

# Predicted probability of meniscus tears: comparing history and physical examination with MRI

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## Summary

**BACKGROUND:** The indication for surgical treatment of a meniscal lesion should not only rely on magnetic resonance imaging (MRI) findings, but also on a detailed history and a thorough clinical examination. However, various intra-articular lesions may often produce similar symptoms. So, what kinds of symptoms are more associated with a meniscal tear? Is MRI worth doing?

**OBJECTIVE:** The aims of this study were to identify sensitive and specific clinical tests and elements of patients' history with a high predictive value, and to assess the combined diagnostic accuracy of sensitive and specific clinical tests and elements of patients' history with MRI.

**METHODS:** Data from 281 consecutive knee arthroscopies to investigate and treat suspected internal knee pathologies were retrospectively collected between March 2009 and April 2010. The study group consisted of 262 knees. Statistically significant factors in the clinical diagnosis of meniscal tears were screened by a chi-square test. Logistic regression analysis was used to determine which factors associated with meniscal tears found during arthroscopy. The diagnostic values of MRI and the sensitive and specific clinical tests and elements of patients' history with high predictive value for meniscal tears were calculated.

**RESULTS:** The overall diagnostic value of MRI for meniscal tears was: accuracy, 88.8%; sensitivity, 95.7%; specificity, 75.8%; positive predictive value (PPV), 88.2%; and negative predictive value (NPV), 90.4%. Giving way, locking and McMurray's test were independent diagnostic factors with a predicted correct percentage of 80.0% ( $p < 0.05$ ) for the diagnosis of meniscal tears found during arthroscopy. Locking, McMurray's test and MRI increased the predicted correct percentage of meniscal tears found during arthroscopy to 91.6% ( $p < 0.05$ ). For the diagnosis of meniscal tears found during arthroscopy, giving way, locking and McMurray's test had the following values for accuracy (49.2, 60.9, 76), sensitivity (43.5, 55.2, 75.8), specificity (84, 96, 76.9), PPV (94.4, 98.8, 95.1) and NPV (19.4, 25.8, 35.1). Combining MRI, the diagnostic values

of giving way, locking, and McMurray's test were: accuracy, 88.3, 89.9, 89.4; sensitivity, 95.7, 97.4, 97.4; specificity, 74.2, 75.8, 74.2; PPV, 87.5, 88.4, 87.7; and NPV, 90.2, 94, 93.9.

**CONCLUSIONS:** Giving way, locking and McMurray's test are independent clinical diagnostic factors for the diagnosis of meniscal tears. MRI has higher accuracy, sensitivity and NPV for the diagnosis of meniscal tears than giving way, locking and McMurray's test. The combination of giving way, locking, McMurray's test and MRI for confirmation is typical for a meniscal lesion diagnosis. Based on these findings, MRI should be used in a standard manner to detect meniscal tears found during arthroscopy.

**Key words:** locking; McMurray's test; magnetic resonance imaging (MRI); meniscus tear

## Introduction

Meniscus tears, seen in young and old patients alike, are an extremely common cause of knee pain [1]. Incidental meniscal findings on magnetic resonance imaging (MRI) of the knee are common in the general population and increase with increasing age. Among persons with radiographic evidence of osteoarthritis (Kellgren-Lawrence grade 2 or higher), the prevalence of a meniscal tear was found to be higher than the corresponding prevalence among persons without radiographic evidence of osteoarthritis [2]. Arthroscopic surgery in patients with moderate-to-severe osteoarthritis of the knee provides no additional benefit to optimised physical and medical therapy [3]. It is important to make an accurate diagnosis of meniscus tears so that the appropriate treatment can be given. A detailed history and physical examination can help differentiate patients who have a meniscus tear from those whose knee pain arises from other conditions [4–6]. MRI is the test commonly used on patients with meniscus tears of the knee because of its ability to diagnose meniscal tears [7–9]. MRI is commonly used because various intra-articular lesions historically have had common symptoms, patient history

alone is inadequate as a diagnostic tool, and the diagnostic accuracy of clinical tests for meniscal tears has often been questioned. A review of the available literature reveals conflicting results as to their usefulness [10–15]. If the patient had no clinical symptoms, even though MRI showed meniscal tears of a patient, knee arthroscopy was unnecessary. In a high percentage of cases, relying on MRI alone without using clinical judgment may have led to inappropriate treatment. In any case, MRI did not prevent “unnecessary surgery” [16]. The aims of this study were to identify sensitive and specific clinical tests and elements of patients’ history with high predictive value, and to assess the combined diagnostic accuracy of sensitive and specific clinical tests and elements of patients’ history with MRI by using arthroscopy as a gold standard for control.

## Materials and methods

### Study population

Institutional review board approval was obtained before beginning the study, allowing a retrospective review of patient records and images without informed consent.

We retrospectively collected data from 281 consecutive knee arthroscopies performed by 2 experienced knee surgeons between March 2009 and April 2010 to investigate and treat suspected internal knee pathologies [17]. A total of 19 knees which had had previous meniscectomies, knee ligament repair, or reconstruction and knee arthroscopy were excluded from the study (fig. 1). The study group consisted of 262 knees and their medical records were subsequently reviewed for relevant clinical history, MRI reports and operative findings. There were 115 male and 135 female patients in the age group of 7–78 years, with a median age of 41. There were 138 (53%) left knees and 124 (47%) right knees in the study group. The mechanisms of tear for the 262 knees included beyond recall (88 knees, 33.59%), twisting (101 knees, 38.55%), jumping–landing (39 knees, 14.88%), trauma (29 knees, 11.07%), and valgus–varus stress (5 knees, 1.91%).

### Clinical history and index items

Clinical data (including patient demographics, waiting period between MRI and arthroscopy), suggestive symptoms (including pain, swelling, limited motion, giving way locking, and clicking), physical examination, mechanism of tear, clinical diagnosis and operative details were re-

viewed and analysed. Clinical tests included quadriceps atrophy, joint line tenderness test, induration around knee joint, varus or valgus deformity, lack of flexion or extension, floating patella test, Soto-holl test, Apley’s test, McMurray’s test, Kellogg-Speed test, pain on hyperextension and pain on hyperflexion.

### MRI examinations and arthroscopy

All MRI examinations were performed at our institution with a 1.5-T superconducting magnet (Signa, GE Healthcare, USA) and a dedicated knee extremity coil. For most of the examinations, high-resolution FSE proton density–weighted and fat-suppressed, FSE T2-weighted paired sequences were performed in the sagittal and coronal planes. Fat-suppressed, FSE T2-weighted images were also obtained in the axial plane. FSE proton density–weighted sequence parameters were as follows: 2 signals acquired; TR/TE, 2,000/18; echo-train length, 4; receiver bandwidth, 32 kHz; matrix, 256 × 256; field of view, 14–16 cm; and slice thickness, 3 mm. Fat-suppressed, FSE T2-weighted sequence parameters were 2 signals acquired; TR/TE, 4,000/50; echo-train length, 8; receiver bandwidth, 20 kHz; matrix, 256 × 256; field of view, 14–16 cm; and slice thickness, 3 mm. There were 179 knees with suspected meniscal tears that underwent MRI within 6 weeks before arthroscopy. MRI reports of 179 knees with suspected meniscal tears were reviewed and analysed.

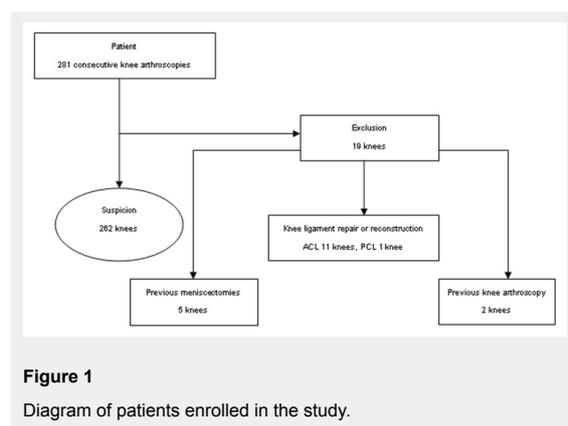
Arthroscopies were performed under general anaesthesia and the usual technique by 2 experienced knee surgeons [18, 19]. Arthroscopy findings served as the study’s gold standard.

### Statistical analysis

The composite data was tabulated on a Microsoft Excel spreadsheet and studied for correlation. The diagnostic accuracy of MRI and the sensitive and specific clinical tests and elements of patients’ history with high predictive value for meniscal tears were determined by calculating sensitivity (Se), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV). Continuous variables were summarised using median values. Categorical variables were summarised using frequency and were compared using the chi-square or McNemar test as appropriate. Logistic regression analysis was used to examine correlations with regard to suggestive symptoms, clinical tests and MRI results associated with meniscal tears. Correlation of the clinical examination and MRI with arthroscopy from the pooled data of 262 knees was expressed as a percentage. All the tests were 2-sided, and a *p*-value of less than 0.05 was considered to be statistically significant. Analyses were performed using SPSS version 13.0 (SPSS, Chicago, IL, USA).

## Results

Of the 262 knees, 189 knees with a meniscal tear were identified at surgery in 180 patients. There were 89 male and 91 female patients in the age group of 7–77 years, with a median age of 41. There were 85 (45%) left knees and 104 (55%) right knees. There were 82 lateral meniscus tears (and 36 discoid lateral meniscus accompanied men-



iscus tears) and 77 medial meniscus tears. There were 179 knees with a suspected meniscal tear that underwent MRI within 6 weeks before arthroscopy (median = 1.3 weeks). The operative diagnoses of 262 knees were meniscal tear (189), osteoarthritis (134), synovial disease (122), loose body (66) and others (30) as listed in table 1.

Of 179 knees that underwent MRI, the operative diagnoses were meniscal tear (117), osteoarthritis (87), synovial disease (68), and loose body (26). Positive findings of MRI were meniscal tear (112), osteoarthritis (11), synovial disease (3), and loose body (4). Of the 179 knees with an MRI diagnosis of suspected meniscal tears, 112 were confirmed on MRI and arthroscopy (true positive); 47 knees had no evidence of meniscal tear on MRI and arthroscopic procedure (true negative); 15 knees which didn't have meniscal tears confirmed by arthroscopy were misinterpreted by MRI (false positive); and 5 knees with meniscal tears confirmed by arthroscopy were not diagnosed by MRI (false negative). MRI diagnosis had an accuracy of 88% for meniscal tears (sensitivity 96%, specificity 76%, positive predictive value 88% and negative predictive value 90%) (table 2).

By performing the chi-square test it was found that items such as swelling, giving way, locking, quadriceps atrophy, joint line tenderness test, lack of flexion or extension, Apley's test, McMurray's test, Kellogg-Speed test, pain on hyperextension, and pain on hyperflexion were common in meniscus tears ( $p < 0.05$ ). The results of univariate analysis by chi square analysis are given in table 3.

Multivariate logistic regression analysis of those significant clinical variables showed that giving way, locking and McMurray's test were independent diagnostic factors with a predicted correct percentage of 80.0% ( $p < 0.05$ ) for the diagnosis of meniscal tears found during arthroscopy (table 4).

We knew that MRI was also a diagnostic factor, and multivariate logistic regression analysis of all the significant variables including clinical items and MRI showed that locking, McMurray's test and MRI were independent diagnostic factors with a higher predicted correct percentage (91.6%) ( $p < 0.05$ ) (table 5).

By using logistic regression analysis of the significant variables (swelling, giving way, locking, quadriceps atrophy, joint line tenderness test, lack of flexion or extension,

Apley's test, McMurray's test, Kellogg-Speed test, pain on hyperextension, and pain on hyperflexion), giving way, locking and McMurray's test were independent diagnostic factors for the diagnosis of meniscal tears.

As 179 knees underwent MRI, in order to compare the value of clinical examination and patients' history with MRI concerning their power to predict a meniscal lesion, we calculated the sensitivity (Se), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV) of giving way, locking, and McMurray's test of 179 knees with MRI. The diagnostic accuracy of giving way, locking, and McMurray's test for meniscal tears are listed in table 6. Giving way, locking and McMurray's test had the following values, respectively, for the diagnosis of meniscal tears: accuracy, 49.2, 60.9, 76; sensitivity, 43.5, 55.2, 75.8; specificity, 84, 96, 76.9; PPV, 94.4, 98.8, 95.1; and NPV, 19.4, 25.8, 35.1. Combining with MRI, the diagnostic accuracy values of giving way, locking, McMurray's test for the diagnosis of meniscal tears found during arthroscopy were: accuracy, 88.3, 89.9, 89.4; sensitivity, 95.7, 97.4, 97.4; specificity, 74.2, 75.8, 74.2; PPV, 87.5, 88.4, 87.7; and NPV, 90.2, 94, 93.9 (table 6). When considering a positive clinical history and/or physical examination (i.e., patients who are symptomatic), the combined diagnostic accuracy of positive locking and positive McMurray's test was: accuracy, 50.8; sensitivity, 43.5; specificity, 96, PPV 98.5, and NPV 21.6. The combined diagnostic accuracy of positive giving way and positive locking and positive McMurray's test was: accuracy, 36.3; sensitivity, 26.6; specificity, 96; PPV, 97.6; and NPV, 17.5 (table 6).

## Discussion

The frequent association of meniscal tears with other intra-articular lesions has been observed. Meniscal tears and other intra-articular lesions also have common symptoms [20–23]. We used 262 samples from 250 individuals with or without meniscal lesions to gain a better estimation of history and physical examination's specificity, and to thus more accurately identify optimal clinical tests to predict the presence of a meniscal tear found in arthroscopy.

As it has been found that McMurray's, joint line tenderness and Apley's [24] tests are not diagnostically accurate when used alone, for example, joint line tenderness was sensitive

**Table 1:** Demographic data of 189 knees with meniscus tears and operative diagnoses of 262 knees.

Knee category	No. of knees	Sex		Median patient age (y)	Lesion location				Median interval (wk) between MRI and surgery
		Male	Female		left	right	lateral (discoid lateral meniscus)	medial	
All knees	262	115	135	41 (7–78)	138	124	82 (36)	77	1.3
Meniscal tear	189	89	91	41 (7–77)	85	104			
Osteoarthritis	134								
Synovial disease	122								
Loose body	66								
Other	30								

**Table 2:** Diagnostic values of MRI for meniscal tears.

Diagnosis	True positive	True negative	False positive	False negative	Accuracy (%)	Se (%)	Sp (%)	PPV (%)	NPV (%)
Meniscal tear	112	47	15	5	88.8	95.7	75.8	88.2	90.4

Note: Se: specificity; Sp: specificity; PPV: positive predictive values; NPV: negative predictive values.

(75%) but not specific (27%), while the McMurray's test was specific (97%) but not sensitive (52%) [11], the diagnostic value of a history plus a physical examination is limited. In unclear situations, the clinician requests an MRI for additional information to aid planning the operation and to predict the prognosis. However, many studies have shown no significant differences in the clinical and MRI diagnosis of meniscal tears [16, 25–30]. For example, the sensitivity of MRI for detecting tears of the posterior horn of the lateral meniscus is lower than for tears at other meniscal locations [31]. One study even showed that, when the MRI was normal, high clinical suspicion and a skilled

clinical examination were more reliable [24]; another study showed that 37% of the operations supported by a significant disorder on MRI were unjustified [32]. Several investigators combined these tests with other components of the physical examination such as patient history and imaging [24, 26, 33]. Unfortunately, no conclusions can be drawn when examining these studies, due to their vast differences. In this study, univariate analysis by the chi-square test revealed that history and physical findings such as swelling, giving way, locking, quadriceps atrophy, joint line tenderness test, lack of flexion or extension, Apley's test, McMurray's test, Kellogg-Speed test, pain on hyperexten-

**Table 3:** Results of univariate analysis by chi square analysis.

Index items	Odds Ratio Value	95% Confidence Interval		Asymp. Sig. (2-sided) ( $p < 0.05$ )
		Lower	Upper	
Pain	0.708	0.306	1.634	0.416
Swelling	0.547	0.317	0.945	0.029
Limited motion	0.639	0.370	1.102	0.106
Giving way	5.586	2.536	12.303	0.000
Locking	3.739	2.043	6.843	0.000
Clicking	2.608	0.748	9.094	0.120
Quadriceps atrophy	2.426	1.373	4.287	0.002
Joint line tenderness test	3.393	1.919	6.001	0.000
Induration around knee joint	0.366	0.114	1.175	0.155
Varus or valgus deformity	1.957	0.225	17.038	0.536
Lack of flexion or extension	0.315	0.128	0.777	0.009
Floating patella test	1.792	0.706	4.552	0.215
Soto-holl test	0.761	0.439	1.321	0.332
Apley's test	11.652	4.820	28.171	0.000
McMurray's test	13.897	6.656	29.014	0.000
Kellogg-Speed test	0.356	0.135	0.935	0.030
Pain on hyperextension	4.786	1.418	16.157	0.006
Pain on hyperflexion	0.072	0.008	0.630	0.009

**Table 4:** Results of multivariate logistic regression analysis of the significant clinical variables.

Variables	B	Sig.
Giving way	1.003	0.030
Locking	0.769	0.037
McMurray's test	2.407	0.000
Swelling	0.098	0.755
Quadriceps atrophy	1.421	0.233
Joint line tenderness test	0.751	0.386
Lack of flexion or extension	0.851	0.356
Apley's test	1.250	0.264
Kellogg-Speed test	1.348	0.246
Pain on hyperextension	0.023	0.879
Pain on hyperflexion	1.965	0.161

**Table 5:** Results of multivariate logistic regression analysis of the significant clinical variables and MRI.

Variables	B	Sig.
Locking	3.009	0.005
McMurray's test	1.531	0.009
MRI	2.262	0.001
Swelling	0.304	0.581
Giving way	0.112	0.738
Quadriceps atrophy	0.003	0.960
Joint line tenderness test	1.289	0.256
Lack of flexion or extension	2.618	0.106
Apley's test	0.182	0.669
Kellogg-Speed test	1.741	0.187
Pain on hyperextension	0.197	0.657
Pain on hyperflexion	0.186	0.667

sion, and pain on hyperflexion were diagnostic factors for a meniscal tear. By logistic regression analysis of the significant clinical variables, giving way, locking and McMurray's test were independent diagnostic factors with a predicted correct percentage of 80.0% ( $p < 0.05$ ) for exhibiting a meniscal tear confirmed by arthroscopy. For the time being, history taking and physical examination, albeit of limited use, should be considered with individual patient demands to provide the basis for further evaluation; synthesis of a group of examination manoeuvres and historical items may be required for adequate diagnosis [34].

Abdon et al. [35] reported that clinical accuracy in diagnosing meniscal tears was 61%, but a combination of patient reported symptoms increased the predictive value of identifying a meniscal lesion to 70–80%. Researchers in that study had been able to determine variables of significant importance by discriminate analysis.

However, patient history and physical examination alone did not provide clinicians with levels of certainty in the 90th percentile that a patient had a meniscal tear. As clinical diagnosis was difficult, all possible steps should be taken to avoid errors [35].

The MRI accuracy for meniscal tears achieved in our study corresponds to that found by others [28, 36–38]. In this study, if an MRI was included in the model, the results of logistic regression analysis were that locking, McMurray's test and MRI were statistically higher risk factors in knee arthroscopy individuals with meniscal tears and that the presence of these increased the predicted correct percentage for the diagnosis of meniscal tears found during arthroscopy to 91.6% ( $p < 0.05$ ).

Though MRI was more sensitive for meniscal tears, Ben-Galim et al. [26] demonstrated that MRI had a false positive rate of 65% for identifying medial meniscal tears and 43% for lateral meniscus tears compared with surgical findings. MRI, in addition to clinical evaluation, is recommended because of its high accuracy and negative predictive value [38].

In our study, giving way, locking, and McMurray's test, respectively, had higher specificity (84, 96, 76.9) and PPV (94.4, 98.8, 95.1) compared with MRI (Ac, 88.8; Se, 95.7; Sp, 75.8; PPV, 88.2; and NPV, 90.4.), but lower accuracy (49.2, 60.9, 76), sensitivity (43.5, 55.2, 75.8) and NPV

(19.4, 25.8, 35.1), for the diagnosis of meniscal tears. Combining MRI, accuracy, sensitivity, NPV of giving way, locking, and McMurray's test for the diagnosis of meniscal tears found during arthroscopy were obviously higher than not combining MRI, and the probability of missed diagnosis obviously decreased from 56.5, 44.8, 24.2 to 4.3, 2.6, 2.6, respectively. When considering a positive clinical history and/or physical examination (i.e., patients who are symptomatic), the combined diagnostic accuracy (Ac, 50.8; Se, 43.5; Sp, 96; PPV, 98.5; and NPV, 21.6.) of positive locking and positive McMurray's test was the highest, and the combined diagnostic accuracy (Ac, 36.3; Se, 26.6; Sp, 96; PPV, 97.6; and NPV, 17.5.) of positive giving way, positive locking and positive McMurray's test was the lowest, so patients with coincidental positive locking and positive McMurray's test were slightly more.

In conclusion, giving way, locking and McMurray's test are independent clinical diagnostic factors for the diagnosis of meniscal tears found during arthroscopy. MRI has higher accuracy, sensitivity and NPV for the diagnosis of meniscal tears than giving way, locking and McMurray's test. The combination of giving way, locking, McMurray's test and MRI for confirmation is typical for a meniscal lesion diagnosis. Based on these findings, MRI should be used in a standard manner to detect meniscal tears found during arthroscopy.

## Limitations

Our study had several limitations: one major limitation was the retrospective design of the study. It also included a wide range of patient ages. This study only included patients admitted for arthroscopy and therefore the selected patient population is likely to have a high rate of meniscal tears. A total of 5 cases waited 6 weeks between the MRI and the arthroscopy, and this time could have permitted meniscus lesions to heal, thus producing false positive MRI.

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**Table 6:** Reliability of giving way, locking, McMurray's test, and combining MRI, for diagnosis of meniscal tears (179 knees).

Variable	True positive	True negative	False positive	False negative	Accuracy (%)	Se (%)	Sp (%)	PPV (%)	NPV (%)	Percentage missed (%)	Probability missed diagnosis	Probability false diagnosis
Giving way	67	21	4	87	49.2	43.5	84	94.4	19.4	56.5	0.56	0.16
Locking	85	24	1	69	60.9	55.2	96	98.8	25.8	44.8	0.45	0.04
McMurray's test	116	20	6	37	76	75.8	76.9	95.1	35.1	24.2	0.24	0.23
Giving way, MRI	112	46	16	5	88.3	95.7	74.2	87.5	90.2	4.3	0.04	0.26
Locking, MRI	114	47	15	3	89.9	97.4	75.8	88.4	94	2.6	0.03	0.24
McMurray's test, MRI	114	46	16	3	89.4	97.4	74.2	87.7	93.9	2.6	0.03	0.26
Giving way+ and locking+	51	24	1	103	41.9	33.1	96	98.1	18.9	66.9	0.67	0.04
Locking+ and McMurray's test+	67	24	1	87	50.8	43.5	96	98.5	21.6	56.5	0.56	0.04
Giving way+ and McMurray's test+	54	23	2	100	43.0	35.1	92	96.4	18.7	64.9	0.65	0.08
Giving way+ and locking+ and McMurray's test+	41	24	1	113	36.3	26.6	96	97.6	17.5	73.4	0.73	0.04

Note: Se: specificity; Sp: specificity; PPV: positive predictive values; NPV: negative predictive values.+ : positive.

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Figures (large format)

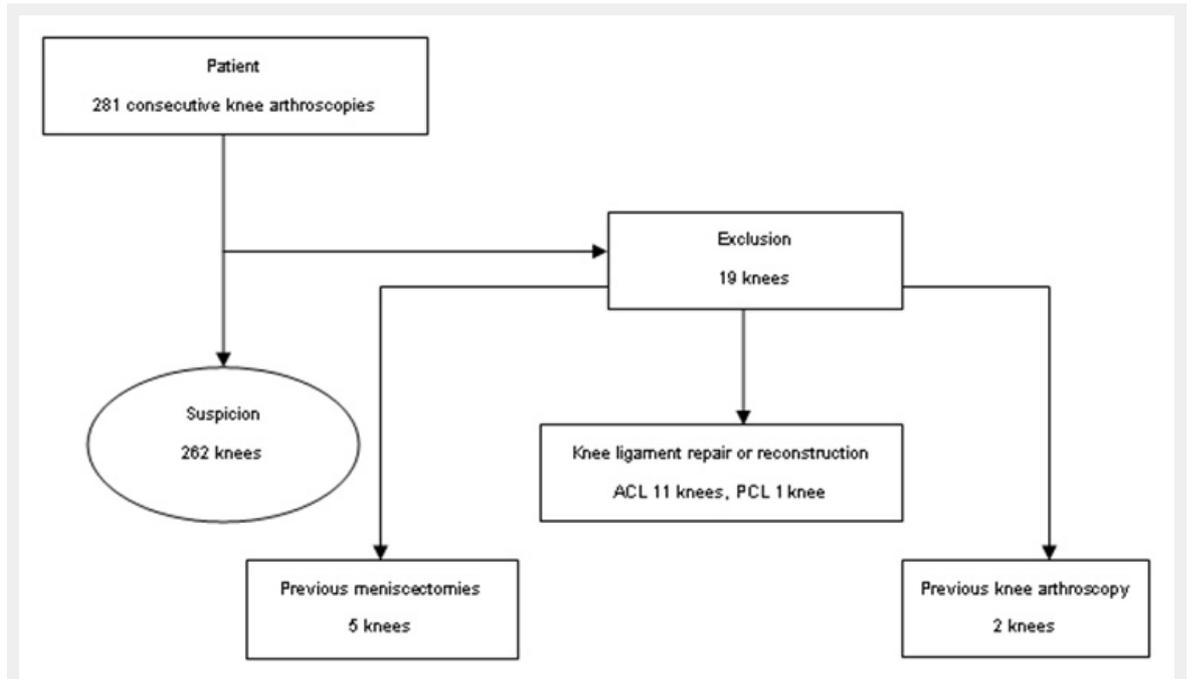


Figure 1  
Diagram of patients enrolled in the study.