (or 2-week delayed) joint mobilization, and return to contact activities 6 to 9 months postsurgery. Only Noyes et al²³ did not allow return to high-impact strenuous activities. However, they evaluated patients operated on between 1995 and 2000, when MAT was still considered an experimental and salvage procedure, thus justifying the caution in allowing a return to full activity. Finally, a longer time to return to sport of 16 months was reported by Chalmers et al.⁷ However, that study included athletes mostly younger than 20 years who underwent concurrent ACL reconstruction or osteochondral transplantation in nearly half of cases.

The main concern related to unrestricted sport activity after MAT is the possible increase in graft ruptures and failure rate in an already compromised joint. In this review, reoperation during follow-up was reported in 23% of cases, which could be considered consistent with the 16% to 32% rate of larger case series,^{27,35} keeping in mind the broad definition and indications for reoperations. When restricted to reoperations related to graft rupture or failure, such as meniscectomies, graft suture, graft removal, or knee replacement, the rate dropped to 13%. However, slightly lower failure rates of 8.7%, 9%, and 10.6% were reported in 3 different systematic reviews^{8,22,27} of more than 40 studies and 1000 MATs in the general population, with longer follow-up but similar failure criteria definitions. An analogous trend was reported when focusing on knee replacement, where a 1.2% rate was reported in the present review of active patients compared with 0.8% in the general population.²² It should also be noted that most of the failures and arthroplasty conversions were reported in series evaluating older patients with more advanced preexisting joint damage.^{31,34}

Based on these results, it can be argued that sport activity after MAT does not dramatically increase the risk of failure and joint replacement compared with the reported rates for the general population. However, because of small differences, the relatively short follow-up of this review, and the lack of numbers to perform a sound statistical analysis, caution should be maintained when allowing athletes to return to sports participation, especially those performing high-impact and strenuous activities. Although MAT is generally considered a salvage procedure and not strictly aimed at returning to physical activity, return to sport and good clinical outcomes were achieved in most patients reviewed. The good results achieved in terms of pain reduction and functional improvement might encourage young patients to resume preinjury sport activity despite medical advice to the contrary. Since Zaffagnini et al³⁵ reported a higher degree of satisfaction and higher Knee injury

and Osteoarthritis Outcome Score values in patients who were able to return to sport practice, participation in low-impact activities such as swimming and cycling should be encouraged to maintain knee and overall wellness. Arguably, it could be recommended that competitive, high-demand sports should be discouraged to preserve the graft as long as possible, unless high-quality evidence becomes available on long-term safety. In this light, the available evidence from retrospective and low-quality studies is encouraging. Clinicians should inform patients of the potential short- and long-term risks of strenuous sport activities and discuss appropriate precautions for those athletes who desire to return to sport due to strong personal or even economic reasons.

The present review has several limitations. First of all, the limited number of studies on highly selective patient populations did not allow for discrimination of high-quality studies, thus reducing the overall level of evidence of the findings. In addition, the limited number of patients did not allow comparison among different techniques and rehabilitation regimens. Finally, the limited follow-up prevents any validation of these encouraging results, thus calling clinicians and investigators to the production of high-quality studies evaluating the long-term effect of sport activity on MAT survival.

CONCLUSION

Seventy-seven percent of athletes and physically active patients were able to return to sport after MAT, and two-thirds were able to participate in sports at the same preinjury level. Graft-related reoperations were reported in 13% of patients while the rate of joint replacement, with partial or total knee prosthesis, was 1.2%. Because of these encouraging results, physical activity after MAT appears possible, especially involving low-impact sports. However, because of the possibility of reoperations, high-impact and strenuous activities should be considered and discussed with caution only in select patients until high-quality evidence of long-term safety becomes available.

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