



# Pediatric Ramp Lesions: Incidence, MRI Sensitivity, and Associated Risk Factors

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## Introduction

The incidence of anterior cruciate ligament (ACL) injuries in children is steadily increasing and over half of cases are associated with meniscal tears.<sup>1,2</sup> One type of meniscal pathology is known as a “ramp” lesion, which describes injury to the meniscocapsular junction, located between the posterior horn of the medial meniscus (PHMM) and the joint capsule. They have been historically underdiagnosed in ACL deficient patients, likely due to their location in a “blind spot” using traditional anterior arthroscopic approaches and the absence of validated MRI criteria.<sup>3,5</sup> However, it is well understood that the PHMM is an important anatomic restraint to anterior tibial translation, particularly in the setting of ACL injury.<sup>6</sup>

Recent studies show that ramp lesions occur in 9-30% of adults with ACL injuries, with repair significantly improving post-operative functional scores.<sup>7-9</sup> While there has been increasing interest in identifying and treating ramp lesions in the adult orthopedic literature, little is known about ramp lesions in pediatric patients.<sup>10</sup> The purpose of this study was to: 1) determine the incidence of ramp lesions in pediatric patients with ACL tears, 2) identify associated risk factors for the occurrence of a ramp lesion, and 3) determine the sensitivity of magnetic resonance imaging (MRI) for identifying ramp lesions.

## Methods

This was a retrospective cohort study of 144 patients  $\leq$  21 years old who underwent ACL reconstruction at a single institution from 2/2019 to 1/2020. Preoperative characteristics, including injury mechanism and exam findings, were recorded from the medical record. Preoperative MRIs, when available, were blinded and reviewed by an experienced musculoskeletal radiologist to determine the presence of a ramp lesion and/or a posteromedial tibial bone bruise. Intraoperative records were also searched for ramp tears and other associated injuries.

Patients were separated into cohorts based on the presence or absence of an arthroscopically-identified ramp lesion. Descriptive statistics for injury risk factors were reported, with Chi-squared and Fisher's exact tests used to analyze categorical variables. Independent T and Mann-Whitney U tests were used to

compare continuous variables after evaluation of normality using Kolmogorov-Smirnov tests. Binary logistic regressions were used to calculate odds ratios and 95% confidence intervals (CI) for significant predictors of arthroscopic ramp lesion identification. Using an  $\alpha$  of 0.05 for significance, all tests were performed utilizing IBM SPSS Statistics for Macintosh (Version 24.0. Armonk, NY).

## Results

One hundred forty-four patients were included in the study: 19 with intra-operatively identified ramp lesions (13.2%) and 125 (86.8%) without. There were no significant differences between groups based on sex, time between injury and surgery, laterality, or prior contralateral ACL injury history (Table 1). Patients with ramp lesions were significantly older ( $16.7 \pm 2.2$  vs  $15.5 \pm 2.3$  years,  $p = 0.037$ ) and were more likely to be undergoing a revision ACL reconstruction (15.8% vs 3.2%,  $p = 0.049$ ). There were no differences in preoperative exam characteristics, mechanism of injury, or the proportion of sports-related injuries. Intraoperatively, patients with ramp tears did not have an increased incidence of concomitant ligamentous or lateral meniscus tears. A revision ACL procedure (OR 5.67, 95% CI 1.16-27.68,  $p = 0.032$ ) and older age (OR 1.25, CI 1.01-1.54,  $p = 0.040$ ) increased the odds of having a ramp lesion, though neither variable achieved significance in multivariate analysis. MRIs were available and reviewed retrospectively for 18 patients with and 120 patients without ramp tears (Table 2). MRI more frequently revealed a complete ramp lesion (33.3% vs 10.8%,  $p = 0.010$ ) or posteromedial tibial bone bruise (88.9% vs 56.7%,  $p = 0.009$ ) for patients with arthroscopically identified ramp tears. The sensitivity of MRI for ramp lesion (full or partial) detection was 50.0% (95% CI 26.0%-74.0%) with a specificity of 72.5% (95% CI 63.6%-80.3%). The overall accuracy was 69.6% (95% CI 61.2%-77.1%).

## Discussion

This is the largest known study describing ramp lesion incidence in a pediatric population, occurring in 13% of our patients. The only significant predictors of a ramp lesion were revision ACL procedure and older age at

**Table 1. Baseline Demographics and Injury Characteristics.**

Variable	No Ramp Lesion	Ramp Lesion	P-value
	(N = 125)	N = 19	
<b>Demographics</b>			
Age at Surgery (yrs)	15.5 ± 2.3	16.7 ± 2.2	<b>0.037</b>
Female Sex	62 (49.6%)	11 (57.9%)	0.500
BMI	23.8 ± 5.2	23.0 ± 3.4	0.758
Left Knee	62 (49.6%)	10 (52.6%)	0.806
<b>Injury Characteristics</b>			
Time from Injury to Surgery (days)	87.7 ± 128.3	56.3 ± 21.4	0.422
Revision ACL	4 (3.2%)	3 (15.8%)	<b>0.049</b>
Prior contralateral ACL injury	7 (5.6%)	1 (5.3%)	1.000
Sports-Related	113 (90.4%)	18 (94.7%)	1.000
Injury Mechanism			
Contact	38 (30.4%)	3 (15.8%)	0.462
Non-Contact	84 (67.2%)	16 (84.2%)	
Unknown	3 (2.4%)	0 (0%)	
Concomitant Injury			
ALL sprain/tear	9 (7.2%)	4 (21.1%)	0.072
LCL sprain/tear	2 (1.6%)	0 (0%)	1.000
MCL sprain/tear	5 (4.0%)	0 (0%)	1.000
Lateral Meniscus Tear	84 (67.2%)	13 (68.4%)	0.916
<b>Exam Findings</b>			
Effusion			
None	25 (20.0%)	3 (15.8%)	0.594
Mild (fluid wave, < 25mL)	64 (51.2%)	8 (42.1%)	
Moderate (easily ballotable, 25-60mL)	34 (27.2%)	8 (42.1%)	
Severe (tense, > 60mL)	2 (1.6%)	0 (0%)	
Lachman Grade‡			
Normal (< 6mm)	12 (10.3%)	0 (0%)	0.349
Abnormal (6-10mm)	87 (74.4%)	17 (89.5%)	
Severely abnormal (> 10mm)	18 (15.4%)	2 (10.5%)	
Positive McMurray's	47 (37.6%)	8 (42.1%)	0.707
Total Beighton score	1.8 ± 2.2	2.2 ± 2.7	0.780

‡Only 136 patient's with recorded Lachman findings

surgery. There were no other significant demographic, injury, or exam differences between patients with and without intraoperatively confirmed tears.

Our findings corroborate past work in adults that has shown revision ACL reconstruction to be predictive of identifying a ramp lesion, though it is unclear if these tears were not seen at initial reconstruction or if they occur more common in repeat injuries.<sup>11</sup> While it is possible that index injuries were missed, the excellent blood supply to the periphery of the meniscus should allow these lesions to heal after ACL reconstruction regardless of lesion management, unless the initial lesion was very large.<sup>12</sup> Therefore, it is possible that there is another biomechanical reason that they occur more commonly during graft tears, given the role of the medial meniscus as a secondary restraint to anterior tibial translation.<sup>6</sup>

Interestingly, younger age has actually been associated with a higher incidence of ramp lesions in adult-based studies,

making it likely that there is a peak injury incidence in athletic young adults.<sup>11, 13</sup> Other previously reported risk factors for ramp tear in adults are an increased time from injury to surgery, male sex, and a contact injury mechanism.<sup>11, 13-15</sup> However, none of these factors were different between the groups in our study.

MRI showed high specificity (72.5%), but low sensitivity (50%) for diagnosing ramp lesions. These values are on the lower end of what has been reported in adults (48-86% sensitivity, 79-99% specificity), which reflects the need for validated imaging criteria.<sup>4, 5, 16</sup> This may be the result of a higher prevalence of peripheral meniscus signal irregularities in children, which lead to a limited ability to preoperatively identify ramp lesions in pediatric patients.<sup>17</sup> Posteromedial tibial edema (or bone bruising), as shown in our study, has also been shown to increase the odds of ramp tear over a meniscal body tear, perhaps related to the higher rate of contact injuries

**Table 2. Preoperative MRI Findings.**

Variables	No Ramp Lesion	Ramp Lesion	P-value
N	120	18	-
Delay from Injury to MRI (days)	30.3 ± 112.2	6.9 ± 4.6	0.105
Delay from MRI to Surgery (days)	57.9 ± 43.7	48.7 ± 21.5	0.824
Location of MRI			
Our Institution	46 (38.3)	7 (38.9)	0.964
Outside Hospital	74 (61.7)	11 (61.1)	
Sequences available for diagnosis			
T2-Weighted	91 (75.8)	13 (72.2)	0.740
Proton-Density Weighted (PD)	44 (36.7)	8 (44.4)	0.525
Other	2 (1.7)	0 (0)	1.000
Ramp Lesion on MRI			
Full	13 (10.8)	6 (33.3)	<b>0.010</b>
Partial	20 (16.7)	3 (16.7)	1.000
Total	33 (27.5)	9 (50.0)	0.096
Posteromedial tibial bone bruise	68 (56.7)	16 (88.9)	<b>0.009</b>

that are associated with both tibial bone bruising and ramp lesions.<sup>14, 15, 18</sup>

## Conclusions

Revision ACL surgery and older age predicted a higher occurrence of ramp lesions in our pediatric and adolescent population. The observed low MRI sensitivity is overall consistent with findings in the adult literature, and emphasizes the need for validated imaging criteria and thorough intraoperative exam in order to consistently identify ramp lesions.

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