

# Post-traumatic knee MRI findings and associations with patient, trauma and clinical characteristics: a subgroup analysis in primary care in the Netherlands

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*Br J Gen Pract* 2017;67(665):e851-e58. doi: 10.3399/bjgp17X693653.

## ABSTRACT

**Background:** The added value of MRI in primary care is still under debate. A high diagnostic yield can be expected in young and active patients with posttraumatic knee complaints. The aim of this study was to determine the frequency of MR abnormalities in these patients and the associations with patient, trauma and clinical characteristics.

**Methods:** This study is a subgroup analysis including 174 patients, aged 18-45 years and a knee trauma <6 months, allocated to MR imaging in a randomised controlled trial on the yield of MRI in primary care. Patients were recruited by 150 GPs from the Netherlands from October 2012 to November 2015. Associations were expressed using mean differences, odds ratio (OR) and predictive values.

**Results:** Sixty-seven patients (39%) had a positive MR finding, predominantly ACL ruptures (22%) and/or traumatic meniscal tears (15%). Patients with a pre-existing musculoskeletal comorbidity had a twofold lower prevalence of positive MR findings (24%), OR 3.0 (95%CI 1.3 to 7.0). A 'Sports related trauma' showed the highest OR of 4.6 (95%CI 2.2 to 9.3) for a positive MR finding. Clinical scores were statistically significant worse in patients with positive MR findings, with mean differences ranging 10-20%. Furthermore, increasing duration of complaints was correlated with decreasing prevalence rates of positive MR findings. Overall, a popping sound and a direct swelling showed the highest positive predictive value of 65% for the presence of a positive MR finding.

**Conclusion:** Our results enable a preselection of patients to increase the diagnostic yield of MR imaging in primary care.

## INTRODUCTION

General practitioners (GPs) are often consulted for posttraumatic knee complaints.<sup>1</sup> Of all sport injuries, the knee is the most commonly affected joint.<sup>2</sup> A trauma of the knee is known to have the highest burden of all sport injuries causing a substantial lowered quality of life in predominantly young and sportive patients.<sup>2,3</sup> They suffer from knee pain and an impaired knee function resulting in less mobility, work absenteeism and decreased sport participation.<sup>2,3</sup> Using Magnetic Resonance (MR) imaging, posttraumatic knee injuries can be diagnosed with a high diagnostic accuracy.<sup>4</sup> It is an established diagnostic tool in secondary care, mainly requested by orthopaedic surgeons in order to select what kind of treatment including surgery is needed.<sup>5,6</sup> During the past decades MRI is increasingly used in primary care as well, with the MR of the spine requested most, followed by respectively the knee and the brain.<sup>5,7,8</sup>

Negative MR findings could reassure patients and treatment in primary care can be continued. In case of positive findings, an early MR scan could contribute to an earlier diagnosis and dedicated treatment. Patients could earlier return to sports or work, with possible improved healthcare outcomes. Especially in young patients with posttraumatic knee complaints a high diagnostic yield can be expected.<sup>5,9-11</sup> Earlier studies in primary care evaluated prevalence rates of MR abnormalities in patients with knee complaints, however, these studies included older patients and patients with chronic knee complaints.<sup>5,11-13</sup> None of these studies assessed the associations of clinical outcomes with the overall MR result, including combinations of important MR findings.

Our goal was therefore to determine the frequency of MR findings in young patients (18-45 years) with posttraumatic knee complaints seen in general practice and to determine the associations with patient and trauma characteristics, duration of complaints and clinical scores.

## METHOD

### Study design

For the current study, data were used from the Traumatic Complaints of the Knee – LUMC and Erasmus MC (TACKLE) Trial, a multicentre randomised controlled trial (RCT) to determine the (cost-) efficacy of MRI requested by the GP in patients with a recent knee trauma. We published the full research protocol earlier.<sup>14</sup> Eligible patients were aged 18-45 years with knee complaints after a recent knee trauma in the preceding 6 months. Exclusion criteria were indications for direct referral (fracture or a locked knee), referrals to secondary care and/or MRI already performed, previous surgery of the affected knee, knee osteoarthritis diagnosed by a physician and contra-indications for MRI. Patients were included from October 2012 to November 2015 by 150 GPs in the Western part of the Netherlands. Eligible patients were selected during consultation by the GP or by an invitational letter from the GP within 12 weeks after the consultation. After

the baseline measurement, patients were evenly allocated to usual care or to MRI. In the MRI arm patients received an MR scan within 2 weeks after the baseline measurement, next to usual care. In the current study we present the results of the MRI group only.

### MR abnormalities

Prior to the start of this study, two orthopaedic surgeons (JV and RN), employed in two different participating centres of the TACKLE Trial, defined 'positive' MR findings that may need further specialized assessment and treatment by an orthopaedic surgeon. These were a trabecular fracture, a complete rupture of a collateral ligament, a meniscus tear, a cruciate ligament rupture and a full thickness cartilage defect. We developed a standardized knee MR report and trained the involved radiologists (appendix 1).

### Patient, trauma and clinical characteristics

We collected the patient characteristics age, gender and BMI and asked for the presence of musculoskeletal comorbidities, defined as pre-existing pain in the hip(s), ankle(s) or spine. We asked for duration of complaints and collected data on trauma characteristics, including the activity during trauma (sports, work, at home, traffic), the trauma mechanism (e.g. rotational, fall, bumping), a popping sensation, the duration from trauma to development of (1) pain and (2) swelling of the knee joint (directly, within 24 hours, within a few days) and the ability to continue their activity.

We used 3 subscales of the Knee Injury and Osteoarthritis Outcome Score (KOOS) to determine the clinical correlation of the MR abnormalities in the present study: the subscale pain (KOOS pain), symptoms (KOOS symptoms) and function in sports and recreation (KOOS sports).<sup>15</sup>

### Statistical analyses

We described the data using absolute numbers with frequencies for binary and categorical data, means with standard deviation (SD) for normally distributed data and medians with interquartile ranges (IQR) for non-normally distributed data. We dichotomized several categorical variables into sensible and clinically relevant variables (e.g. sports related vs non-sports related trauma). Prior to the start of the study all meniscal tears were defined as a positive MR finding. However, in the analyses presence of a horizontal meniscal tear was associated with higher age and not associated with duration of complaints, nor with any clinical outcome measure. Therefore, patients with a horizontal meniscal tear were excluded from the positive MR findings group. Furthermore, we combined presence of effusion and/ or synovitis into one variable 'effusion-synovitis' to assess the clinical correlations. We expressed the associations of MR findings with the collected patient, trauma and clinical characteristics using mean differences for continuous data assessed with the Student's T-test and odds ratios (OR) for dichotomous data using binary logistic regression analyses. Additionally we calculated the 95% Confidence Interval (95%CI) for all associations. We choose for the mean difference because this measure provide more directly relevant information than the correlation coefficient.<sup>16</sup> Furthermore, negative predictive values (NPVs) and positive

predictive values (PPVs) were calculated for the trauma characteristics and the presence of MR findings, using cross tabulations. To express the association of duration of complaints with the presence of MR findings and with mean clinical scores, we stratified all patients into 3 equal groups according to (increasing) days from trauma to MR scan. We determined the statistical significance of differences in prevalence and mean scores across the 3 strata using the 1-way ANOVA test. Statistical analyses were performed with IBM SPSS version 23.0.

## RESULTS

### Study population

In the TACKLE trial, 174 patients received an MR scan (table 1). The median time from baseline measurement to MR scan was 6 days (IQR 4, 9), with 93% of the patients receiving the MR scan within the scheduled 2 weeks after randomisation. Median duration of knee complaints was 42 days (IQR 17, 83).

**Table 1** Baseline patient, trauma and clinical characteristics of patients aged 18-45 with a recent knee trauma, seen in primary care, n=174

Variables	
Median age, years (IQR)	34 (26, 41)
Male, n (%)	110 (63)
BMI, mean (SD)	25.3 (3.9)
Musculoskeletal comorbidities, n (%)	39 (22)
Duration of complaints, median days (IQR)	42 (17, 83)
Sports related trauma, n (%)	105 (60)
Rotational trauma, n (%)	70 (40)
Popping sensation during trauma, n (%)	64 (37)
Direct pain after trauma, n (%)	127 (73)
Direct swelling after trauma, n (%)	43 (25)
Not able to continue activity after trauma, n (%)	124 (71)
KOOS Pain, mean (SD) <sup>a</sup>	58 (20)
KOOS Symptoms, mean (SD) <sup>b</sup>	61 (20)
KOOS Sports, mean (SD) <sup>c</sup>	35 (27)

n: number, IQR: interquartile range, SD: Standard Deviation. <sup>a,b,c</sup> Knee specific scores on respectively pain, symptoms and limitations in sports, ranging 0: worst score to 100: best score.

### Prevalence of MR findings

A positive MR finding was present in 67 patients (39%), mostly being an ACL rupture in 38 patients (22%) and/or a traumatic meniscal tear in 26 patients (15%) (table 2). A positive MR finding was in 49 patients (73%) accompanied by effusion-synovitis, in 43 patients (64%) accompanied by a

bone bruise and in 59 patients (88%) by effusion-synovitis and/or a bone bruise (figure 1). In 30 patients (17%) no abnormalities were found, leaving 77 patients (44%) with minor MR findings, not requiring an evaluation by an orthopaedic surgeon.

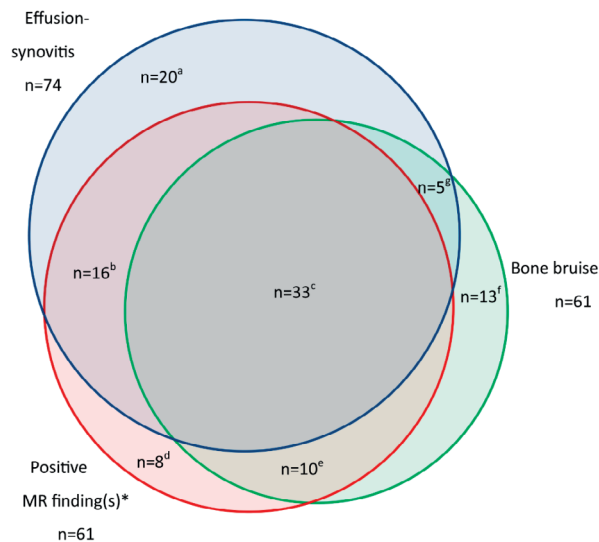
**Table 2** MR findings in patients aged 18-45 years with a recent knee trauma, seen in primary care, n=174

	Prevalence of MRI findings	
	n	%
<b>Knee trauma</b>		
<b>No abnormalities</b>	<b>30</b>	<b>17</b>
<b>Soft tissue</b>	<b>89</b>	<b>51</b>
Effusion	71	41
Synovitis	36	21
Baker's cyst	23	13
Bursitis	5	3
Ganglion	5	3
Thickened plica	6	3
<b>Bone bruises</b>	<b>61</b>	<b>35</b>
In femorotibial joint	60	35
Medial compartment	37	21
Lateral compartment	37	21
Medial and lateral	16	9
In patella	4	2
Trabecular fracture	12	7
<b>Cartilage defects</b>	<b>39</b>	<b>22</b>
Femorotibial joint	28	16
Partial thickness defects	19	11
Full thickness defects	9	5
Patellofemoral joint	17	10
Partial thickness defects	16	9
Full thickness defects	1	1
<b>Cruciate ligaments</b>	<b>40</b>	<b>23</b>
ACL rupture	38	22
Partial	21	12
Complete	17	10
PCL complete rupture	2	1
<b>Collateral Ligaments</b>	<b>27</b>	<b>16</b>
MCL partial distortion	16	15
MCL complete distortion	1	1
PCL partial distortion	2	1
<b>Menisci</b>	<b>67</b>	<b>39</b>
Medial meniscus	54	31
Muroid degeneration	12	7

**Table 2** MR findings in patients aged 18-45 years with a recent knee trauma, seen in primary care, n=174 (continued)

	Prevalence of MRI findings	
Horizontal tear	25	14
Traumatic tear	17	10
Lateral meniscus	26	15
Muroid degeneration	4	2
Horizontal tear	9	5
Traumatic tear	13	8
Medial and/or lateral tear	54	31
Horizontal	30	17
Traumatic	26	15
<b>Positive MR findings<sup>a</sup></b>	<b>67</b>	<b>39</b>

ACL: Anterior Cruciate Ligament, PCL: Posterior Cruciate Ligament, MCL: Medial Collateral Ligament, LCL: Lateral Collateral Ligament. <sup>a</sup>Positive MR findings: trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect.

**Figure 1** Venn diagram of combinations of MRI findings in patients aged 18–45 years with recent knee trauma, seen in primary care.

Shown here are all patients with effusion-synovitis and/or a bone bruise and/or a positive MRI finding (N = 95 patients). Overlapping areas represent combinations of MRI findings. <sup>a</sup>Positive MRI finding(s): trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect. <sup>b</sup>Knees with effusion-synovitis, but without a bone bruise and positive MRI findings. <sup>c</sup>Knees with a positive MRI finding and effusion-synovitis, but no bone bruise. <sup>d</sup>Knees with a positive MRI finding and effusionsynovitis and a bone bruise. <sup>e</sup>Knees with a positive MRI findings, but no effusion-synovitis or a bone bruise. <sup>f</sup>Knees with a positive MRI finding and a bone bruise, but no effusion-synovitis. <sup>g</sup>Knees with a bone bruise, but no positive MRI finding or effusion-synovitis. <sup>h</sup>Knees with effusion-synovitis and a bone-bruise, but no positive MRI finding.

**Table 3** Prevalence of MR findings and mean clinical scores according to duration of complaints from trauma to MR scan, stratified into 3 equal groups, n=174.

	Stratum 1 (n=58)		Stratum 2 (n=58)		Stratum 3 (n=58)		P-value	
	Duration of knee complaints (days)							
	N	n	%	n	%	n		%
				0-34	35-76	77-178		
<b>MR finding</b>	<b>N</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	<b>P-value</b>
Effusion-synovitis	74	39	67	21	36	14	24	<.001
Bone bruise	61	30	52	22	38	9	16	<.001
Fracture	12	9	16	3	5	0	0	.004
MCL distortion	27	15	26	9	16	3	5	.012
Horizontal meniscal tear	30	12	21	10	17	8	14	.690
Traumatic meniscal tear	26	9	16	13	22	4	7	.081
ACL rupture	38	18	31	14	24	6	10	.034
Full thickness cartilage defect	9	6	10	3	5	0	0	.048
Positive MR findings <sup>a</sup>	67	34	59	25	43	8	14	<.001
<b>Clinical outcome measures</b>	<b>N</b>	<b>mean (SD)</b>		<b>mean (SD)</b>		<b>mean (SD)</b>		<b>P-value</b>
KOOS pain <sup>b</sup>	174	47 (18)		61 (19)		66 (19)		<.001
KOOS symptoms <sup>c</sup>	174	50 (17)		62 (19)		72 (18)		<.001
KOOS sports <sup>d</sup>	174	18 (20)		39 (27)		48 (24)		<.001

n: number, ACL: anterior cruciate ligament, MCL: medial collateral ligament. <sup>a</sup>Positive MR findings: trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect. <sup>b,c,d</sup>Knee specific scores on respectively pain, symptoms and limitations in sports, ranging 0: worst score to 100: best score

### Associations of MR findings with patient and clinical characteristics

Higher age was correlated with the presence of a horizontal meniscal tear, but with no other MR abnormality. Patients with a horizontal meniscal tear had a mean age of 38 (SD 7) years, compared to a mean age of 32 (SD 8) years in patients without a horizontal meniscal tear; mean difference 6 (95%CI 3 to 9) years. Furthermore, patients with pre-existing musculoskeletal comorbidities had a statistically significant lower prevalence of positive MR findings; 8 of 39 patients (21%) compared to 59 of 135 patients (44%) without a musculoskeletal comorbidity, OR 3.0 (95%CI 1.3 to 7.0). No statistically significant associations were found for BMI or gender with the presence of MR findings.

The longer the duration of complaints, the fewer MR abnormalities were present and the fewer knee specific symptoms were reported (table 3). Only patients with a horizontal meniscal tear were evenly distributed across the three strata.

The group with positive MR findings had statistically significant worse scores on all 3 tested KOOS subscales, with the highest mean difference of 22 (95%CI 15 to 30) in the KOOS sports score. Most single positive MR findings showed a statistically significant association with clinical scores, with the exception of the horizontal meniscal tear. Also effusion/synovitis and the presence of a bone bruise were associated with significantly worse scores on the three KOOS subscales, with mean differences ranging 10 to 19 (95%CI 4 to 27).



**Table 4** Trauma characteristics and associations with the predictive values for the MR abnormalities in patients aged 18-45 years and a recent knee trauma seen in primary care, n=174

Trauma characteristics	n	ACL rupture n=38 (22%)			Traumatic meniscal tear n=26 (15%)			Positive MR finding(s) <sup>a</sup> n=67 (39%)			
		OR (95%CI)	NPV	PPV	OR (95%CI)	NPV	PPV	OR (95%CI)	NPV	PPV	
Sports related trauma	yes	105	3.7	90	30	3.2	93	20	4.6	81	51
	no	69	(1.5 to 9.0)			(1.1 to 8.9)			(2.2 to 9.3)		
Rotational trauma	yes	70	1.1	79	23	1.9	88	20	2.0	68	49
	no	104	(0.5 to 2.3)			(0.8 to 4.4)			(1.1 to 3.8)		
Popping sound	yes	64	3.1	85	34	3.3	91	25	2.1	68	50
	no	113	(1.5 to 6.5)			(1.4 to 7.9)			(1.1 to 4.0)		
Direct pain	yes	127	3.9	91	26	2.3	91	17	3.0	79	45
	no	47	(1.3 to 11.8)			(0.7 to 6.9)			(1.4 to 6.6)		
Direct swelling	yes	43	1.6	80	28	1.1	85	16	2.0	66	51
	no	131	(0.7 to 3.5)			(0.4 to 2.9)			(1.0 to 4.0)		
Inability to continue activity	yes	124	2.6	88	26	1.4	88	16	2.5	76	44
	no	50	(1.0 to 6.6)			(0.5 to 3.8)			(1.2 to 5.3)		
<b>Combinations</b>											
Popping sound and direct swelling	yes	17	2.8	80	41	3.7	87	35	3.3	64	65
	no	157	(1.0 to 8.1)			(1.2 to 11.2)			(1.2 to 9.4)		
Rotational trauma and direct swelling	yes	21	1.5	79	29	0.6	86	19	3.0	65	62
	no	153	(0.5 to 4.2)			(0.4 to 4.6)			(1.2 to 7.6)		

<sup>a</sup>Positive MR findings: trabecular fracture, traumatic meniscal tear, cruciate ligament rupture, complete rupture collateral ligament and/or a full thickness cartilage defect. ACL: anterior cruciate ligament, n: number of patients, OR: odds ratio, 95%CI: 95% Confidence Interval. NPV= Negative Predictive Value, PPV: Positive Predictive Value, both expressed in percentages.

### Associations of MRI findings with trauma characteristics

Associations of MRI findings with trauma characteristics All trauma characteristics were statistically significantly associated with the presence of one or more positive MRI finding, of which sports-related trauma showed the strongest association (Table 4). Of the six trauma characteristics, four were associated

with a higher prevalence of ACL rupture, of which 'direct pain after trauma' showed the strongest association with an OR of 3.9 (95% CI = 1.3 to 11.8). Overall high NPVs were observed: highest for sports-related trauma and direct pain after trauma, with NPVs ranging from 90% to 93%. Furthermore, highest PPVs for a positive MRI finding were seen for the combinations of a popping sound during trauma and a direct swelling, and for a rotational trauma with a direct swelling, with PPVs ranging from 62% to 65% (Table 4). The classical combination of a popping sound and a direct swelling showed a 41% PPV for an ACL rupture.

## DISCUSSION

### Summary

In this study we determined the MR findings in young adults with a recent knee trauma seeking medical attention in primary care. Almost 40% of the patients had one or more positive MR finding potentially requiring further evaluation by an orthopaedic surgeon. These findings were usually accompanied by effusion-synovitis and/or a bone bruise. Patients without a pre-existing musculoskeletal comorbidity showed a twofold higher prevalence of these positive MR findings. Increasing duration of complaints was associated with decreasing prevalence rates of positive MR findings. Six trauma characteristics showed a statistically significant association with positive MR findings of which a sports related trauma showed the highest OR. A popping sound with direct swelling showed the highest PPV for a positive MR finding. Patients with a positive MR finding showed statistically significant more impaired knee function and more knee pain.

### Strengths and limitations

A strength of our study is the selection of patients in which the highest yield of MR imaging is expected, including young patients aged 18 to 45 years with posttraumatic knee complaints, thereby excluding older patients with possible degenerative findings which are often confusing to clinicians and lack therapeutic options. Furthermore, we focused on the overall MR result and correlated this with clinical scores, not exclusively concentrating on single ligamentous or meniscal injuries.

Limitations could be noticed as well. We gathered no information on the findings of physical examination performed by the GP. This decision was based on logistic reasons with the primary goal of the TACKLE trial being the yield of MR imaging in primary care, but also on evidence from the literature showing the minor to absent additive value of physical examination of the knee by GPs for the diagnosis of ACL ruptures and meniscal tears.<sup>13,17,18</sup> Furthermore, the tested associations in this study were based on MR findings, not confirmed by arthroscopy. However, MR imaging is known to have a high diagnostic accuracy for posttraumatic knee injuries.<sup>19</sup> A few false positive or false negative findings could have been made, probably not influencing our main results.

### Comparison with existing literature

#### *Prevalence of MR findings*

Our prevalence rates are comparable with earlier studies in patients with posttraumatic knee complaints seen in primary care. In our sample, 15% of the patients had a traumatic meniscal tear, this is comparable with the prevalence rate of 17% in a similar group of primary care patients.<sup>12</sup> We observed an overall meniscal tear prevalence rate of 31%, in contrast to 47% in the aforementioned study. This could be due to the relatively older patients included in their study with a mean age of 41 year.<sup>12</sup> For ACL ruptures, these authors found a prevalence rate of 17%. In

another study in primary care (with a trauma rate of 66%) 18% of the patients had an ACL rupture, in our cohort this was 22%.<sup>13</sup>

### **Horizontal meniscal tears**

Another marked finding was the relative high frequency (17%) of horizontal meniscal tears in our targeted population, which were not associated with higher scores on pain or function loss. A horizontal tear is generally believed to be of degenerative origin. First a linear signal change inside the meniscus develops, reflecting slowly developing meniscal degradation; most of these signal changes later progress to horizontal meniscal tears.<sup>20</sup> Earlier studies already suggested these tears were an incidental finding, but these studies were performed in older patients.<sup>12,20,21</sup> Our results provide additional evidence that an isolated horizontal meniscal tear should be considered an age related phenomenon, not requiring referral to an orthopaedic surgeon, even in relatively young adults with posttraumatic knee complaints.

### **Duration of complaints**

An important finding in this study was the decreasing prevalence rates of most MR findings with increasing duration of complaints. This was also true for the prevalence rate of positive MR findings. We expected the clinical outcome scores to improve over time, but did not foresee this clear association. An earlier study assessed duration of complaints and the association with the prevalence of positive MR findings, but found no statistically significant difference.<sup>22</sup> However, in that study, the mean duration of symptoms was over 6 months, a time period in which the effect is probably diminished. Our finding can be explained by the natural recovery of patients in which bone bruises resolve, effusion diminishes and injuries to the meniscus and collateral ligaments heal. There is also evidence that partial and even complete ACL ruptures are able to regain continuity over time, although our time span might be too short for this event to occur.<sup>23</sup> Another possible explanation is that earlier consultation was achieved by patients with more severe complaints, resulting in a shorter period from trauma to MR imaging.

### **Patient, trauma and clinical characteristics**

A new finding in this study is the association of pre-existing musculoskeletal comorbidities with a lower prevalence of positive MR findings. A musculoskeletal comorbidity is known to be associated with a higher score on knee specific pain subscales<sup>24</sup>, but to our knowledge, no earlier studies reported on the lower prevalence of MR findings in these relative young patients with a recent knee trauma. Future studies should confirm our finding. The strongest association of a trauma characteristic with positive MR findings was a 'sports related trauma', with a 30% higher prevalence rate of positive MR findings compared to a non-sports related knee trauma. This association was not found in previous studies.<sup>17,18,25</sup> However, a recent study confirmed a statistically significant association of a sport-related trauma with a higher prevalence of medial meniscal tears, compared to patients with a non-sports related knee trauma.<sup>26</sup>

### Implications for practice

In this paper we presented an overview of MR findings observed in a population of young patients (aged 18-45 years) with traumatic knee complaints. Several patient, trauma and clinical characteristics associated with positive MR findings were identified. Duration of complaints should be taken into account by the GP when referring a patient for an MR scan to appraise the possible yield of MR imaging. A sports related trauma is a strong predictor for positive MR findings, while presence of a musculoskeletal comorbidity results in less positive MR findings. Furthermore, horizontal meniscal tears are even in relatively young adults with a recent knee trauma an incidental finding without clinical relevance. The predictive values of the trauma characteristics could enable a preselection of patients with a greater likelihood to have an abnormal MR scan, thereby increasing the yield of MR imaging in primary care.

#### How this fits in

At a time of ongoing discussion about the added value of magnetic resonance imaging (MRI) in primary care, a subgroup analysis was conducted with all patients allocated to MRI in a randomised controlled trial. A potential subgroup of patients that could benefit from MRI was studied. It contained relatively young patients (18-45 years) with post-traumatic knee complaints. The MRI findings were expounded and several patient, trauma and clinical characteristics associated with higher prevalence rates of positive MRI findings were identified. The study findings help GPs to preselect patients with post-traumatic knee complaints in whom an increased diagnostic yield of MRI can be expected

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### Appendix 1 Standardized knee MR report

Six hospitals and MR centres were involved in this trial. Prior to the start of the study, our project group's radiologists (MR, HB, PA) evaluated and approved all 'acute knee' MR protocols used in each centre. These protocols were optimized for each MR scanner, were familiar to the radiologists in that particular centre and provided a good reflection of the actual diagnostics used in the Netherlands. All protocols included sequences in the sagittal, coronal and transversal planes, with at least one sequence with fat suppression and one gradient echo sequence targeted on cartilage damage. All protocols were executed on 1.5 Tesla MR system using dedicated knee coils. Twelve musculoskeletal radiologists were involved in the study and were trained prior to the start of the study. We developed a standardized MR knee report, based on the MR knee report template of the Radiological Society of North America<sup>1</sup>, the latest literature and experts' opinions (musculoskeletal radiologists and orthopaedists). Furthermore, we developed a traumatic knee MR atlas that could be consulted by all collaborating musculoskeletal radiologists.

Below we present the structured MR knee report that was filled in by the radiologist, in addition to the original free text report sent to the general practitioner.

#### MR knee report

- What is the date of the MR scan?
- Which side is scanned?
- Are there any abnormalities on this MR scan? If yes, specify:

#### Soft tissue

Are there any abnormalities in the soft tissue? If yes, specify:

- Effusion (only moderate to severe)
- Synovitis
- Bursitis, specify [free text]
- Baker's cyst
- Subcutaneous oedema
- Ganglion, specify [free text]
- Plica
- PVNS
- Other, specify [free text]

#### Extensor mechanism

Are there any abnormalities of the extensor mechanism? If yes, specify:

- Quadriceps tendon, specify [free text]
- Patellar tendon, specify [free text]
- Patellar retinaculum, specify [free text]
- Other, specify [free text]

#### Bone and bone marrow

Are there any abnormalities of the bone or bone marrow? If yes, specify:

- Bone bruise, if yes, specify:
  - Medial femurcondyl
  - Intercondylar femoral notch
  - Lateral femurcondyl
  - Medial tibial condyle
  - Central tibial condyle
  - Lateral tibial condyle
  - Fibular head
  - Patella

- Osteochondral defect (specified location as above)
  - Stage II (Subchondral cysts and/or partial disruption of osteochondral lesion with bone marrow edema)
  - Stage III (Complete disruption osteochondral lesion with surrounded by fluid)
  - Stage IV (Dislocated osteochondral fragment)
- Are there any abnormalities of the trochlea? e.g. dysplastic trochlea medial/ lateral, patellar tilt or subluxation (lateralisation) If yes, specify [free text]
- Is there a fracture? If yes specify, location and morphology (trabecular/micro, impression, stress, avulsion, Segond)
- Are there any other abnormalities of the bone or bone marrow? If yes, specify [free text]

#### Menisci<sup>2,3</sup>

Are there abnormalities of the menisci? If yes, specify:

- Mucoïd degeneration, yes/no, if yes: specify medial and/or lateral
- Meniscal tear A tear is present with an abnormal shape of the meniscus or with an increased signal within the meniscus, extending to the surface., yes/ no:
- Medial meniscus tear? If yes:
  - Location:
    - o Anterior horn
    - o Body
    - o Posterior horn/ root
  - Type or shape of tear:
    - o Longitudinal/ vertical
    - o Horizontal
    - o Radial
    - o Complex: bucket handle
    - o Complex: other
- Lateral meniscus tear? If yes (same as above):...
- Other meniscal pathology?
  - Parameniscal cyst, specify [free text]
  - Meniscal extrusion (>3mm), specify [free text]
  - Disrupted/ dislocated meniscal fragment, specify [free text]
  - Discoid meniscus, specify [free text]
- Abnormalities of a meniscal ligament, specify [free text]
- Other, specify [free text]

#### Cruciate ligaments<sup>4</sup>

Are there abnormalities of the cruciate ligaments? If yes, specify:

- Mucoïd degeneration, anterior/ posterior ligament?
- Rupture
  - Anterior/ posterior
    - o Partial
    - o Complete

#### Collateral ligaments

*Including medial collateral ligament and posterolateral corner.*

Are there abnormalities of the collateral ligaments? If yes, specify:

- Medial collateral ligament
  - Partial rupture:



- o Grade 1 distortion (high signal medial or superficial of ligament, normal signal of the ligament itself)
- o Grade 2 distortion (high signal medial of ligament with a high signal within the ligament itself)
- Complete rupture:
  - o Grade 3 distortion
- Posterolateral corner, if yes (same as above):...

#### Cartilage

Are there abnormalities of the cartilage? If yes, specify:

- Grade:
  - Grade I: focal spots of hyper intensities, normal contour of the cartilage
  - Grade II: <50% cartilage thickness defect
  - Grade III: 50-100% cartilage thickness defect
  - Grade IV: full thickness cartilage defect
- Location:
  - Patellofemoral joint: patella
  - Patellofemoral joint: femoral side: anterior/ trochlea
  - Medial femoral condyle
  - Lateral femoral condyle
  - Medial tibial condyle
  - Central tibial condyle
  - Lateral tibial condyle

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