

# Incidence and Detection of Meniscal Ramp Lesions on Magnetic Resonance Imaging in Patients With Anterior Cruciate Ligament Reconstruction

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**Background:** Meniscal ramp lesions have been reported to be present in 9% to 17% of patients undergoing anterior cruciate ligament (ACL) reconstruction. Detection at the time of arthroscopy can be accomplished based on clinical suspicion and careful evaluation. Preoperative assessment via magnetic resonance imaging (MRI) has been reported to have a low sensitivity in identifying meniscal ramp lesions.

**Purpose:** To investigate the incidence of meniscal ramp lesions in patients with ACL tears and the sensitivity of preoperative MRI for the detection of ramp lesions.

**Study Design:** Case series; Level of evidence, 4.

**Methods:** All patients who underwent ACL reconstruction by a single surgeon between 2010 and 2016 were included in this study, and patients with medial meniscal ramp lesions found at the time of arthroscopy were identified. The sensitivity of MRI compared with the gold standard of arthroscopic evaluation was determined by review of the preoperative MRI musculoskeletal radiologist report, mimicking the clinical scenario. The incidence was calculated based on arthroscopic findings, and the potential secondary signs of meniscal ramp tears were evaluated on MRI.

**Results:** In a consecutive series of 301 ACL reconstructions, 50 patients (33 male, 17 female) with a mean age of 29.6 years (range, 14-61 years) were diagnosed with a medial meniscal ramp lesion at arthroscopic evaluation (16.6% incidence). The sensitivity of MRI for ramp lesions was 48% based on the preoperative MRI report. A secondary finding of a posteromedial tibial bone bruise was identified on preoperative MRI in 36 of the 50 patients with ramp lesions in a retrospective MRI review by 2 orthopaedic surgeons.

**Conclusion:** Medial meniscal ramp lesions were present in approximately 17% of 301 patients undergoing ACL reconstruction, and less than one-half were diagnosed on the preoperative MRI. A posteromedial tibial bone bruise was found to be a secondary sign of a ramp lesion in 72% of patients. Increased awareness of this potentially combined injury pattern is necessary, and careful intraoperative evaluation is required to identify all meniscal ramp tears.

**Keywords:** knee; knee ligaments; meniscus

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Increased attention has been directed toward the identification and treatment of concomitant knee injuries associated with anterior cruciate ligament (ACL) tears to best restore knee biomechanics and function. Studies have reported that 43% of patients with ACL tears have concomitant lateral or medial meniscal tears.<sup>6</sup> Meniscocapsular tears of the posterior horn of the medial meniscus are of specific interest because of the reported difficult visualization of the posteromedial “blind spot” when operating via traditional anteromedial and anterolateral portals.<sup>11</sup> These meniscocapsular lesions have recently been termed *ramp lesions*,<sup>9</sup> and their incidence has been reported to be 9% to 17% of all ACL tears.<sup>2,7</sup>

Ramp lesions are a tear of the peripheral attachment of the posterior horn of the medial meniscus at the meniscocapsular

junction.<sup>2,12</sup> Investigation of these lesions is important because recent biomechanical data suggest these lesions can result in increased anterior tibial displacement and increased strain on both the native ACL and ACL-reconstructed graft.<sup>4,8,10</sup>

Much of the literature regarding ramp lesions has focused on repair techniques and outcomes after surgery.<sup>3,8-10,12</sup> However, a relative paucity of studies is available on the diagnosis of ramp lesions using preoperative magnetic resonance imaging (MRI) with arthroscopic correlation.<sup>2</sup> Given this gap in knowledge, the aim of this study was to report the incidence of ramp lesions in patients with ACL reconstruction, to determine the sensitivity of preoperative MRI for the detection of ramp lesions with comparison to the gold standard of arthroscopy, and to examine possible secondary signs of a ramp lesion on MRI.

## METHODS

### Study Design

A prospectively collected patient outcomes database was retrospectively queried. Query of the database identified 301 patients who underwent primary or revision ACL reconstruction by a single surgeon (R.F.L.) between April 2010 and July 2016 and had a confirmed medial meniscal tear. Inclusion criteria were defined as patients with a confirmed ACL tear and medial meniscal tear. Exclusion criteria were defined as patients who had a concomitant medial meniscal root tear on their ipsilateral knee. All patients were clinically examined preoperatively and underwent standardized preoperative imaging evaluation with plain radiographs and an MRI.

### Imaging Evaluation

The arthroscopic procedures were reviewed to determine the presence of a ramp lesion and concomitant injuries. A ramp lesion was defined as a tear of the peripheral attachment of the posterior horn of the medial meniscus at the meniscocapsular junction. In patients identified to have a ramp lesion, the preoperative MRI report was reviewed to determine whether a ramp lesion was diagnosed by the interpreting musculoskeletal radiologist, and the sensitivity was calculated. Additionally, 2 independent orthopaedic surgeons (J.C., A.G.G.) evaluated the preoperative MRI to assess for potential associated injury patterns. The most common magnet strength for MRI was 3.0 T (n = 40) followed by 1.5 T (n = 10). All patients who had a 3.0-T MRI were scanned at our institution, and the remaining 1.5-T scans were reviewed from outside imaging facilities. Evaluation for meniscal ramp lesions was best visualized on proton-density, fat-saturated, T2-weighted images using the sagittal view.

### Surgical Technique

Standard anteromedial and anterolateral portals were made for routine arthroscopy; no additional portals were required

to assess for the presence of meniscal ramp lesions. Viewing from the anterolateral portal, the surgeon advanced the arthroscope through the intercondylar notch with the patient's knee in 30° of flexion for inspection of the posterior horn of the medial meniscus. A probe was directed over the superior aspect of the posterior horn of the medial meniscus to allow for inspection of the junction between the meniscus and capsule to identify whether a ramp lesion was present. The probe was used to retract the posteromedial capsule away from the posteromedial meniscocapsular attachment to assess for any tears, and a ramp lesion was diagnosed if a tear or separation was present. An accessory posteromedial portal was not required to completely visualize the posterior meniscocapsular attachment.

## RESULTS

Of the 301 consecutive patients with ACL reconstruction who met the study criteria, 50 patients had diagnosed meniscal ramp lesions at the time of arthroscopy. Review of the preoperative MRI reports of these 50 patients revealed that 24 patients (48%) had a ramp lesion diagnosed preoperatively (Figure 1). Of the 24 patients with meniscal ramp lesion identified on preoperative MRI, 18 (75%) had acute tears and 6 (25%) had a chronic lesion (>6 weeks).

Review of the preoperative MRI revealed that a posteromedial tibial bone bruise was identified in 72.0% (n = 36) of the 50 patients with ramp lesion. Of the 50 patients, 31 (62%) had acute injuries and 19 (38%) had chronic injuries (>6 weeks). Patient demographics are presented in Table 1.

All patients reported an acute injury or reinjury before undergoing arthroscopy for ACL reconstruction and meniscal ramp repair. The majority of patients were injured during sport or athletic participation (Figure 2).

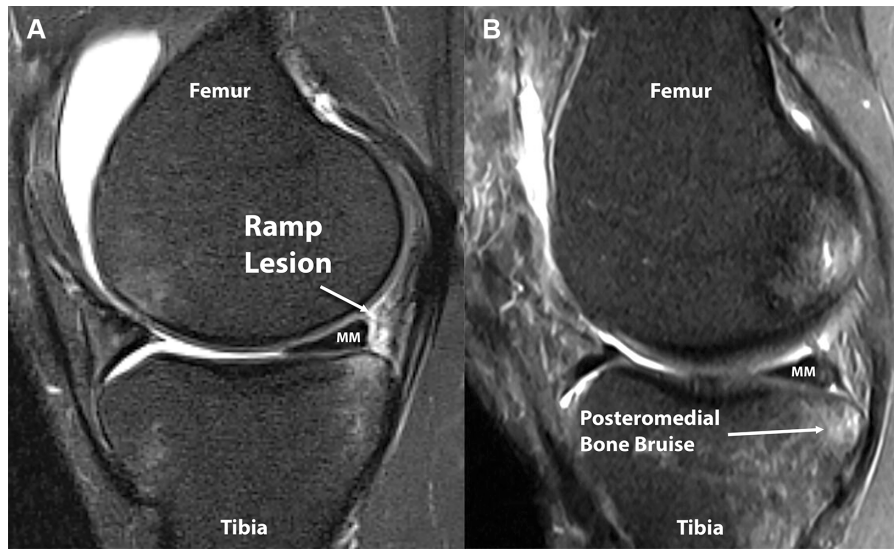
Mechanisms of injury included twisting (n = 34, 68.0%), jump-landing (n = 9, 18.0%), and falling on a flexed knee (n = 7, 14.0%). Of the 50 patients with ramp lesion, 16 patients (32.0%) underwent revision ACL reconstruction (Table 2) and 3 patients (6.0%) had prior medial meniscal repairs that had return.

The mean time ( $\pm$ SD) from injury to primary ACL reconstruction with ramp repair was  $5.7 \pm 9.7$  weeks (n = 34, 68.0%). The mean time from reinjury to revision ACL reconstruction with ramp repair was  $6.1 \pm 8.2$  months (n = 16, 32.0%). Thirty-nine of the 50 patients with ramp lesion (78.0%) had concomitant lateral meniscal tears at the time of arthroscopy; 28 of the 39 (72%) were repaired and 11 (28%) underwent partial meniscectomy for lateral meniscal tears (Table 3).

All ramp lesions were repaired with an inside-out vertical mattress technique. Ramp lesions in this series were repaired with an average of  $8.5 \pm 3.2$  sutures (Figure 3).

## DISCUSSION

The most important findings of this study were that MRI had a low sensitivity (48%) for the detection of medial meniscal ramp lesions and that the incidence of ramp



**Figure 1.** Preoperative magnetic resonance image (MRI) demonstrating meniscal ramp lesion and associated posteromedial tibial bone bruise pattern, best visualized on sagittal fat-saturated, T2-weighted images. (A) Meniscal ramp lesion, indicated by an increase in signal intensity at the peripheral margin of the posterior horn of the medial meniscus at the meniscocapsular junction. (B) Posteromedial tibial bone bruise and posterior medial meniscal contusion present on preoperative MRI in a patient with a combined anterior cruciate ligament tear and meniscal ramp lesion diagnosed at the time of arthroscopy. MM, medial meniscus.

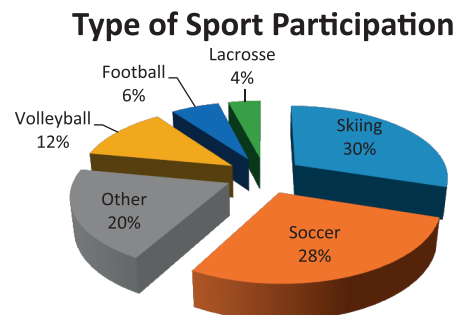
**TABLE 1**  
 Characteristics of the 50 Patients  
 With Medial Meniscal Ramp Lesions<sup>a</sup>

Clinical Characteristics	Total	Male	Female
Sex, n (%)		33 (66.0)	17 (34.0)
Age, y	29.6 ± 12.5	30.8 ± 13.4	27.1 ± 10.7
Body mass index, kg/m <sup>2</sup>	24.1 ± 2.5	24.7 ± 2.6	23.0 ± 1.9
Time from injury to surgery, wk	14.7 ± 27.5	14.5 ± 29.4	15.0 ± 24.0

<sup>a</sup>Data are provided as mean ± SD unless otherwise noted.

lesions in patients with concomitant ACL tears was 16.6%. A secondary finding of a posteromedial tibial bone bruise on MRI in 72% of all patients with a medial meniscal ramp lesion was identified. To our knowledge, this is one of the first studies to report MRI sensitivity for diagnosis of meniscal ramp lesions in patients who had ACL reconstruction and medial meniscal tear compared with the gold standard of arthroscopy.

On retrospective MRI review with comparison to arthroscopic detection of ramp lesions, a posteromedial tibial bone bruise on MRI was found to be an important secondary sign of a medial meniscal ramp lesion during arthroscopy. This finding is similar to the posteromedial bone bruise pattern previously reported in correlation with combined ACL and posterolateral corner (PLC) injuries<sup>5</sup>; however, only 2 patients in the present study sustained a PLC injury. Therefore, we propose that this secondary finding may not be specific for PLC injury. Due to the low sensitivity of MRI and difficult detection preoperatively,<sup>4,7</sup>



**Figure 2.** Type of sport or athletic activity reported at the time of injury for medial meniscal ramp lesions.

a meniscal ramp lesion should be suspected in the presence of an ACL tear and a posteromedial tibial bone bruise with or without a PLC injury.

In 2010, Bollen<sup>2</sup> reported on a prospective evaluation of 183 consecutive patients undergoing ACL reconstruction and found a 9.3% incidence of meniscal ramp lesions at the time of arthroscopy. Preoperative MRI failed to identify the meniscocapsular tear in all patients with an available MRI; however, MRI was reviewed in only 11 of the 17 patients with ramp lesion (64.7%). Subsequently, Bollen proposed that because the MRI is performed with the knee near full extension, the meniscocapsular separation is most likely reduced during imaging, leading to a large number of false negatives.

Liu et al<sup>7</sup> reported a 16.6% incidence of meniscal ramp lesions at the time of arthroscopy in 868 patients undergoing ACL reconstruction. However, MRI findings were not compared with arthroscopic findings.<sup>7</sup> In a retrospective

TABLE 2  
Previous Surgical Procedures, Graft Type, Time From Index Surgery, and Time From  
Reinjury to Revision ACLR and Meniscal Ramp Repair (n = 16)<sup>a</sup>

Study ID <sup>b</sup>	Previous Surgical Procedure (ACLR Graft Type)	Time From Index Surgery to Revision ACLR With Ramp Repair, mo	Time from Reinjury to Revision ACLR With Ramp Repair, mo
1	ACLR (HS auto)	7	5.6
3	ACLR (BPTB auto), medial meniscal repair	15	12.8
4	ACLR (BPTB auto)	180	1
5	1. ACLR (BPTB auto) 2. Revision ACLR (BPTB allo)	300	0.8
6	ACLR (iliotibial band auto)	36	30.4
7	ACLR (BPTB auto), lateral meniscal repair	14	3.7
15	ACLR (BPTB allo)	8	6.4
16	1. ACLR (HS auto) 2. Medial meniscal repair 3. Revision ACLR (tibialis anterior allo)	192	19.2
21	1. ACLR (BPTB auto), medial meniscal repair 2. Revision ACLR (BPTB allo) 3. Re-revision ACLR (BPTB allo), medial collateral ligament-R	58	6.4
23	ACLR (BPTB allo)	36	1
28	ACL repair	12	1.2
29	1. ACLR (quadriceps auto) 2. Revision ACLR (contralateral BPTB auto) 3. Partial meniscectomy	56	0.6
30	1. ACLR (BPTB allo) 2. Revision ACLR (HS auto)	21	4
31	1. ACLR (BPTB auto) 2. Revision ACLR (BPTB allo)	65	2
40	ACLR (BPTB allo)	58	1
49	ACLR (BPTB allo)	108	2

<sup>a</sup>Mean time from index surgery to revision ACL reconstruction was  $6.0 \pm 6.9$  years. ACLR, anterior cruciate ligament reconstruction; allo, allograft; auto, autograft; BPTB, bone–patellar tendon–bone; HS, hamstring; MCLR, medial collateral ligament reconstruction.

<sup>b</sup>Deidentified study number for patients with ramp lesions.

TABLE 3  
Concomitant Injuries Treated at Time of  
Surgery for Anterior Cruciate Ligament Reconstruction  
and Meniscal Ramp Lesion Repair (n = 50)<sup>a</sup>

Concomitant Injuries	No. of Injuries	Surgical Procedure, n
Lateral meniscal tear	39	Repair: 28 Meniscectomy: 11
FCL tear	7	FCLR: 7
MCL tear	7	MCLR: 7
PLC injury	2	PLCR: 2

<sup>a</sup>FCL, fibular collateral ligament; MCL, medial collateral ligament; PLC, posterolateral corner; R, reconstruction.

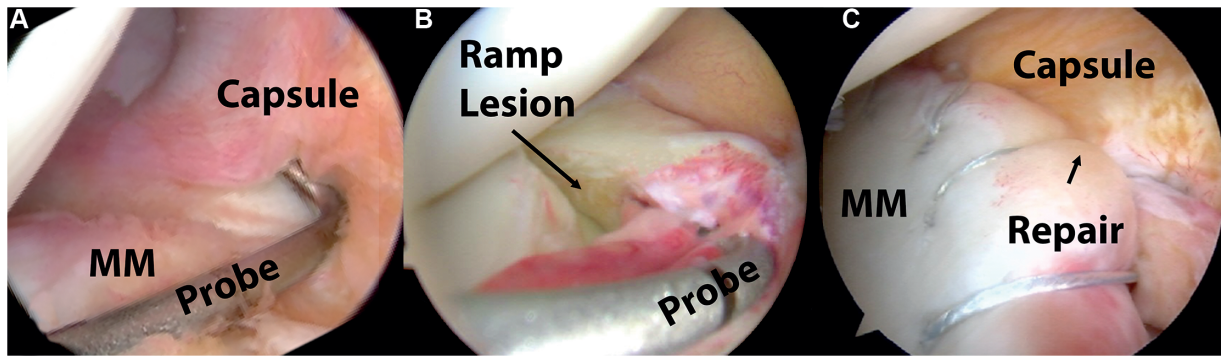
review, Edgar et al<sup>4</sup> reported on 337 patients who underwent primary ACL reconstruction over a 5-year period. Meniscal ramp lesions were found in 44 patients, for an overall incidence of 13.1%. Therefore, the present study, reporting a 16.6% incidence in patients undergoing ACL reconstruction, is in agreement with the previous literature.

Edgar et al<sup>4</sup> reported the suspicion of a meniscal ramp lesion via MRI in 33 of 43 patients with ramp lesion, yielding a sensitivity of 77% for meniscal ramp detection on MRI.

In the present study, however, a sensitivity of only 48% for meniscal ramp lesions was reported on preoperative MRI. The poor sensitivity of MRI in identifying ramp lesions in our study could be attributed to the reduction of such a tear as the knee is extended during the imaging process.<sup>2</sup>

Previously reported clinical characteristics associated with ramp lesions include age, sex, and time from ACL injury to surgery. Liu et al<sup>7</sup> reported a higher prevalence in males than females, in patients younger than 30 years, and in patients who had ACL surgery within 24 months after ACL injury. Our findings are consistent with prior reported associated factors, because 66% of patients with meniscal ramp lesion were males and 34% were females. The mean age of patients with meniscal ramp lesion was 29.6 years and the mean time from new injury to ACL reconstruction and ramp repair was 3.6 months, supporting previously identified associated factors.

At the time of arthroscopy, all ramp lesions were identified without the use of an accessory posteromedial portal. Previous studies suggested that an accessory posteromedial portal was needed to reliably identify ramp lesions.<sup>1,9,12</sup> In contrast, the technique of the senior author (R.F.L.) presented herein evaluated for the presence of ramp lesions by displacing the posteromedial capsule away (posterior) from the meniscal tissue with a probe, thereby avoiding



**Figure 3.** Intraoperative left knee meniscal ramp lesion. (A) Normal meniscocapsular junction with no evidence of ramp lesion. (B) Meniscal ramp lesion identified at time of arthroscopy (viewed through the intercondylar notch). (C) Restoration of meniscocapsular stability with ramp lesion repair via inside-out vertical mattress technique. MM, medial meniscus.

the creation of accessory portals and diminishing the overall morbidity and surgical time.

Some study limitations were identified for this study. Without evaluation of a noninjured population, we are unable to report the specificity of MRI for medial meniscal ramp lesions. Additionally, there was variability in the imaging center, MRI parameters, and interpreting radiologist; however, this variability replicates the clinical scenario and thus may improve the generalizability of our findings.

## CONCLUSION

Medial meniscal ramp lesions were present in 17% of 301 patients undergoing ACL reconstruction, and less than one-half of these lesions were identified on preoperative MRI. A posteromedial tibial bone bruise was identified on preoperative MRI in 72% of all patients with a combined ACL tear and medial meniscal ramp lesion. Because MRI has been reported to have low sensitivity in identifying meniscal ramp lesions, clinicians should suspect a ramp lesion in the presence of a posteromedial tibial bone bruise on MRI in patients with an ACL tear. Increased awareness of this potentially combined injury pattern is necessary, and careful intraoperative evaluation is required to identify all lesions.

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