



High short-term return to sports rate despite an ongoing healing process after acute meniscus repair in young athletes

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Abstract

Purpose Acute meniscus repair in young athletes is always a challenge due to the long rehabilitation process and time to return to sport (RTS). The purpose was to investigate signal alterations in short-term follow-up after acute meniscus repair on specific magnetic resonance imaging (MRI) scan sequences. It was hypothesized that (1) MRI signal changes over the first postoperative healing phase and represent a continuous healing process and (2) meniscus healing properties correlates with clinical outcomes and RTS.

Methods Young athletes with traumatic meniscus lesion and arthroscopic meniscus repair within 6 weeks and available preoperative MRI were enrolled. Clinical examination, outcome scores (IKDC, KOOS, Lysholm Score, Tegner activity score) and RTS were surveyed preoperatively and 6 and 12 weeks and 6 months after surgery. Radiological follow-up examinations were performed 2, 4, 6, 12 weeks and 6 months after operation using a 3T-MRI. Evaluation was based on ISAKOS meniscus classification system, meniscus healing were classified according to Henning's criteria.

Results At final follow-up (FU) 30 patients (28 month, 2 week) with a total of 35 meniscus tears (19 medial, 16 lateral) were included. Clinical scores improved significantly after surgery: IKDC Score (preOP: 39.4 ± 18.5 , final FU: 78.8 ± 15.3) KOOS (preOP: 45.7 ± 22.1 , final FU: 82.7 ± 12.5) and Lysholm Score (preOP: 42.8 ± 23.7 , final FU: 84.4 ± 13.8) ($p < 0.01$). Tegner activity score showed a steadily increase to 4 (range 3–9) at 6 months but did not reached the pre-injury level of 6 (range 3–9). RTS rate was 100% whereof 44.8% reached their pre-injury level. MRI examination revealed a continuous healing process and menisci were classified as 55.9% healed, 35.3% partially healed and 8.8% non-healed at final FU.

Conclusion This study showed that MRI signal alterations of the meniscus steadily occur within the first 6 months postoperatively. MRI reveals an ongoing healing process at final FU that have to be carefully considered when RTS is discussed with high demanding patients. However, young athletes provide good clinical results and RTS rate even though MRI alterations are still present.

Level of evidence Therapeutic study, prospective case series, Level IV.

Keywords Meniscus repair · Magnetic resonance imaging · Meniscus healing · Short-term · Clinical outcome · Prospective, return to sports, athletes

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Introduction

Meniscus tears are the most common knee injury and result either from traumatic knee injury or on the basis of degenerative changes [13, 33]. First-line treatment is mostly depending on meniscus tear location, configuration and patient's demands. Partial meniscus resection leads to fast recovery and pain relief but also to the deterioration of meniscus function and subsequently to joint degeneration [14, 15, 18]. Therefore, treatment algorithm has changed over the last years and meniscus repair is increasingly performed also in highly active patients to preserve meniscus tissue [31]. Biomechanical studies showed that meniscus tears as well as resection lead to an increase of peak pressure and knee laxity, whereas meniscus repair could restore biomechanical function [5, 9, 24, 25]. However, the low vascularization limits the healing potential of the meniscus especially within the central meniscus segment [2, 3]. Despite better surgical techniques non-healing remains still a major issue in meniscus surgery. Previous studies reported of a non-healing rate between 10–30% in short- to mid-term follow up [10, 16, 19, 23, 28, 30]. Rates of secondary partial meniscus resection have ranged up to 25% [26]. Accordingly, rehabilitation program following meniscus repair is very cautious to enhance meniscus healing [11, 27]. Full weight bearing is usually restricted for the first postoperative phase and return to sport (RTS) is earliest recommended between 12 and 24 weeks [7, 11]. In contrast to the limited healing capacity and careful rehabilitation program, athletes expect a rapid recovery and return to their previous sports level. However, current literature revealed a long convalescence of 5–6 months until return-to-sports could be achieved [7, 22, 35].

The current gold standard to control results of meniscus repair is clinical symptoms, such as swelling, effusion, joint tenderness and meniscus test. Beside clinical scores, objective outcome measurements are rare. Therefore, the purpose was to prospectively investigate signal alterations in short-term follow-up after acute meniscus repair on specific magnetic resonance imaging (MRI) scan sequences and correlate it with clinical outcomes and RTS. It was hypothesized that (1) MRI signal changes over the first postoperative healing phase and represent a continuous healing process and (2) meniscus healing properties correlates with clinical outcomes and RTS. This study is the first that describe continuous MRI signal changes over the first healing period and provide information to help clinicians interpreting early postoperative MRI examinations after meniscus repair.

Materials and methods

This prospective study was conducted to clinically and radiologically investigate the healing properties of the meniscus within the first 6 months postoperatively and to correlate these findings with RTS in recreational sportsmen. It was approved by the Institutional Review Board (No.: 518/15S) and conducted according to the Declaration of Helsinki. All patients gave their written informed consent. The study was registered in the German Clinical Trials Register (DRKS): drks: 00009866.

Patients with acute traumatic meniscus tears between 18 and 45 years of age and subsequent arthroscopic meniscal repair within 6 weeks after trauma were included. All meniscus tears were located in the red or red/white zone and, therefore, considered repairable. Patients with concomitant rupture of the anterior cruciate ligament (ACL) were also included. Exclusion criteria contained degenerative meniscus lesions without history of trauma and meniscus root tears. Patients with previous knee surgery, chondral lesions, osteoarthritis > grade III according to Kellgren/Lawrence and multi ligament injuries were also excluded.

Clinical assessment

All patients underwent clinical assessment preoperatively, 6, 12, 26 weeks after surgery. This included the documentation of range of motion (ROM) using a goniometer and manual meniscus and knee stability testing. The International Knee Documentation Society Score (IKDC), The Knee Injury and Osteoarthritis Score (KOOS) and Lysholm Score were obtained to quantify subjective and objective knee function. Sports participation was measured via the Tegner activity score. Pain was assessed by visual analog scale (VAS). Clinical outcome was determined using Barrett's criteria including the absence of (1) swelling, (2) clicking or blocking, (3) tenderness of joint line and (4) a negative McMurray test [4].

Radiological assessment

All patients underwent standardized radiographs (a.-p. and lateral view) and MRI examination preoperatively. All knee were graded after Kellgren/Lawrence osteoarthritis classification and meniscal tears were described according to the ISAKOS meniscus classification system [21, 36].

Postoperative MRI examinations were performed after 2, 4, 6, 12 and 26 weeks using a 3 T whole-body MRI scanner and a dedicated 8-channel knee coil (Ingenia, Philips, Best, The Netherlands). The following pulse sequences were acquired with a section thickness of 3 mm: coronal and sagittal T1- and intermediate weighted

turbo spin echo (TSE) with DRIVE pulse sequences and coronal and sagittal T2-weighted and fat-suppressed intermediate weighted TSE sequences. Meniscus healing was classified according to Henning's criteria in (1) healing, (2) partial healing and (3) non-healing [32]. The meniscus was classified not healed if fluid-equivalent signal was present in the tear zone in more than 50% of tear size. Two experienced orthopedic knee surgeons rated MRI images and consensus was obtained in case of primary disagreement.

Surgical technique

All patients underwent arthroscopic meniscus repair by experienced orthopaedic knee surgeons. A tourniquet was used at 280 mmHg and Cefuroxim 1.5 was administered as perioperative prophylaxis. After standardized diagnostic round the torn meniscus was repaired using either all-inside (AI) (Fast-Fix, Smith & Nephew, Andover, MA, USA) or sutures in inside-out (IO) technique depending on tear location. Sutures were placed every 5 mm to provide reliable repair strength. Non-absorbable Fiberwire sutures (Arthrex Inc, Naples, Florida, USA) were used for inside-out technique. Parasyovial rasping and microfracturing of the intracondylar region were performed to enhance healing. In case of concomitant ACL rupture a reconstruction with ipsilateral semitendinosus tendon was performed. The graft was femoral fixed with the Tight-Rope system (Arthrex Inc, Naples, Florida, USA) and tibial with an interference screw.

For postoperative management, all patients had their operated leg secured in a brace for 6 weeks. ROM was restricted to either 90° or 60° of flexion after medial meniscus and lateral meniscus repair, respectively. In the case of medial meniscus repair, weight bearing was only allowed in full extension, after lateral meniscus repair weight bearing was prohibited for 6 weeks. Physiotherapists treated patients 2–3 times a week.

Statistical analysis

Data were analyzed using SPSS statistics software version 23.0 (IBM, New York, USA). Results are given in mean \pm standard deviation (SD) with a measurement accuracy of one decimal. Paired *t* test was used to explore differences between pre- and postoperative scores. ANOVA and Fisher's exact test was used to analyze for any association between meniscus integrity and demographic variables and surgical technique. To find a correlation between meniscus integrity and clinical outcome scores Spearman correlation test were used. ICC was calculated for inter-rater reliability. Statistical significance was set at a *p* value of <0.05 . A preliminary sample size calculation resulted in a total number of 26 patients to detect the minimal clinically important difference (MCID) of the IKDC score of 11.5 ± 10.0 points between patients with healed and non-healed meniscus with a statistical power of 80% and a critical *p* value of 0.05 [20].

Results

30 of 32 patients (93.8%) preoperatively included patients with 35 meniscus lesions were examined throughout the study. Two patients quit participation after the first MRI investigation and were, therefore, completely excluded. One patient refused to participate at 6 months visit leaving 29 patients for the final assessment. 28 men and 2 women with an average age of 28.0 ± 7.7 years and a BMI of 24.8 ± 3.0 kg/m² were surveyed. The period between trauma and surgery was 17.8 ± 15.9 days.

Clinical outcome

The clinical healing rate according to Barrett criteria was 44.8% after 3 months and 64.3% after 6 months. Clinical and radiological healing was significantly correlated after 3 months ($p=0.027$) but not after 6 months (n.s.). All clinical outcome score improved significantly at all postoperative follow-up assessments (Table 1). KOOS subgroups

Table 1 Clinical outcomes measures

	Pre-operative	6 weeks	12 weeks	26 weeks	<i>p</i> value
IKDC	39.4 \pm 18.5	47.5 \pm 12.6 [#]	66.1 \pm 11.1 [*]	78.8 \pm 15.3 [*]	[#] $p < 0.05$ [*] $p < 0.01$
KOOS	45.7 \pm 22.1	59.3 \pm 15.8 [*]	75.2 \pm 12.1 [*]	82.7 \pm 12.5 [*]	[*] $p < 0.01$
Lysholm score	42.8 \pm 23.7	59.8 \pm 22.2 [*]	78.4 \pm 15.4 [*]	84.4 \pm 13.8 [*]	[*] $p < 0.01$
VAS	4.2 \pm 2.4	1.6 \pm 2.1 [*]	1.4 \pm 1.8 [*]	0.8 \pm 1.0 [*]	[*] $p < 0.01$

All clinical outcome scores improved significantly compared to the previous examination ([#] $p < 0.05$, ^{*} $p < 0.01$)

IKDC The International Knee Documentation Society Score, KOOS The Knee Injury and Osteoarthritis Score, VAS visual analog scale

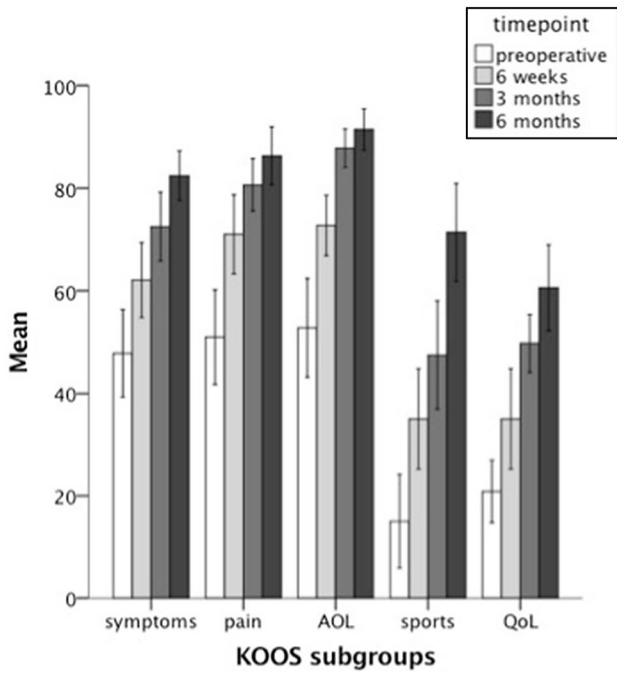


Fig. 1 Bar chart of KOOS subscores. All KOOS subscores improved significantly at each time point in comparison to previous state ($p < 0.01$). AOL activity of daily life, QOL quality of life, KOOS knee outcome and osteoarthritis score

improved significantly at 6, 12 and 26 weeks postoperatively (Fig. 1). Sports and quality of life subgroups show minor scores due to restrictive rehabilitation program.

Regarding return to sports, preoperative Tegner activity score showed a continuous increase from 2 (range, 0–5) after 6 weeks, to 4 (range, 2–6) after 3 months and to 4 (range, 3–9) at final follow-up but did not reached the pre-injury level of 6 (range, 3–9). RTS rate was 100% whereof 44.8% reached their pre-injury level. Patients with isolated meniscus repair showed a significant higher RTS rate than with concomitant ACL reconstruction (Table 2, $p < 0.01$).

Radiological outcome

Meniscus lesions have been preoperatively classified according to ISAKOS MRI classification (Table 3).

Table 2 Return to sports rate according to ACL state

	ACL intact	ACL reconstruction	Total
RTS	11 (78.6%)	3 (18.8%)	14 (46.6%)
No RTS	3 (22.4%)	13 (81.2%)	16 (53.4%)
Total	14 (46.6%)	16 (53.4%)	30

RTS after 6 months is highly depending on concomitant anterior cruciate ligament (ACL) reconstruction ($p < 0.01$)

Table 3 Meniscus lesions according to ISAKOS meniscus classification [36]

	Number (%)
Meniscus	
Medial	19 (54.3%)
Lateral	16 (45.7%)
Side	
Right	10 (33.3%)
Left	20 (66.6%)
Rim zone	
Zone 1—red	26 (74.3%)
Zone 2—red/white	9 (25.7%)
Zone 3—white	0
Location	
Anterior horn	0
Pars intermedia	15 (42.9%)
Posterior horn	20 (57.1%)
Type	
Bucket-handle	14 (40.0%)
Longitudinal	9 (25.7%)
Radial	5 (14.3%)
Flap	3 (8.6%)
Horizontal	4 (11.4%)
ACL	
Reconstruction	16 (53.3%)
Intact	14 (46.7%)
Total	35

The postoperative results of the MRI examination revealed a continuous healing process until 6 months (Fig. 2). A steady signal alteration was observed in the early healing phase in all menisci (Table 4). 19 (55.9%) were classified as completely healed, 12 (35.3%) partially healed and 3 (8.8%) of the menisci were deemed not healed at final follow-up. The ICC was 0.93 (95% CI, 0.86–0.96) for inter-rater reliability.

Patients- and meniscus-specific risk factors did not influence the healing at final follow-up (Table 5). There was no correlation between the return to pre-injury sports level and clinical healing and MRI (Table 6; n.s.).

Discussion

The most important finding of this study was that meniscus repair leads to a high rate of RTS within 6 months despite an ongoing healing process of the meniscus at this time point. 55.9% showed complete healing after 6 months while MRI findings indicate a continuing healing process. Clinical symptoms as swelling and joint line tenderness correlated

Fig. 2 MRI examination of meniscus healing. MRI examination of a patient with a longitudinal tear of the medial meniscus **a** 2 weeks, **b** 4 weeks, **c** 6 weeks and **d** 12 weeks post-operatively. It shows continuous signal alterations towards healing

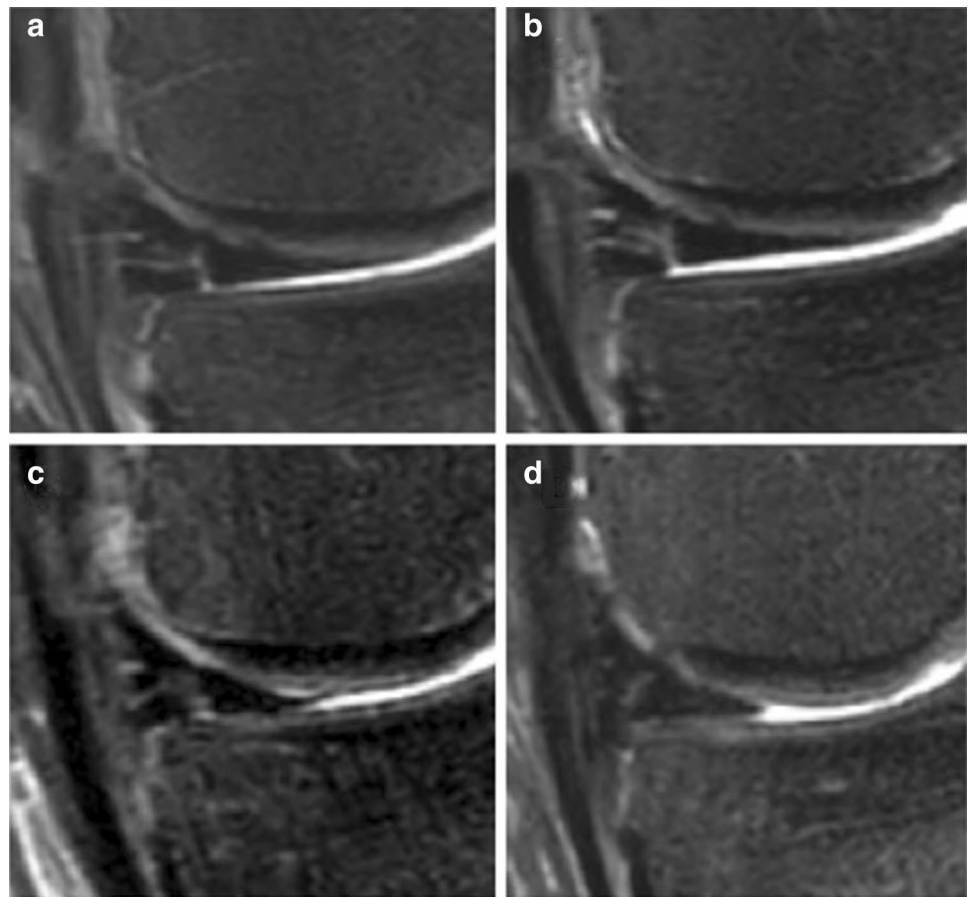


Table 4 Results of meniscus healing according Henning criteria [32]

Henning criteria	2 weeks (%)	4 weeks (%)	6 weeks (%)	3 months (%)	6 months (%)
Healing	34.3	44.1	48.5	51.5	55.9
Partial healing	31.4	29.4	33.3	36.4	35.3
Non-healing	34.3	26.5	18.2	12.1	8.8

MRI examination reveals a continuous healing process within the first postoperative healing phase

with prolonged healing after 3 months and could, therefore, be a reference for RTS decision.

The limited healing potential of the meniscus and the high failure rate after repair are still a major concern when performing meniscus surgery in young and high demanding patients. Partial meniscectomy is often performed in elite athletes to ensure fast recovery and return to play since meniscus repair requires a long convalescence. Nevertheless, detrimental effects of partial meniscectomy are frequently seen in sportsmen because their knees are exposed to high load during activity [6, 8]. As a consequence, meniscus repair gained popularity in the treatment of athletes and recent studies have reported on clinical outcomes in young sportive patients [1, 22, 29, 34, 35].

Overall, meniscal repair leads to satisfactory results in sportsmen and can achieve return to pre-injury sports level in

up to 89% of patients [12, 34]. The period between surgery and RTS varies between 4.3 and 6.5 months [17, 35]. Long-term results in professional athletes showed an excellent rate of RTS after recovery from surgery that, however, declined over time [1, 22]. Logan et al. [22] reported a period to RTS of 5.6 months whereas return to pre-injury level was over 10 months. Secondary partial meniscectomy was necessary in up to 26% in this population after 42 months follow up [22]. In comparison, the present results could achieve a RTS of 100% whereof only 44.8% reached their pre-injury level after 6 months. Even though 44.1% of the repairs showed still not complete healing RTS was possible in these patients without clinical symptoms. In accordance to other studies we could show that concomitant ACL reconstruction prolonged the return to sports in our population due to the more restrictive rehabilitation program [22, 34].

Table 5 Patients- and surgery-related factors concerning meniscal-healing status

Factors	Healing	Partial healing	Non-healing	Total	<i>p</i> value
Age (years)	28.7 ± 8.2	27.8 ± 8.0	28.0 ± 4.6	27.9 ± 7.7	n.s.
BMI (kg/m ²)	24.4 ± 3.0	25.4 ± 3.3	24.2 ± 2.4	24.8 ± 3.0	n.s.
Period					
Trauma/surgery (days)	20.1 ± 15.6	13.5 ± 8.3	31.0 ± 41.0	17.8 ± 15.3	n.s.
Number of sutures	2.8 ± 1.3	3.5 ± 1.9	4.0 ± 2.6	3.2 ± 1.7	n.s.
Tear length	17.0 ± 10.3	19.3 ± 10.0	25.0 ± 18.0	18.0 ± 10.9	n.s.
Meniscus (<i>n</i>)					
Medial	9 (50.0%)	7 (38.9%)	2 (11.1%)	18	n.s.
Lateral	10 (62.5%)	5 (31.3%)	1 (6.2%)	16	
Anatomic location (<i>n</i>)					
Posterior horn	13 (65.0%)	6 (30.0%)	1 (5.0%)	20	n.s.
Pars intermedia	6 (42.9%)	6 (42.9%)	2 (14.2%)	14	
Rim zone (<i>n</i>)					
Red	13 (52.0%)	9 (36.0%)	3 (12.0%)	25	n.s.
Red/white	6 (66.7%)	3 (33.3%)	0	9	
Tear pattern (<i>n</i>)					
Bucket handle	6 (46.2%)	5 (38.5%)	2 (15.3%)	13	n.s.
Longitudinal	5 (55.6%)	3 (33.3%)	1 (11.1%)	9	
Radial	3 (60.0%)	2 (40.0%)	0	5	
Flap	3 (100%)	0	0	3	
Horizontal	2 (50.0%)	2 (50.0%)	0	4	
ACL (<i>n</i>)					
Intact	5 (38.5%)	6 (46.2%)	2 (15.3%)	13	n.s.
Reconstruction	14 (66.7%)	6 (28.6%)	1 (4.7%)	21	

Table 6 Comparison of clinical and radiological healing rates with return to sports (RTS)

	3 months (%)	6 months (%)
Clinical healing (Barrett criteria)	44.8	64.3
MRI	51.5	55.9
RTS	50.0	100
RTS pre-injury level	0	44.8

Despite a lower healing rate in clinical and MRI examination a 100% RTS rate could be achieved after 6 months whereof 44.8% could return to the pre-injury level

After screening the literature, a distinct recommendation regarding the time after allowing patients to return to training has not been defined yet. Currently, this decision is based on clinical findings. Therefore, MRI healing rate in the first postoperative healing phase might provide useful information to choose the correct moment. In short-term MRI follow up, Pujol et al. showed in their cohort 58% of complete, 24% of partial and 18% of non-healing after 6 months follow-up [30]. These outcomes are similar to our results 6 months postoperatively and show a high rate of partial and non-healed menisci. The present study showed that this might be a result of a continuous healing process with even lower

number of healed menisci at the beginning follow-up examinations but improvement over time.

Consequently, the provided MRI findings support a restrictive rehabilitation program after meniscus repair with a large number of partial- and non-healing menisci even after 6 months. Furthermore, they support other articles that promote a slow increment in weight bearing and range of motion during the first postoperative phase [7, 22, 27]. As a consequence, sportive patients have to be informed preoperatively that meniscus repair requires an extensive rehabilitation until RTS can be achieved. Similar to ACL reconstruction, biological healing is the limiting factor before allowing full RTS without a high risk of recurrence. Previous studies showed that RTS is achieved after 5–6 months in elite athletes after an intensive postoperative training program [22, 35]. However, surgeons have to be aware that about 45% of the meniscus repairs are not completely healed at this point [30].

The present study has some limitations. Different tear patterns have been investigated that might have unequal healing properties. Further, AI and IO technique were used that demonstrated dissimilar primary repair strength. The analysis of MRI signal alterations is based on semi-quantitative criteria described by Henning et al., which only allows cross-sectional evaluation of the meniscus. Due to ethical reasons an

intra-articular contrast agent was not administered, which could have improved sensitivity and specificity. However, the strength of this study was the prospective study design and the consecutive inclusion of young athletes according to specific criteria. All patients underwent high-resolution 3T-MRI at a priori defined time points and MRI was independently analysed by two orthopaedic surgeons. Clinical examination was performed using standardized clinical assessment tools and reliable outcome scores.

In summary, despite an ongoing healing process RTS can be achieved in young and sportive patients in short-term follow-up period. Although MRI clearly identified intrameniscal fluid in 44% of the patients, it might rather display a fibrovascular proliferation than a re-tear and should, hence, be interpreted with caution in the early postoperative phase. As a consequence, the clinical examination and the patients' symptoms play an important role for the allowance of RTS after meniscus repair.

Conclusion

This study showed that MRI signal alterations of the meniscus steadily occur within the first 6 months postoperatively. MRI reveals an ongoing healing process at final FU that have to be carefully considered when RTS is discussed with high demanding patients. However, young athletes provide good clinical results and RTS rate even though MRI alterations are still present.

Compliance with ethical standards

Conflict of interest A.B.I. is consultant of medi and Arthrosurface. All other authors declare that they have no competing interests.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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