

Diagnostic Ability of Magnetic Resonance Imaging among Patients with Anterior Cruciate Ligament Tears to Detect Meniscal Ramp Lesions: A Systematic Review

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Abstract

The clinical importance of meniscal ramp lesions in patients with anterior cruciate ligament (ACL) tear has emerged as a major issue. Nevertheless, the diagnostic accuracy of magnetic resonance imaging (MRI) for detecting ramp lesions is not yet concluded. This study aims to systematically review the diagnostic ability of MRI to detect meniscal ramp lesions together with the imaging findings and the approached MRI sequences. For that, a systematic electronic database search was conducted for relevant studies published, from inception till 28th June 2020, in seven databases. Finally, we included nine papers, involving 10 cohorts, for this systematic review. The prevalence of meniscal ramp lesions was extremely variable; ranging from 62.9% to 14.4%, which implies the need to develop accurate diagnostic approaches for better detection and visualization of meniscal ramp lesions. The sensitivity of MRI to detect meniscal ramp lesions ranged between 23 - 100%. Unlike sensitivity, heterogeneity among specificity rates was found minimal; ranging from 59.3% to 100%. Only four of our included studies reported positive and negative predictive values. The positive predictive values ranged between 28% and 100% while the negative predictive values ranged between 71.1% and 100%. The findings of our systematic review indicate that MRI can be used for detecting meniscal ramp lesions that are usually associated with ACL injuries. We recommend that further reports should be sought with larger populations and proper study designs.

Keywords: Diagnostic Value; MRI; Meniscal Ramp Lesions; Anterior Cruciate Ligament; Tear

Introduction

Meniscal ramp lesion has been reported as separation, damage, or disruption of the peripheral meniscocapsular ligaments in the posterior horn of the medial meniscus (PHMM) [1,2]. They are commonly reported with anterior cruciate ligament (ACL) injuries [3]. It has been recently identified also as injuries in the superior meniscocapsular, and inferior meniscotibial ligaments or both [4,5]. This lesion in the posterior horn of the medial meniscus has been reported with high incidence and prevalence rates [5-9]. A classification of the ramp lesions has been proposed based on the damage pattern and its correlation to a meniscotibial attachment tear [10]. Although surgical ap-

proaches are questionable in managing ramp lesions, neglectation of these injuries can lead to serious effects as elevated ACL strain, knee pain, instability, and abnormal kinematics [4,11-14]. Despite vague biomechanical complications of ramp lesions, the PHMM has an important role in maintaining knee stability [15]. It is even more important in ACL-deficient knees as more pressure is applied to the PHMM [12]. Therefore, awareness about meniscal ramp lesions should be considered during ACL reconstruction surgeries.

During knee arthroscopy, the visualization and identification of such injuries are difficult by using anteromedial and anterolateral approaches due to their location [13,16]. Thus, surgeons should have a sense of suspicion perioperatively to be aware of any meniscal ramp lesions [16]. Moreover, preoperative diagnosis of such lesions will help surgeons with better dealing with such important lesions intraoperatively. Magnetic resonance imaging (MRI) has been reported to be of value in detecting meniscal ramp lesions. Different approaches have been assessed by MRI to visualize these lesions [17]. However, the diagnostic accuracy of this imaging is a point of debate and the reported sensitivity is variable, therefore, the diagnostic accuracy may be overlapping for many healthcare practitioners [1]. Many published studies about the ability of MRI to detect such lesions have reported that the process was a success in a small number of patients [8,18]. On the other hand, many published studies have reported the ability of posteromedial or 70° arthroscope to improve the visualization and detection of these injuries [16,19-21]. Moreover, another technique representing the introduction of a probe in the meniscocapsular area for better examination and avoiding hidden lesions [18,22]. Consequently, establishing clear and confound criteria for assessing the management of meniscal ramp lesion has been a point of investigation in this scope [17,23-25]. This will help health care practitioners in better dealing with such lesions which will consequently enhance the knee kinematics and stability and decrease ACL strain [16].

Aim of the Study

This study aims to systematically review the diagnostic ability of MRI to detect meniscal ramp lesions together with the imaging findings, and the approached MRI sequences. It would be important to do so, as the number of published reports in this field is small and their results present heterogeneity in the diagnostic ability of MRI.

Methods

Search strategy and study selection

The study process was conducted following the accepted methodology recommendations of the PRISMA checklist for systematic review [26]. A systematic electronic database search was conducted for relevant studies published, from inception till 28th June 2020, in seven databases including Google Scholar, Scopus, Web of Science (ISI), PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), Embase and CINAHL. Search terms related to “MRI” or “MR arthrography” were combined with “ramp lesion” or “meniscocapsular” as follows: ((MR) OR (MRI) OR (“magnetic resonance”) OR (“magnetic resonance imaging”) (MRA) OR (“magnetic resonance arthrography”) OR (“MR arthrography”) OR (“MR arthrogram”)) AND ((“ramp lesion”) OR (“ramp lesions”) OR (“meniscocapsular”)) [27]. Moreover, We conducted a manual search of references from the included articles by searching the primary studies that had cited our included papers and scanning references of the relevant papers in PubMed and Google Scholar to avoid missing any relevant publications [28,29].

We included all original relevant studies, which are discussing the Diagnostic ability of MRI among Patients with ACL tears to detect meniscal ramp lesions. Papers were excluded if there was one of the following exclusion criteria: pilot studies, duplicate records, data could not be reliably extracted or incomplete reports, abstract only articles, thesis, books, conference papers. Title and abstract screening were done independently by four reviewers. Then, three independent reviewers performed a full-text screening to ensure the inclusion of relevant papers in our systematic review. Any disagreement was resolved by discussion and referring to the senior author when necessary [30].

Data extraction

Two authors developed the data extraction sheet using the Microsoft Excel software. Data extraction was performed by three independent reviewers using the excel sheet. The fourth independent reviewer performed data checking to ensure the extracted data accuracy. All the disagreements and discrepancies were resolved by discussion and consultation with the senior author when necessary [31].

Quality assessment

Three independent reviewers evaluated the methodological quality using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool [32]. Inconsistencies between the reviewers were resolved through discussion.

Results and Discussion

Search results

We searched for included studies in 454 records using the title and abstract screening method after the exclusion of 113 duplicated records. The process resulted in the inclusion of 56 papers for a further full-text screening assessment. Manual search trials did result in the inclusion of one new study. Finally, we included nine papers, involving 10 cohorts, for this systematic review (Figure 1).

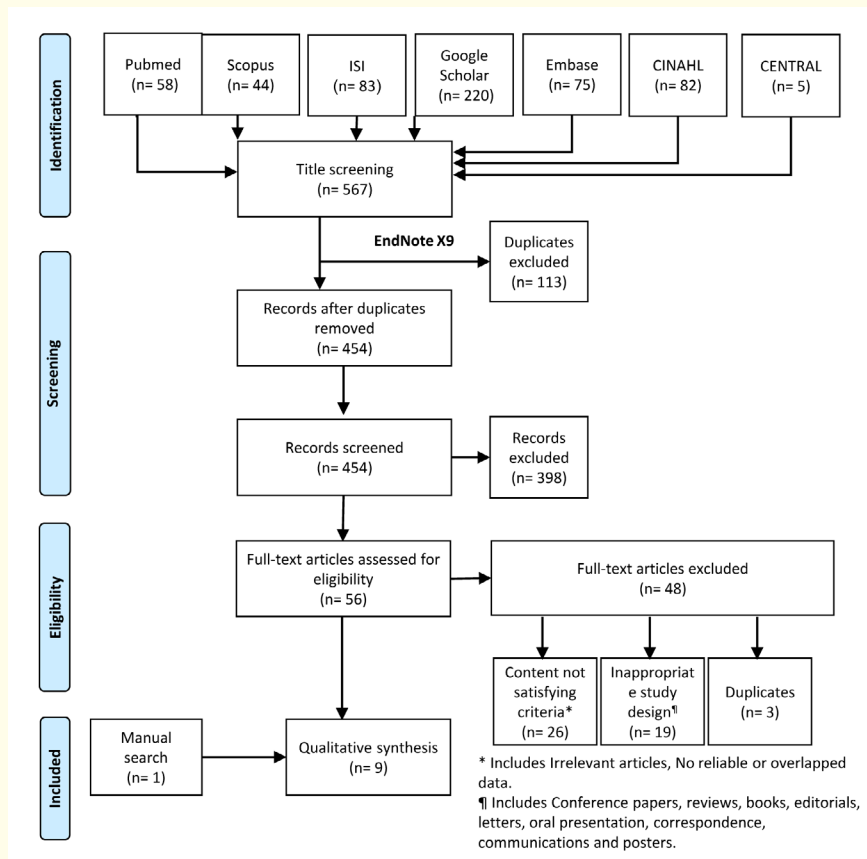


Figure 1: PRISMA flow diagram showing the process of the review.

Study characteristics and quality of the included studies

The sample size of the included studies ranged from 25 to 195 patients. The mean male percentage was 67%, ranging from 41% to 88%. The mean age of all patients ranged from 14 up to 37.3 years (Table 1).

Author (Year)	Country	Study duration	Study Design	Sample size	Ramp Lesion (%)	Age (Years)	Male (%)	Injury-to-MRI time interval	MRI-to-arthroscopy time interval (Day)
						Mean ± SD (Range)		Mean ± SD (Range)	Mean ± SD (Range)
Arner (2017) [23]	United States	2013 to 2015	Prospective, nonconsecutive	90	14.4	28 ± 10	50	NR	57.3
Hata-yama (2018)¶ [35]	Japan	April 2013 to August 2017	Prospective, consecutive	46	26.1	25.3 (13-60)	NA	NR (Range: 1 d to 10 Years)	42
Hata-yama (2018)¶ [35]	Japan	April 2013 to August 2017	Prospective, consecutive	109	31.2	25.3 (13-60)	NA	NR (Range: 1 d to 10 Years)	42
Kaplan (1999) [36]	United States	NR	Retrospective, consecutive	25	12	28 (16-52)	80	NR	NR
Kim (2018) [37]	South Korea	June 2011 to April 2015	Prospective, consecutive	195	25.6	31.7 ± 11.7	88.2	NR	NR
Kumar (2018) [34]	United States	January 2006 to June 2016	Retrospective, consecutive	178	62.9	NR	NA	NR	NR
Malatray (2018) [38]	France	October 2014 to May 2016	Prospective, consecutive	56	23.2	14 (12-17)	76.8	NR	NR
Okazaki (2020) [39]	Japan	August 2014 to March 2020	Retrospective, consecutive	43	37.2	24.6 ± 9.5	49	14.6 ± 11.4	NR
Song (2016) [33]	China	January 2011 to December 2013	Prospective, nonconsecutive	106	50	26.1 ± 7.3	40.6	NR	NR
Yeo (2018) v[40]	South Korea	January 2015 to September 2017	Retrospective, consecutive	78	9	37.3 (19-52)	82.1	NR	57

Table 1: Characteristics of the included studies.

MRI: Magnetic Resonance Imaging; NA: Not Available; NR: Not Reported; ¶ This study used 2 different cohorts to compare 2 different magnet strengths for diagnosing ramp lesion.

Overall, none of the studies were considered to be seriously flawed according to the QUADAS-2 assessment. Two studies [23,33] had a high risk of bias in terms of patients’ selection, which is related to their study design. Moreover, two studies had some concerns about their quality in the flow and timing parameters [33,34] (Figure 2 and 3).

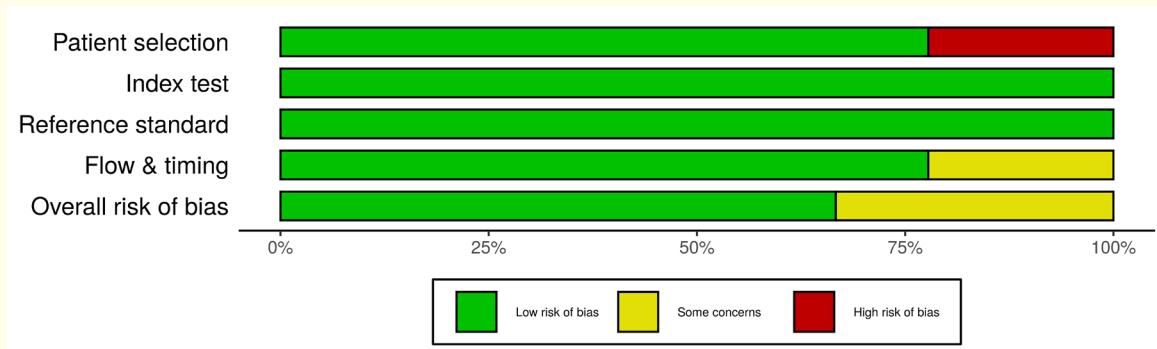


Figure 2: Risk of bias summary: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Study	Risk of bias domains				Overall
	D1	D2	D3	D4	
Arner (2017)	High	Low	Low	Low	Some concerns
Hatayama (2018)	Low	Low	Low	Low	Low
Kaplan (1999)	Low	Low	Low	Low	Low
Kim (2018)	Low	Low	Low	Low	Low
Kumar (2018)	Low	Low	Low	Some concerns	Some concerns
Malatray (2018)	Low	Low	Low	Low	Low
Okazaki (2020)	Low	Low	Low	Low	Low
Song (2016)	High	Low	Low	Some concerns	Some concerns
Yeo (2018)	Low	Low	Low	Low	Low

Domains:
D1: Patient selection.
D2: Index test.
D3: Reference standard.
D4: Flow & timing.

Judgement
High (Red X)
Some concerns (Yellow -)
Low (Green +)

Figure 3: Quality of the included studies: review authors' judgements about each risk of bias item for each included study.

Diagnostic ability of magnetic resonance imaging (MRI)

Although arthroscopic approaches are widely used for detecting ramp lesions, efforts have been applied to use MRI, instead. Certain signs as meniscal displacement and peripheral corner damage, elevated peri-meniscal intensity, and the presence of fluid deep to the medial collateral ligament have been reported on MRI to be correlated to ramp lesions. However, they are poorly correlated with the findings of arthroscopy [4,41]. Identifying ramp lesions before the orthopedic surgical operation for ACL reconstruction might be of great help for surgeons in surgery planning to pay attention to other underlying pathologies that may be hidden or hard to find normally. Various risk factors for meniscal ramp lesions have been reported. These include the presence of lateral meniscal tears, bone marrow edema in the posteromedial tibial position, young age (< 30 years old), male sex, and increased meniscal slope [9,17,33,34,42]. Therefore, the presence of these factors should alert surgeons to perform diagnostic approaches to detect any possible lesions.

In this systematic review, we included nine original studies involving 10 cohorts as Hatayam., *et al.* [35] included two populations in his study as he compared two different approaches for the detection of meniscal ramp lesions. Using MRI for detecting ramp lesions, the prevalence of these lesions was extremely variable. Kumar., *et al.* [34] reported the highest prevalence rate to be 62.9%. On the other hand, Yeo., *et al.* [40], Kaplan., *et al.* [36], and Arner., *et al.* [23] reported the lowest prevalence rates of ramp lesions being 9, 12 and 14.4%, respectively, while the rest of the included studies reported moderate prevalence rates [33,35,37-39]. Moreover, a study reported a low incidence rate of 15.8% among their included population [43]. This wide range of prevalence rates implies the need to develop accurate diagnostic approaches for better detection and visualization of meniscal ramp lesions.

The sensitivity of MRI to detect meniscal ramp lesions ranged between 23 - 100%. A previously published meta-analysis showed similar rates, and when data were pooled, the sensitivity rate was found to be 71% [27]. The same study found a significant correlation between knee position, MRI interpreter, magnet strength, and the heterogeneity of MRI sensitivity rates in detecting ramp lesions. The presence of musculoskeletal radiologists, neutral knee position and increased magnet strength (3.0-T MRI) were reported with high sensitivity rates. On the other hand, full extended knee position decreased magnet strength, and the presence of orthopedic surgeons alone was associated with low sensitivity rates. In our study, Malatray., *et al.* [38] reported the lowest sensitivity rate (23%). We found that two of the included studies did not report the knee position [34,36]. Among the other seven studies, only two [37,40] assessed patients in the neutral position while others assessed them in a full or near full extension position [23,33,35,38]. Moreover, Song., *et al.* [33], Yeo., *et al.* [40], Kim., *et al.* [37], Kaplan., *et al.* [36] and Hatayama., *et al.* [35], assessed patients in the presence of musculoskeletal radiologist to interpret MRI results. On the other hand, Arner., *et al.* [23], Kumar., *et al.* [34], Malatray., *et al.* [38], and Okazaki., *et al.* [39] assessed patients with orthopedic surgeons only. These were the factors associated with elevated and decreased sensitivity rates of using MRI for detecting meniscal ramp lesions as reported by other studies.

Unlike sensitivity, heterogeneity among specificity rates was found minimal. The range for specificity rates for all of our included studies was 59.3% and 100%. It is worth mentioning that Okazaki., *et al.* [39] reported two specificity rates with two different knee positions. The first-rate was 59.3% at the 10⁰ knee flexion position. The second rate was much higher being 85.2% at 90⁰ knee flexion position. The same author, however, did not discuss any correlation between knee position and enhanced specificity rates. The authors agreed with the previously published meta-analysis [27] which found that magnet strength only was correlated with elevated specificity rates. In our study, only Hatayama., *et al.* [35], and Kim., *et al.* [37], used a 3.0-T MRI, while Yeo., *et al.* [40] used both 1.5 and 3.0-T MRI. Moreover, four studies [23,33,35,36] used a 1.5-T MRI, while two of our included studies [34,38] did not report it. Okazaki., *et al.* [39] was the only study that used a 1.2-T MRI technique.

Other criteria to be considered are the positive and negative predictive values. Only four of our included studies reported these [23,37,39,40]. The positive predictive values ranged between 28% and 100% while the negative predictive values ranged between 71.1% and 100%. Moreover, the features of MRI include a separation between PHMM and capsule margin as a positive sign for ramp lesions as

reported in six studies [23,34-36,39,40]. Other signs were peripheral longitudinal tears of the meniscocapsular junction of PHMM as reported in three studies [33,37,38] and Posterior irregularity in the PHMM as reported in two of our included studies [39,40]. Interestingly, the accuracy of ramp lesions detection by MRI enhanced when the separation between PHMM and capsule margin sign was detected as reported in Okazaki, *et al.* [39] and Yeo, *et al.* [40]. However, no statistical significance was reported, and consequently, further investigations are needed.

Limitation of the Study

Limitations to our study include the small number of studies that met our inclusion criteria, in addition to the relatively small number of sample sizes of the included studies and the nature of data collection in some of them. Another limitation is the absence of control groups which should have been used as a reference for comparing the accuracy of MRI with arthroscopy in detecting meniscal ramp lesions.

Conclusion

The findings of our systematic review indicate that MRI can be used for detecting meniscal ramp lesions that are usually associated with ACL injuries. The sensitivity was found to be moderate while the specificity was excellent with good overall accuracy in some studies. Besides, other risk factors should be considered and routine investigations should be conducted. Finally, we recommend that further reports should be sought with larger populations and proper study designs.

Funding

None.

Conflicts of Interest

No conflicts related to this work.

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