MR imaging of the knee in primary care

Oudenaarde, K. van

CHAPTER 5

Referral to Magnetic Resonance Imaging by the General Practitioner in patients with traumatic knee complaints is not additive in predicting return to sports

NM Swart, K van Oudenaarde, SMA Bierma-Zeinstra, JL Bloem,
PJ Bindels, PR Algra, M Reijnierse, PAJ Luijsterburg

Submitted

Abstract

Background

It remains unclear to what extent patients with traumatic knee complaints aged 18-45 years seen in general practice experience difficulties with return to sports. Therefore, this study aims to determine the proportion of patients with a knee trauma that return to sports at 6-weeks and 3-months follow-up. Also examined were associations between no return to sports and baseline patient/trauma characteristics, knee complaints and MR findings, as well as the additive value of MR findings.

Methods

Included were patients with traumatic knee complaints participating in a randomised controlled trial assessing the cost-effectiveness of an MR scan in general practice. Patients were classified as 'no return to sports' or 'return to sports' (sports on pre-injury or adapted level). Potential baseline predictors for no return to sports were assessed using logistic regression analyses. The area under the curves (AUC) were compared.

Results

At 6-weeks and 3-months follow-up, 147 (59%) and 175 (74%) patients, respectively, reported return to sports. Combining patient characteristics, trauma characteristics and knee complaints predicted no return to sports with an AUC of 0.86 (95%CI:0.81-0.90) at 6-weeks and of 0.82 (95%CI:0.76-0.88) at 3-months follow-up. After adding MR findings, the AUC was 0.79 (95%CI:0.71-0.87) at 6-weeks and 0.79 (95%CI:0.70-0.88) at 3-months follow-up.

Conclusions

Three out of 4 patients with a knee trauma in general practice reported return to sports at 3-months follow-up. A combination of patient/trauma characteristics and knee complaints predicted no return to sports, whereas MR findings had no additive value.

Introduction

An injury of the knee due to a trauma during sports or leisure is a common indication for which patients visit their general practitioner (GP).[1] Patients with traumatic knee complaints regularly ask when they can resume sports activities. To help address this, the GP's tools for diagnosis and management of these complaints are described in the Dutch guideline for traumatic knee complaints.[2] In the acute phase, the diagnosis is mainly based on history taking, whereas physical examination adds little diagnostic value.[3-5] Studies have shown the potential diagnostic value of a magnetic resonance scan (MR scan) in traumatic knee complaints (requested by the GPs) by improving patients knee related quality of life and reducing medical costs.[6-8] However, the national Dutch guideline for traumatic knee complaints does not recommend MR scan due to uncertainty about its (cost)effectiveness compared to usual care (i.e. no MR scan). The guideline advises a wait-and-see policy in the first 3 months when a fracture or locked knee is ruled out. In most patients with traumatic knee complaints in general practice, full recovery or major improvement is reported after 1 year.[9] However, the return to sports after traumatic knee complaints remains precarious.[10] Currently, in patients aged 18-45 years visiting a GP, the impact of a knee trauma on their return to sports activities remains unclear.

Methods

Aim

The aim of this study is to assess at 6-weeks and 3-months follow-up: the proportion of patients returning to sports after a knee trauma which patient characteristics, trauma characteristics, severity of knee complaints and MR findings, all measured at baseline, are associated with no return to sports whether MR findings have an additive value in predicting no return to sports.

Design and setting

The present study included patients with traumatic knee complaints participating in a randomised controlled trial (RCT) that aimed to assess the (cost)effectiveness of an MR scan in general practice for patients with knee complaints due to a trauma (TACKLE Trial).[11] In

the TACKLE trial, patients from 150 participating general practitioners were randomised to an MR scan or usual care. The recruitment for the TACKLE Trial took place from November 2012 to December 2015. The usual care group was treated according to the guideline of the Dutch College of General Practitioners for traumatic knee complaints, i.e. no MR scan.[2] The study was approved by the Medical Ethics Committee of the Erasmus Medical Centre (Dutch Trial Registration: NTR3689).[12]

Study population

Patients aged 18-45 years visiting their GP with knee complaints due to a trauma in the preceding 6 months were eligible for the TACKLE Trial. Excluded from the study were patients with: i) an indication for direct referral to an orthopaedic surgeon, ii) knee complaints already treated in secondary care, iii) previous surgical intervention of the affected knee, iv) knee osteoarthritis diagnosed by a medical specialist, v) other non-traumatic arthropathy (i.e. isolated patellofemoral joint pain), vi) a previous MR scan for current knee complaints, or vii) a contra-indication for an MR scan. For the present study, also excluded were patients: i) who did not participate in sports before the knee trauma, and ii) who did not return to sports after the knee trauma due to reasons other than knee complaints. Patients were invited to participate in the TACKLE Trial by the GP during the consultation or were invited shortly after the consultation. These latter patients were identified through a search of the medical records for the preceding 3 months and, therefore, had a longer time from trauma to study inclusion (median 75 days; IQR 49, 107 days) than the patients invited during consultation (median 22 days; IQR 8, 45 days).

Data collection

The questionnaires were filled in by the patients in the web-based program Limesurvey.[13] The following question about sports participation was included in the questionnaires filled in at baseline, and at 6-weeks and 3-months follow-up: "*Are you able to participate in sports with your knee at this moment*?" The answers were dichotomised to "No return to sports" (not able to participate in sports because of the knee complaints) or "Return to sports" (sports at the same level as before the knee trauma, or at an adapted level). At baseline information on the following characteristics were collected: age, gender, height, weight,

educational level (low/high), musculoskeletal co-morbidity (yes/no) previous knee complaints (yes/no), symptom side (right/left), paid job (yes/no), and hours spent on the paid job per week. Also, information on the date, occasion (sport/job/home/traffic/other) and the mechanism (fall/rotation/bump/squatting) of the knee trauma were assessed and dichotomised to: trauma during sport (yes/no) and rotational trauma (yes/no). In addition, the following were also assessed: the type of sport (ball sport: yes/no), hours of sport per week, and whether the sport was played in competition before knee trauma (yes/no).

The baseline scores of the following outcome measures were used to assess the severity of knee complaints: i) the numeric pain rating scale [NPRS; scores ranging from 0 (no pain) to 10 (unbearable pain)], for the average severity of knee pain during the previous 48 hours and the previous week[14], ii) the Lysholm scale comprising 8 items on symptoms and limitations in activities (scores ranging from 0-100, with higher scores indicating better knee function[15], iii) a modified Tegner score to measure work load and sport participation, ranging from 0 (not able to work/sport due to knee complaints) to 10 (complete return to work/sports)[15], iv) the five dimensions of the Knee Injury and Osteoarthritis Outcome Score (KOOS) to measure disability due to knee complaints[16]; the KOOS consists of five dimensions (pain, symptoms, function in daily living, function in sport and recreation, and knee-related quality of life) rated on a scale from 0-4: for every dimension, a score is calculated on a scale from 0-100 with a higher score indicating better knee function, v) the shortened version of the Tampa scale that measures fear of pain, movement and injury (TSK-11), scored from 1 (strongly disagree) to 4 (strongly agree)[17,18], the total score ranges from 11-44, with a higher score indicating more fear regarding pain, movement and injury.

MR findings were scored by one of the 12 participating (experienced) radiologists at a median of 13 (IQR 8, 20) days after inclusion. On a 1.5 Tesla system images were made in the coronal, sagittal and transversal plane, using a T1 and PD-weighted sequence, with or without fat suppression. A standardised report was used, developed in agreement with the GPs, radiologists and orthopaedic surgeons of the TACKLE trial project group. The following items were scored: the amount of synovial fluid (effusion) , abnormalities in soft tissues, meniscal injuries, anterior and posterior cruciate ligament ruptures, medial and lateral collateral ligament distortions and bone and cartilage injuries. The MR findings were

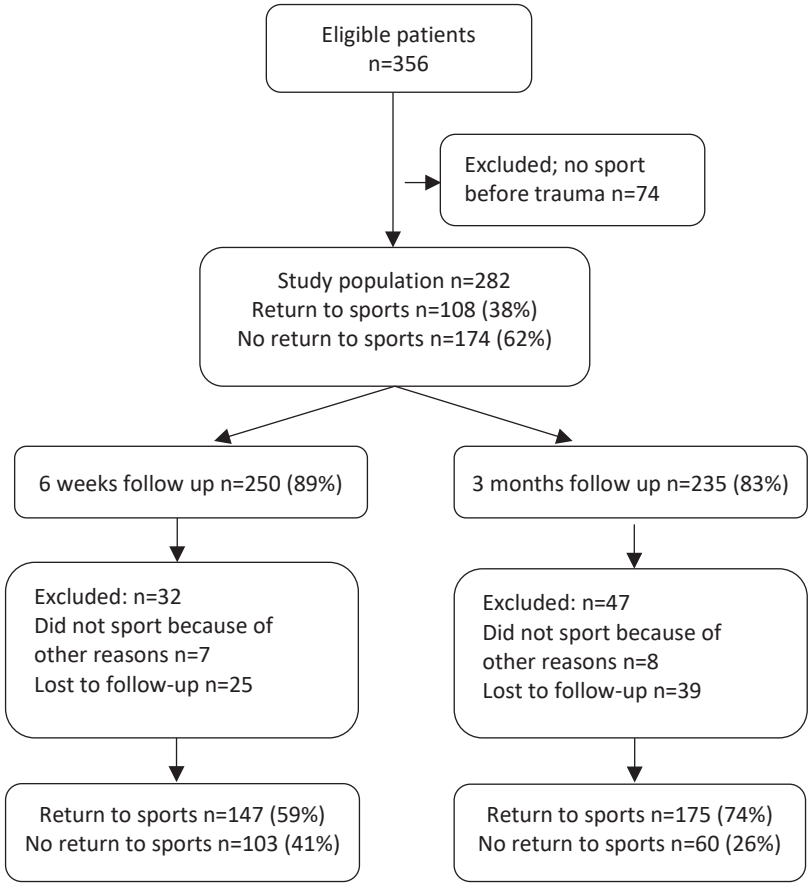
dichotomised to the presence or absence of effusion, a bone bruise of the femorotibial joint (FTJ), fracture, traumatic meniscal tear (longitudinal, radial or complex meniscal tear), grade I-III distortion of the medial or lateral collateral ligament (MCL/LCL), partial or complete anterior or posterior cruciate ligament tear (ACL/PCL) and cartilage damage grade I-IV.

Statistical analyses

Descriptive statistics were used to describe the participants. Data were tested on a normal distribution with the Kolmogorov-Smirnov test. The mean and standard deviation (SD) were reported in case of normal distributed data and median and inter quartile range (IQR) in case of skewed data. The baseline associations of patient characteristics, trauma characteristics, severity of knee complaints and MR findings with return to sports (1=no, 0=yes) were assessed with logistic regression analyses, adjusted for the time from trauma to study inclusion and return to sports at baseline. Candidate predictors for the logistic regression analyses were selected based on expert consensus (PL, SBZ, NS). The number of selected candidate predictors was based on the number of patients in the smallest group (return to sports group, or no return to sports group).[19] Separate models were built for patient characteristics, trauma characteristics, baseline severity of knee complaints and MR findings. Candidate predictors with a univariate association of $p<0.2$ were all entered into a multivariable logistic regression analysis in one block (Enter method). In case of multicollinearity ($r>0.5$) of the candidate predictors the variable with the strongest association (odds ratio) with no return to sports was selected for the multivariable logistic regression analysis. In the latter analyses, variables with $p>0.2$ were removed.

Variables with an association of $p<0.2$ in the multivariable logistic regression analysis of the separate models were selected for a final multivariable logistic regression analysis (Enter method) with a combination of patient characteristics, trauma characteristics and baseline severity of knee complaints. Finally, the MR findings were added to the combined model to assess the additive value of an MR scan. A receiver operating characteristic curve was created and the area under the curve (AUC) was calculated to compare the separate models.[20] SPSS version 21.0 was used for all analyses.

Figure 1 Flow chart



Results

Patient inclusion

Figure 1 is a flow chart of the process. Eight hundred and thirty-six patients were invited to participate in the TACKLE trial. Of the 356 patients included in the RCT, 282 (79%) participated in sports before the knee trauma and were included in the present study. At 6-weeks and 3-months follow-up, 250 (89%) and 235 (83%) patients, respectively, were available for analysis.

Baseline characteristics

Baseline characteristics are presented in Table 1. Median age was 32 (IQR 26, 39) years and 63% of the patients was male. Median time from trauma to study inclusion was 39 (IQR 13, 80) days. The four most commonly performed sports before trauma were: i) soccer, ii) fitness training or aerobics, iii) athletics or running, and iv) combat sport with 99 (35%), 60 (21%), 40 (14%) and 16 (6%) patients, respectively. For 188 (67%) patients the trauma occurred during sports, and in total, 114 (40%) patients experienced a rotational trauma.

Of the 282 patients included at baseline, 138 (49%) had received an MR scan (Table 2). Median time from trauma to MR scan was 48 (IQR 23, 88) days. In 114 (83%) patients one or more abnormalities were detected on the MR scan. In 50 (36%) patients there was a bone bruise of the FTJ and in 11 (8%) there was a (micro) fracture; also 25 (18%) patients had a traumatic meniscal tear, 24 (17%) had an MCL/LCL distortion, 34 (25%) had an ACL/PCL tear, and 31 (22%) patients had cartilage defect.

Return to sports

At baseline, 108 (38%) patients returned to sport on the pre-injury level or an adapted leve). At 6-weeks and 3-months follow-up 147 (59%) and 175 (74%) patients, respectively, returned to sports.

Associations with no return to sports

The results of the bivariate logistic regression analyses for return to sports are presented in the Appendix. The results of the multivariable logistic regression analyses for no return to sports are shown in Table 3.

Patient characteristics

At 6-weeks follow-up, ‘age’, ‘musculoskeletal comorbidities’ and ‘ball sport before trauma’ predicted no return to sports with an AUC of 0.85 (95%CI:0.80-0.89). At 3-months follow-up only ‘age’ predicted no return to sports with an AUC of 0.73 (95%CI:0.66-0.80).

Table 1 Baseline characteristics of included patients (n=282)

Patient characteristics	**Study population**
Age in years, median (IQR)	32 (26, 39)
Male gender	178 (63%)
BMI, median (IQR)	24.6 (22.7, 26.9)
High educational level	117 (41%)
MSK comorbidities	63 (22%)
Previous knee complaints	116 (41%)
Time trauma to inclusion in days, median (IQR)	39 (13, 80)
Symptom on the right knee	128 (45%)
Sports before trauma	282 (100%)
Hours spend on sport p/w, median (IQR)	3 (2, 5)
Ball sport	126 (45%)
Sport in competition	124 (44%)
Soccer	99 (35%)
Fitness training/aerobics	60 (21%)
Athletics/running	40 (14%)
Combat sport	16 (6%)
Paid job before trauma	252 (89%)
Hours spend on paid job p/w, median (IQR)	38 (30, 40)
Trauma characteristics	
Occasion of trauma	
During sports	188 (67%)
During work	18 (6%)
At home	12 (4%)
During traffic	24 (9%)
Other	40 (14%)
Mechanism of trauma	
Fall	72 (26%)
Rotation	114 (40%)
Bump	19 (7%)
Squatting	24 (9%)
Other	51 (18%)
Immediate pain	208 (74%)
Immediate effusion	72 (26%)
Continuation activity impossible	196 (70%)
Popping sensation during trauma	89 (35%)
Severity of knee complaints	
Invited afterward consultation	106 (38%)
Severity of knee pain (NPRS previous 48h), median (IQR)	3 (5, 7)
Symptoms and limitations in activities (Lysholm), median (IQR)	73 (56, 85)
Work load and sport participation (Tegner), median (IQR)	3 (2, 4)
Fear of pain, movement and injury (TSK-11), median (IQR)	26 (22, 30)
KOOS pain, median (IQR)	58.3 (44.4, 75)
KOOS symptoms, median (IQR)	64.3 (46.4, 78.6)
KOOS function in daily living, median (IQR)	69.1 (50, 85.7)
KOOS sport and recreation, median (IQR)	30 (15, 55)
KOOS quality of life, median (IQR)	43.8 (37.5, 50)

Data are presented as numbers (percentages), unless otherwise stated. Missing values ranged up to 0.7%. IQR: inter quartile range. BMI: body mass index. MSK: musculoskeletal. p/w: per week. NPRS: Numeric Pain Rating Scale on a scale from 0 to 10, with a higher score indicating more pain. Lysholm scale from 0 to 100, with a higher score indicating less problems. TSK-11: Shortened version of the Tampa scale for kinesiophobia from 11 to 44, with a higher score indicating more kinesiophobia. KOOS: Knee injury and Osteoarthritis Outcome Score on a scale from 0 to 100, with a higher score indicating less problems.

Table 2 Knee Magnetic Resonance findings of the 138 patients with the MR scan

MR findings	**Study population**
Time from trauma to MR-scan in days, median (IQR)	48 (23, 88)
Abnormalities present	114 (83%)
Effusion	58 (42%)
Bone bruise FTJ	50 (36%)
(Micro) fracture	11 (8%)
Traumatic meniscal tear[1]	25 (18%)
MCL/LCL distortion[2]	24 (17%)
ACL/PCL tear[3]	34 (25%)
Cartilage damage[4]	31 (22%)
Combinations	
ACL/PCL tear and bone bruise FTJ	24 (17%)
Traumatic meniscal tear and bone bruise FTJ	13 (9%)
Traumatic meniscal tear and ACL/PCL tear	12 (9%)
MCL/LCL distortion and bone bruise FTJ	11 (8%)

Data are presented as numbers (percentages), unless otherwise stated. Missing values ranged up to 1.4%.
MR: magnetic resonance. IQR: inter quartile range. FTJ: femorotibial joint. MCL: medial collateral ligament. LCL: lateral collateral ligament. ACL: anterior cruciate ligament. PCL: posterior cruciate ligament.
[1]Longitudinal, radial or complex meniscal tear. [2]Grade I-III. [3]Partial or complete tear. [4]grade I-IV.

Trauma characteristics

At 6-weeks follow-up, ‘trauma during sport’, ‘rotational trauma’ and ‘popping sensation’ predicted no return to sports with an AUC of 0.84 (95%CI:0.79-0.89). At 3-months follow-up, ‘trauma during sport’, ‘rotational trauma’ and ‘popping sensation’ predicted no return to sports with an AUC of 0.78 (95%CI:0.71-0.85).

Baseline severity of knee complaints

At 6-weeks follow-up, ‘effusion during previous week’, ‘NPRS previous 48h’ and the ‘Tegner score’ predicted no return to sports with an AUC of 0.83 (95%CI:0.78-0.88). At 3-months follow-up ‘effusion during previous week’, ‘NPRS previous 48h’ and ‘KOOS QoL’ predicted no return to sports with an AUC of 0.81 (95%CI:0.75-0.87).

Table 3 Multivariable logistic regression analysis for return to sports

6-week follow-up (n=250)			3-month follow-up (n=235)		
Patient characteristics	**OR**	**95% CI**	**Patient characteristics**	**OR**	**95% CI**
Time from trauma to inclusion	1.00	0.99-1.01	Time from trauma to inclusion	1.00	0.99-1.01
Return to sports at baseline	0.04	0.01-0.10*	Return to sports at baseline	0.12	0.04-0.31*
Age	1.10	1.05-1.15*	Age	1.04	1.00-1.08**
MSK comorbidities	2.04	0.91-4.57**			
Ball sport before trauma	2.23	1.14-4.33*			
AUC = 0.85 (95% CI 0.80-0.89). R^2=0.46			AUC = 0.73 (95% CI 0.66-0.80). R^2=0.20		
Trauma characteristics			**Trauma characteristics**		
Time from trauma to inclusion	1.01	1.00-1.01	Time from trauma to inclusion	1.00	0.99-1.01
Return to sports at baseline	0.04	0.02-0.11*	Return to sports at baseline	0.12	0.04-0.33*
Trauma during sport	1.89	0.96-3.72**	Trauma during sport	2.50	1.16-5.39*
Rotational trauma	1.64	0.85-3.16**	Rotational trauma	1.84	0.92-3.69**
Popping sensation	2.11	1.07-4.14*	Popping sensation	1.97	1.00-3.91*
AUC = 0.84 (95% CI 0.79-0.89). R^2=0.43			AUC = 0.78 (95% CI 0.71-0.84). R^2=0.27		
Baseline severity of knee complaints[1]			**Baseline severity of knee complaints[2]**		
Time from trauma to inclusion	1.00	1.00-1.01	Time from trauma to inclusion	1.00	0.99-1.01
Return to sports at baseline	0.09	0.04-0.24*	Return to sports at baseline	0.25	0.09-0.68*
Effusion previous week	1.83	0.93-3.62**	Effusion previous week	2.49	1.14-5.41*
NPRS previous 48h	1.26	1.08-1.48*	NPRS previous 48h	1.30	1.09-1.55*
Tegner score	0.89	0.76-1.05**	KOOS QoL	0.97	0.94-1.00**
AUC = 0.83 (95% CI 0.78-0.89). R^2=0.44			AUC = 0.81 (95% CI 0.75-0.87). R^2=0.32		
Magnetic Resonance subgroup (n=128)			**Magnetic Resonance subgroup (n=121)**		
Findings on Magnetic Resonance scan[3]			**Findings on Magnetic Resonance scan[4]**		
	OR	**95% CI**		**OR**	**95% CI**
Time from trauma to inclusion	1.00	0.99-1.01	Time from trauma to inclusion	1.01	1.00-1.02
Return to sports at baseline	0.08	0.02-0.27*	Return to sports at baseline	0.14	0.04-0.53*
Effusion	2.55	1.07-6.09*	Effusion	2.71	1.02-7.21*
Traumatic meniscal tear	2.17	0.71-6.66**	Traumatic meniscal tear	3.10	1.01-9.49*
			MCL/LCL distortion	0.35	0.10-1.26**
AUC = 0.80 (95% CI 0.72-0.87). R^2=0.37			AUC = 0.79 (95% CI 0.70-0.88). R^2=0.29		

Adjusted for time from trauma to inclusion and baseline return to sports. Missing values ranged up to 1.6%. MR: magnetic resonance. 95% CI; 95% confidence interval. OR: odds ratio. AUC: area under the curve. *P=<0.05. **P=<0.20. MSK: musculoskeletal. NPRS: Numeric Pain Rating Scale on a scale from 0-10, with a higher score indicating more pain. KOOS: Knee injury and Osteoarthritis Outcome Score ranging from 0-100, with a higher score indicating less problems. QoL: quality of life. Tegner score from 0-10, with a higher score indicating less problems. MCL/LCL distortion: distortion of the medial or lateral collateral ligament. [1]'KOOS QoL' removed because of p>0.2. [2]'TSK-11' removed because of p>0.2. [3]'BML FTJ' and 'fracture' removed because of p>0.2. [4]'ACL/PCL tear' removed because of p>0.2.

MR findings

At 6-weeks follow-up, 'effusion' and 'traumatic meniscal tear' predicted no return to sports with an AUC of 0.80 (95%CI:0.72-0.87). At 3-months follow-up, 'effusion', 'traumatic meniscal tear' and 'MCL/LCL distortion' predicted no return to sports with an AUC of 0.79 (95%CI:0.70-0.87).

Additive value of the Magnetic Resonance scan

The results of the multivariable logistic regression analyses for return to sports of the combined models and the additive value of the MR scan are shown in Table 4.

Combining the model of patient characteristics, trauma characteristics and baseline severity of knee complaints, the AUC was 0.86 (95%CI:0.81-0.90) at 6-weeks follow-up and 0.82 (95%CI:0.76-0.88) at 3-months follow-up. When adding the MR information, the AUC was 0.79 (95%CI:0.71-0.87) at 6-weeks follow-up and 0.79 (95%CI:0.70-0.88) at 3-months follow-up.

Discussion

The results of this study show that, at 6-weeks follow-up 41% of the patients aged 18-45 years with traumatic knee complaints reported not to have returned to sports. After 3 months, 1 in 4 patients was still not able to return to sports. These results emphasise the difficulty these patients with traumatic knee complaints have with return to sports. Several patient characteristics, trauma characteristics and baseline severity of knee complaints were associated with no return to sports during follow-up. At 6-weeks follow-up, for patients with a higher age, and for patients who reported more pain in the previous 48 hours at baseline, the odds of reporting no return to sports increased. At 3-months follow-up, for patients who experienced a trauma during sport, for those who reported effusion during the previous week at baseline, and for patients who reported more pain in the previous 48 hours at baseline, the odds of reporting no return to sports increased.

Table 4 Multivariable logistic regression analysis of the combined models for return to sports

6-week follow-up (n=250)			3-month follow-up (n=235)		
	OR	**95% CI**		**OR**	**95% CI**
Patient characteristics, trauma characteristics and baseline severity of knee complaints[1]			Patient characteristics, trauma characteristics and baseline severity of knee complaints[2]		
Time from trauma to inclusion	1.00	0.99-1.01	Time from trauma to inclusion	1.01	1.00-1.02
Return to sports at baseline	0.05	0.02-0.13*	Return to sports at baseline	0.19	0.07-0.52*
Age	1.09	1.04-1.14*	Trauma during sport	2.58	1.17-5.72*
NPRS previous 48 h	1.32	1.12-1.54*	Effusion previous week	2.77	1.27-6.05*
			NPRS previous 48 h	1.33	1.12-1.59*
AUC = 0.86 (95% CI 0.81-0.90). R^2=0.47			AUC = 0.82 (95% CI 0.76-0.88). R^2=0.33		
Magnetic Resonance subgroup (n=128)			**Magnetic Resonance subgroup (n=121)**		
Patient characteristics, trauma characteristics, baseline severity of knee complaints and Magnetic Resonance findings[3]			Patient characteristics, trauma characteristics, baseline severity of knee complaints and Magnetic Resonance findings[4]		
	OR	**95% CI**		**OR**	**95% CI**
Time from trauma to inclusion	1.00	0.99-1.01	Time from trauma to inclusion	1.01	0.99-1.02
Return to sports at baseline	0.04	0.02-0.10*	Return to sports at baseline	0.23	0.06-0.83*
Age	1.09	1.04-1.14*	NPRS previous 48 h	1.29	1.04-1.61*
			Traumatic meniscal tear	5.43	1.77-16.62*
AUC = 0.79 (95% CI 0.71-0.87). R^2=0.36			AUC = 0.79 (95% CI 0.70-0.88). R^2=0.28		

Adjusted for time from trauma to inclusion and baseline return to sports. Missing values ranged up to 1.6%. 95% CI; 95% confidence interval. OR: odds ratio. AUC: area under the curve. *p=<0.05. NPRS: Numeric Pain Rating Scale on a scale from 0-10, with a higher score indicating more pain. [1]'Ball sport before trauma', 'trauma during sports', 'rotational trauma', 'popping sensation' and 'Tegner score' removed because of p>0.05. [2]'Age', 'MSK comorbidities', 'effusion during previous week', 'rotational trauma', 'popping sensation' and 'KOOS QoL' removed because of p>0.05. [3]'NPRS previous 48h', 'effusion on MR scan' and 'traumatic meniscal tear' removed because of p>0.05. [4]'Trauma during sport', 'effusion previous week', effusion on MR scan and 'MCL/LCL distortion' removed because of p>0.05.

Adding MR findings to the patient characteristics, trauma characteristics and baseline severity of knee complaints did not improve the prediction of no return to sports at 6-weeks or 3-months follow-up. Therefore, a combination of patient characteristics, trauma characteristics, and the NPRS for the previous 48 h, can be used during history taking by the GP to predict no return to sports at 6-weeks and 3-months follow-up.

Comparison with literature

We found no studies focusing on return to sports in patients with traumatic knee complaints seen in general practice. In secondary care, in a pair-matched comparison of conservatively treated patients with ACL injuries versus ACL reconstruction, a return to sports rate of 68% was seen after 1 year in the conservative group; this persentage was not significantly

different between the groups.[21] The rate is lower than the 74% found in our study at 3-months follow-up. However, our population included patients with all types of intra/extra-articular damage due to a trauma, in which only 34 (34.5%) patients had an ACL/PCL tear. In the present study, ACL injury showed no association with no return to sports at 6-weeks or 3-months follow-up. The return to sport percentages for patients with traumatic knee complaints after surgery are even lower: i.e. 55% of the patients returned to sports after ACL reconstruction[10] and 61% after arthroscopic lateral meniscectomy.[22]

The results of a study in patients with traumatic knee complaints in general practice showed that age >40 years is the main predictor for persistent knee complaints.[9] In the present study, older age was also a predictor for no return to sports at 6-weeks follow-up, but not at 3-months follow-up.

In patients after ACL reconstruction, younger age, male gender, playing elite sport and having a positive psychological response favoured returning to the preinjury level of sport.[10,23] In our study, there was no association between the Tegner score and the TAMPA scale with no return to sports. Possibly, these factors play an important role in the return to pre-injury level of sports, but not in the return to an adapted level of sports.

The range of predictors found reflects one of the key messages of the 2016 consensus statement on return to sport from the First World Congress in Sports Physical Therapy stated that biological, psychological and social factors influence the decision to return to sports.[24] Possible predictors for no return to sports not measured in the present study include: details on tissue stress during the sports (e.g. position played and limb dominance), and risk tolerance modifiers (e.g. timing in the season, pressure from athletes, and from the coach). However, these factors are more applicable for athletes, which does not apply to our study population.

In this study, an MR scan had no additive value to patient/trauma characteristics and severity of knee complaints in predicting no return to sports at 6-weeks and 3-months follow-up. Possibly, an MR scan can be additive in revealing information regarding the underlying cause of the knee complaints which can be important in a later stage, for example in predicting re-injury. Our finding is however in accordance with a recent study

on the absence of an additive value of an MR scan in the prediction of recovery in patients with low back pain in general practice.[25]

Limitations

In this study, the p-value for the selection of variables for the multivariable analysis was set at 0.2. This might have caused a type 1 error; however, the number of variables tested were limited in the ratio of 1 per 10 patients. The final model of patient characteristics, trauma characteristics and baseline severity of knee complaints was used in the subgroup of patients to assess the additive value of MR scan. Although we did not validate the model in the subgroup, the groups were based on randomisation and there were no differences in patient characteristics between the groups (with exception of the time from trauma to study inclusion, for which the analyses were adjusted: data not shown).

Strengths

To our knowledge, this is the first study on return to sports in patients with traumatic knee complaints in general practice. Identification of important predictors for no return to sports may serve to improve the treatment of patients with traumatic knee complaints in general practice. Another strength of this study is the use of a standardised report used by the radiologists for the MR scan, drafted by the investigator in consensus with experts; this decreased the odds of missed observations by the radiologist.

Conclusions

Three out of 4 patients with a knee trauma in general practice reported return to sports at 3-months follow-up. A combination of patient/trauma characteristics and knee complaints predicted no return to sports, whereas MR findings had no additive value.

References

1. Linden van der MW, Westert GP, Bakker de DH, Schellevis FG. Second national study to disaeses and actions in general practice: complaints and disorders in the population and in general practice (in Dutch). Utrecht, Bilthoven: NIVEL/RIVM. 2004.
2. Belo JN, Berg HF, Klein Ikkink AJ, Wildervanck-Dekker CMJ, Smorenburg HAAJ, Draijer LW. Clinical guideline 'traumatic knee complaints' from the Dutch College of General Practitioners (in Dutch). Huisarts en Wetenschap. 2010;54:147-158.
3. Kastelein M, Wagemakers HP, Luijsterburg PA, Verhaar JA, Koes BW, Bierma-Zeinstra SM. Assessing medial collateral ligament knee lesions in general practice. Am J Med. 2008;121(11):982-988 e2.
4. Wagemakers HP, Heintjes EM, Boks SS, et al. Diagnostic value of history-taking and physical examination for assessing meniscal tears of the knee in general practice. Clin J Sport Med. 2008;18(1):24-30.
5. Wagemakers HP, Luijsterburg PA, Boks SS, et al. Diagnostic accuracy of history taking and physical examination for assessing anterior cruciate ligament lesions of the knee in primary care. Arch Phys Med Rehabil. 2010;91(9):1452-1459.
6. Berg HF, Vermeulen M, Algra PR, Boonman-de Winter LJ. Direct access to magnetic resonance imaging improved orthopaedic knee referrals in the Netherlands. Fam Pract. 2016;33(5):482-487.
7. DAMASK TRIAL TEAM. Cost-effectiveness of magnetic resonance imaging of the knee for patients presenting in primary care. Br J Gen Pract. 2008;58(556):e10-e16.
8. DAMASK TRIAL TEAM. Effectiveness of GP access to magnetic resonance imaging of the knee: a randomised trial. Br J Gen Pract. 2008;58(556):e1-8; discussion 774.
9. Wagemakers HP, Luijsterburg PA, Heintjes EM, et al. Outcome of knee injuries in general practice: 1-year follow-up. Br J Gen Pract. 2010;60(571):56-63.
10. Ardern CL, Taylor NF, Feller JA, Webster KE. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. Br J Sports Med. 2014;48(21):1543-1552.
11. Swart NM, van Oudenaarde KK, Algra PR, et al. Efficacy of MRI in primary care for patients with knee complaints due to trauma: protocol of a randomised controlled non-inferiority trial (TACKLE trial). BMC Musculoskelet Disord. 2014;15:63.
12. Dutch Trial Registration. Available from: www.trialregister.nl. Accessed: October 17, 2-16.
13. Schmitz C, LimeSurvey Project Team. LimeSurvey: An Open Source survey tool. Project Hamburg, Germany. Available from: www.limesurvey.org.
14. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. J Clin Nurs. 2005;14(7):798-804.
15. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res. 1985(198):43-49.
16. Groot de IB, Favejee MM, Reijman M, Verhaar JA, Terwee CB. The Dutch version of the Knee Injury and Osteoarthritis Outcome Score: a validation study. Health Qual Life Outcomes. 2008;6:16.
17. Woby SR, Roach NK, Urmston M, Watson PJ. Psychometric properties of the TSK-11: a shortened version of the Tampa Scale for Kinesiophobia. Pain. 2005;117(1-2):137-144.
18. George SZ, Lentz TA, Zeppieri G, Lee D, Chmielewski TL. Analysis of shortened versions of the tampa scale for kinesiophobia and pain catastrophizing scale for patients after anterior cruciate ligament reconstruction. Clin J Pain. 2012;28(1):73-80.

19. Steyerberg EW, Eijkemans MJ, Harrell FE, Jr., Habbema JD. Prognostic modeling with logistic regression analysis: in search of a sensible strategy in small data sets. Med Decis Making. 2001;21(1):45-56.
20. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology. 1982;143(1):29-36.
21. Grindem H, Eitzen I, Moksnes H, Snyder-Mackler L, Risberg MA. A pair-matched comparison of return to pivoting sports at 1 year in anterior cruciate ligament-injured patients after a nonoperative versus an operative treatment course. Am J Sports Med. 2012;40(11):2509-2516.
22. Aune KT, Andrews JR, Dugas JR, Cain EL, Jr. Return to Play After Partial Lateral Meniscectomy in National Football League Athletes. Am J Sports Med. 2014;42(8):1865-1872.
23. Ardern CL. Anterior Cruciate Ligament Reconstruction-Not Exactly a One-Way Ticket Back to the Preinjury Level: A Review of Contextual Factors Affecting Return to Sport After Surgery. Sports Health. 2015;7(3):224-230.
24. Ardern CL, Glasgow P, Schneiders A, et al. 2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. Br J Sports Med. 2016;50(14):853-864.
25. Schepper de EI, Koes BW, Oei EH, Bierma-Zeinstra SM, Luijsterburg PA. The added prognostic value of MRI findings for recovery in patients with low back pain in primary care: a 1-year follow-up cohort study. Eur Spine J. 2016;25(4):1234-1241.

Appendix:

- Adjusted for duration of complaints at study inclusion and return to sports at baseline. Data are presented as numbers (percentages) unless otherwise stated.
- Missing values ranged up to 1.6%.
- p/w: per week.
- NPRS: Numeric Pain Rating Scale on a scale from 0 to 10, with a higher score indicating more pain.
- TSK-11: Shortened version of the Tampa scale for kinesiophobia, from 11 to 44, with a higher score indicating more kinesiophobia.
- KOOS: Knee injury and Osteoarthritis Outcome Score on a scale from 0 to 100, with a higher score indicating less problems.
- QoL: quality of life.
- Tegner score from 0 to 10, with a higher score indicating less problems.

Table 1 shows the results for the 6 weeks follow up.
Table 2 shows the results for the 3 months follow up.

Appendix Table 1 Results of the bivariate logistic regression analysis for return to sports after 6 weeks follow-up

	Return (n=147)	No return (n=103)	OR (95% CI)
Patient characteristics[1]			
Age in years, median (IQR)	32 (25, 39)	34 (27, 41)	1.09 (1.04-1.14)*
Male gender	92 (62.6%)	66 (64.1%)	0.88 (0.47-1.65)
BMI, median (IQR)	24.7 (22.6, 26.9)	24.7 (22.9, 27)	1.04 (0.96-1.14)
High educational level	67 (45.6%)	41 (39.8%)	1.21 (0.65-2.25)
MSK comorbidities	29 (19.7%)	27 (26.2%)	1.80 (0.84-3.86)**
Previous knee complaints	57 (38.8%)	47 (45.6%)	1.14 (0.77-2.69)
Ball sport before trauma	58 (39.5%)	56 (54.4%)	1.56 (0.85-2.87)**
Hours sport p/w, median (IQR)	3 (2, 5)	3 (2, 5)	0.97 (0.87-1.10)
Paid job before trauma	130 (88.4%)	95 (92.2%)	0.78 (0.24-2.52)
Hours spend on paid job p/w, median (IQR)	36 (30, 40)	40 (32, 40)	1.01 (0.98-1.04)
Trauma characteristics[2]			
Trauma during sport	93 (63.3%)	74 (71.8%)	1.92 (1.00-3.71)*
Rotational trauma	48 (32.7%)	56 (54.4%)	2.01 (1.08-3.74)*
Immediate pain	106 (27.1%)	78 (75.7%)	1.06 (0.53-2.11)
Immediate effusion	36 (24.5%)	31 (30.1%)	1.09 (0.56-2.12)
Continuation activity impossible	94 (63.9%)	77 (74.8%)	1.00 (0.50-1.99)
Popping sensation	38 (25.9%)	48 (46.6%)	2.42 (1.27-4.59)*
Severity of knee complaints[3]			
Invited afterward consultation	69 (46.9%)	29 (28.2%)	0.96 (0.45-2.05)
Effusion previous week	56 (38.1%)	73 (70.9%)	2.18 (1.13-4.20)*
NPRS previous 48h, median (IQR)	5 (2, 6)	6 (4, 7)	1.29 (1.11-1.50)*
Tegner score, median (IQR)	4 (3, 5)	2 (1, 4)	0.87 (0.75-1.03)**
TSK-11, median (IQR)	25 (21, 29)	27 (24, 32)	1.04 (0.98-1.10)
KOOS QoL, median (IQR)	50 (37.5, 56.2)	37.5 (31.3, 50)	0.98 (0.95-1.01)**
Magnetic Resonance findings	Return (n=73)	No return (n=55)	OR (95% CI)
Effusion	21 (28.8%)	33 (60%)	2.83 (1.20-6.65)*
Bone bruise FTJ	17 (23.3%)	31 (56.4%)	2.48 (1.05-5.84)*
Fracture	2 (2.7%)	9 (16.4%)	3.42 (0.68-17.23)**
Traumatic meniscal tear	8 (11%)	14 (25.5%)	2.65 (0.88-8.03)**
MCL/PCL distortion	11 (15.1%)	12 (21.8%)	0.92 (0.34-2.50)
ACL/PCL tear	12 (16.4%)	20 (36.4%)	2.05 (0.81-5.20)
Cartilage damage	15 (20.5%)	15 (27.3%)	1.07 (0.42-2.72)

MR: magnetic resonance. IQR: interquartile range. 95% CI; 95% confidence interval. OR: odds ratio. BMI: body mass index. MSK: musculoskeletal. FTJ: femorotibial joint. MCL: medial collateral ligament. LCL: lateral collateral ligament. ACL: anterior cruciate ligament. PCL: posterior cruciate ligament. *p=<0.05. **p=<0.20. † Unable to compute because of complete separation. [1]The variables 'sports in competition' and the 'Tegner score before trauma' were removed from the analysis because of multicollinearity with ball sport before trauma. [2]The variable 'trauma during ball sport' was removed from the analyses because of multicollinearity with trauma during sport. [3]The variables 'pain during previous week', the 'Lysholm score', 'KOOS pain', 'KOOS symptoms' and 'KOOS function in daily living' and KOOS sport and recreation were removed from the analyses because of multicollinearity.

Appendix Table 2 Results of the bivariate logistic regression analysis for return to sports after 3 months follow-up

	Return (n=175)	No return (n=60)	OR (95% CI)
Patient characteristics[1]			
Age in years, median (IQR)	33 (25, 39)	32 (27, 40.8)	1.04 (1.00-1.08)**
Male gender	110 (62.9%)	39 (65%)	0.85 (0.44-1.64)
BMI, median (IQR)	24.6 (22.8, 26.6)	24.2 (22.1, 26.9)	1.01 (0.92-1.10)
High educational level	76 (43.4%)	28 (46.7%)	1.45 (0.77-2.75)
MSK comorbidities	40 (22.9%)	14 (23.3%)	1.01 (0.47-2.17)
Previous knee complaints	69 (39.4%)	29 (48.3%)	1.38 (0.72-2.61)
Ball sport before trauma	76 (43.4%)	33 (55%)	1.24 (0.65-2.35)
Hours sport p/w, median (IQR)	3 (2, 5)	4 (2, 5)	1.03 (0.93-1.15)
Paid job before trauma	157 (89.7%)	55 (91.7%)	0.84 (0.24-2.96)
Hours spend on paid job p/w, median (IQR)	40 (32, 40)	38 (28, 40)	0.98 (0.95-1.02)
Trauma characteristics[2]			
Trauma during sport	110 (62.9%)	47 (78.3%)	2.45 (1.16-5.20)*
Rotational trauma	64 (36.6%)	37 (61.7%)	2.15 (1.12-4.14)*
Immediate pain	127 (72.6%)	47 (78.3%)	1.21 (0.57-2.55)
Immediate effusion	42 (24%)	18 (30%)	1.22 (0.61-2.44)
Continuation activity impossible	120 (68.6%)	45 (75%)	0.83 (0.39-1.74)
Popping sensation	52 (29.7%)	31 (51.7%)	2.32 (1.22-4.41)*
Severity of knee complaints[3]			
Invited afterward consultation	68 (38.9%)	18 (30%)	1.41 (0.63-3.15)
Effusion previous week	74 (42.3%)	46 (76.7%)	3.20 (1.53-6.71)*
NPRS previous 48h, median (IQR)	4 (2, 6)	6 (5, 7)	1.36 (1.15-1.60)*
Tegner score, median (IQR)	3 (2, 5)	2 (1, 4)	0.96 (0.82-1.13)
TSK-11, median (IQR)	25 (21, 28)	28 (24, 32)	1.05 (0.99-1.12)**
KOOS QoL, median (IQR)	50 (37.5, 56.3)	37.5 (31.3, 43.8)	0.96 (0.92-0.99)*
Magnetic Resonance findings	**Return (n=85)**	**No return (n=36)**	**OR (95% CI)**
Effusion	28 (32.6%)	22 (61.1%)	3.03 (1.23-7.51)*
Bone bruise FTJ	28 (32.6%)	17 (47.2%)	1.11 (0.46-2.67)
Fracture	5 (5.8%)	5 13.9%)	1.79 (0.46-6.89)
Traumatic meniscal tear	8 (9.3%)	12 (33.3%)	4.79 (1.65-13.91)*
MCL/PCL distortion	18 (20.9%)	4 (11.1%)	0.32 (0.10-1.08)**
ACL/PCL tear	16 (18.6%)	13 (36.1%)	1.96 (0.78-4.92)**
Cartilage damage	17 (19.8%)	10 (27.8%)	1.26 (0.48-3.31)

MR: magnetic resonance. IQR: inter quartile range. 95% CI; 95% confidence interval. OR: odds ratio. BMI: body mass index. MSK: musculoskeletal. FTJ: femorotibial joint. MCL: medial collateral ligament. LCL: lateral collateral ligament. ACL: anterior cruciate ligament. PCL: posterior cruciate ligament. *p=<0.05. **p=<0.20. † Unable to compute because of complete separation. [1]The variables 'sports in competition' and the 'Tegner score before trauma' were removed from the analysis because of multicollinearity with ball sport before trauma. [2]The variable 'trauma during ball sport' was removed from the analyses because of multicollinearity with trauma during sport. [3]The variables 'pain during previous week', the 'Lysholm score', 'KOOS pain', 'KOOS symptoms' and 'KOOS function in daily living' and KOOS sport and recreation were removed from the analyses because of multicollinearity.