

Characterization and Prevalence of Pediatric Ramp Lesions Associated with Anterior Cruciate Ligament Tears.

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Abstract

Background: Ramp lesions correspond to posterior meniscocapsular tears of the medial meniscus and are common with anterior cruciate ligament (ACL) tears. They cannot be recognized easily on preoperative magnetic resonance imaging (MRI) scans and are difficult to visualize even using standard arthroscopic approaches. We aim to (1) characterize and evaluate the prevalence of ramp lesions in pediatric patients at a major tertiary children's hospital, providing important insights into demographics, diagnosis, treatment, and functional disability and (2) evaluate the efficacy of MRI in its diagnosis.

Materials and Methods: We retrospectively reviewed patients under 21 years old undergoing posterior medial meniscal injuries and anterior cruciate ligament ruptures with arthroscopic examination and positive ramp lesions from 2018 to 2021. Patient demographics (including gender and age), initial presentation, physical examination findings, mechanism of injury, pre-operative radiologic findings, and treatment were collected and reviewed via electronic medical record. Exclusion criteria included patients over 18 years old, patients that did not have an MRI, and patients that were not treated surgically.

Results: There were 117 patients that met the inclusion criteria out of 690 patients. The mean age at diagnosis was 15.6±1.6 years and the mean BMI was 26.7±6.4. 83% of injuries occurred secondary to sporting activities. Ramp lesions were only detected on preoperative MRI in 63% of cases, suspected in 3%, and not detected in 33%. The sensitivity of the MRI was 63%.

Conclusions: Ramp lesions were found in 117/690 (16.9%) of patients undergoing ACL reconstruction. MRI had a low sensitivity rate of 63%. During ACL reconstruction, a careful review of the posteromedial compartment is important to recognize less obvious trauma. Lack of treatment may lead to continued instability and risk of complications in these patients.

Keywords: ACL, MRI, meniscus, reconstruction

Introduction:

The "Ramp" lesion is a particular injury subtype defined by a longitudinal vertical and/or oblique peripheral tear affecting the posterior horn of the medial meniscus (PHMM) that

may lead to meniscocapsular or meniscotibial disruption, often associated with ACL ruptures.[1]

A meniscocapsular separation at the PHMM is of special interest because of its potential hidden location within the posterior septum, especially when the knee is near full extension.

As such it is sometimes called a "hidden lesion" because this meniscocapsular tear is, topographically, located in the blind spot of the knee, being difficult to visualize by standard arthroscopic approaches [2] (Figure 1).

The medial meniscus has more peripheral attachments to the capsule and is significantly less mobile in the normal knee than the lateral meniscus. In biomechanical and anatomic studies, the PHMM serves as an important secondary restraint to anterior tibial translation [3], but ramp

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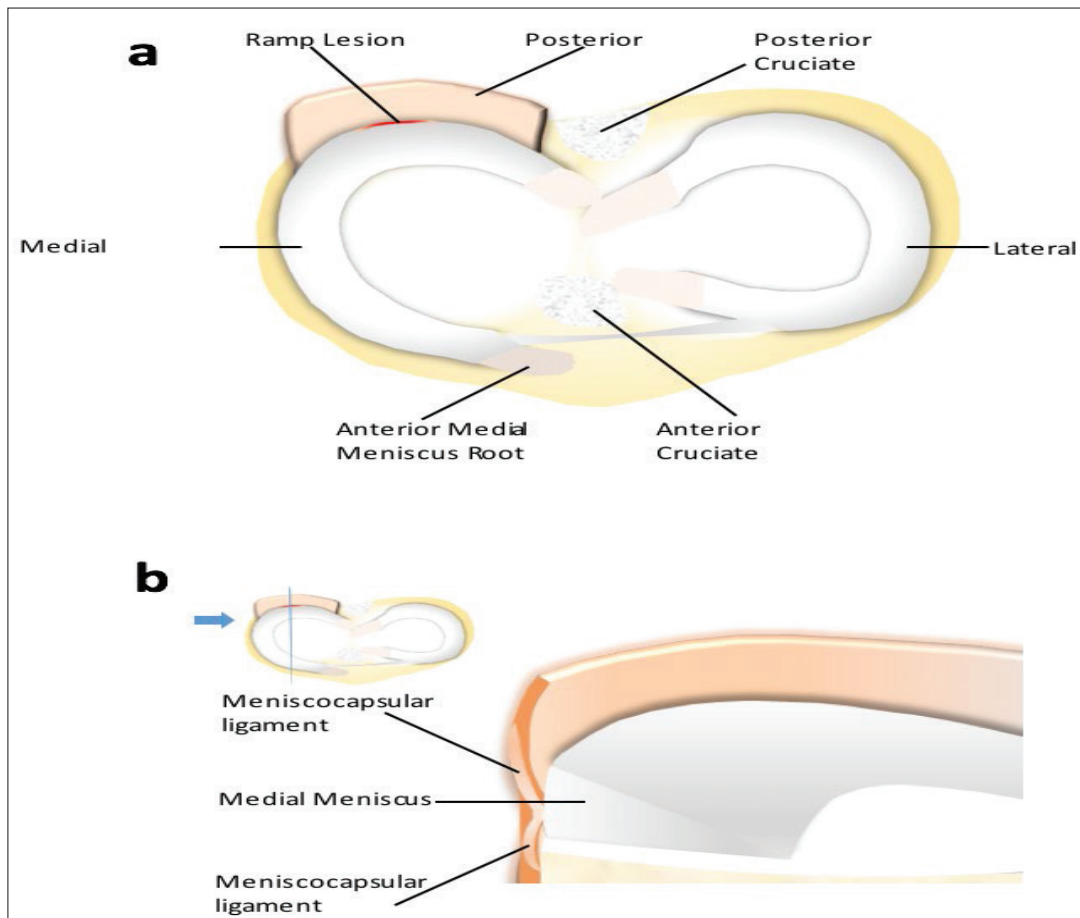


Figure 1. (a) Axial view of the middle level of the medial compartment, (b) Coronal view of the left knee showing posterior location of a Ramp.

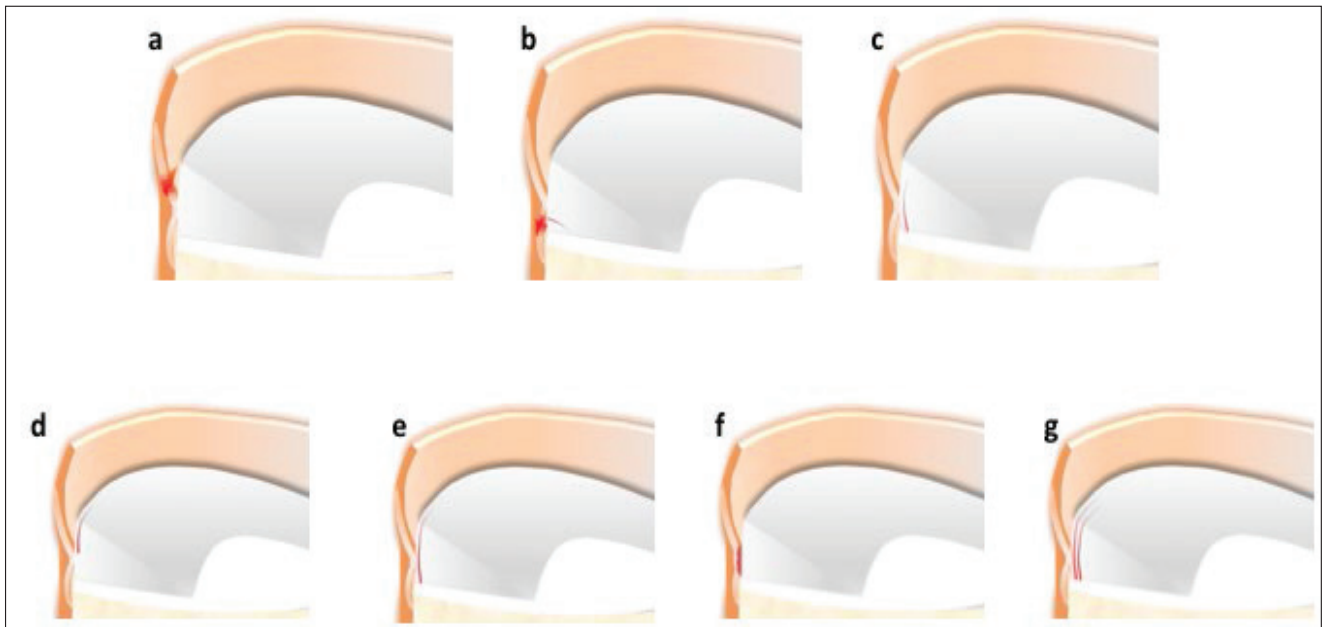


Figure 2. (a) Type 1 ramp lesion illustration, defined as meniscocapsular ligament tear, (b) Type 2 meniscal ramp lesion illustration, defined as partial superior peripheral posterior meniscal horn tear, (c) Type 3A meniscal ramp lesion illustration, defined as partial inferior peripheral posterior horn meniscal tear, (d) Type 3B meniscal ramp lesion illustration, defined as a partial inferior tear affecting the meniscotibial ligament, (e) Type 4A meniscal ramp lesion illustration, defined as complete peripheral posterior horn meniscal tear, (f) Type 4B meniscal ramp lesion illustration, defined as complete meniscocapsular junction tear, (g) Type 5 meniscal ramp lesion illustration, defined as peripheral posterior horn meniscal double tear.

lesions historically have not been consistently identified or well understood. [4-7]

Thaumat et al. [8] proposed a classification of the medial posterior capsular-meniscal lesions. The classification is based on the tear pattern (partial or complete) and its association to a meniscotibial ligament tear. It is divided into 5 types: general ramp lesion, partial superior lesion, partial inferior or hidden lesion, complete tear, and double tear. Grief et al modified this classification by splitting type 3 and 4 in type 3A, 3B, 4A and 4B (**Figure 2**).

Although these lesions are usually associated with an anterior cruciate ligament tear, it remains an under-recognized lesion to many orthopedic surgeons because it is difficult to visualize using standard arthroscopic approaches and cannot be recognized easily on preoperative magnetic resonance imaging (MRI) scans.[4, 7]

However, it is generally considered that arthroscopic evaluation is necessary to completely rule out or accurately make a diagnosis.[3, 9] Diagnosis and treatment of Ramp lesions are important because, if neglected, they can cause anteroposterior instability or injury to the body of the medial meniscus, resulting in early failure of the reconstructed ACL or early osteoarthritis of the knee joint.[10]

While there has been increased interest in diagnosing, treating, and understanding the effects of ramp lesions in the adult orthopedic literature, little information about ramp lesions in pediatric patients currently exists. *Nguyen et al.* [11] found increased medial meniscus tears in pediatric patients with Ramp lesions compared to patients without, *Bernadini et al.* [12] reviewed pediatric ACL reconstruction and found a non-correlated MRI sensitivity of 57% compared to arthroscopic diagnosis, and a positive predictive value of 40%, and *Malatray et al.* [13] had a prospective cohort of pediatric ACL ruptures with a 23% Ramp lesion rate.

We aim to (1) characterize and evaluate the prevalence of ramp lesions in pediatric patients at a major tertiary children's hospital, providing important insights into demographics, diagnosis, treatment and functional disability and (2) evaluate the efficacy of MRI in its diagnosis.

Materials and Methods

With permission from the institutional review board, patients under 18 years old undergoing posterior medial meniscal injuries and anterior cruciate ligament ruptures were reviewed retrospectively from January 2018 to December 2021. Inclusion criteria included patients with a Ramp lesion confirmed on arthroscopy via surgeon notes.

Exclusion criteria included patients over 18 years old, patients that did not have an MRI, and patients that were not treated surgically. 690 patients were identified as having been diagnosed and treated for an ACL tear and/or posterior medial meniscal tear. 105 patients were found to have a medial meniscus ramp lesion at arthroscopy, for

an incidence of 15%. Patient age, sex, initial presentation, physical examination findings, mechanism of injury, pre-operative radiologic findings and treatment were collected and reviewed via electronic medical record.

Arthroscopy surgical technique

Treatment in all cases consisted of arthroscopic suturing with all inside technique and stability testing.

Modified Gillquist portal and maneuver was used to identify the ramp lesion. With the help of arthroscopic hook, the lesion was checked and seen if it was stable or not. A shaver was used to roughen the lesion fragments and the adjacent posterior capsule too. Then the lesion was fixed with all inside technique and the stability of it was tested with the arthroscopic probe.

Data analysis

Descriptive statistics were estimated and reported as means with standard deviation or counts with percentages.

Results

There were 62 females and 43 males, with an average age of 15.3 years \pm 1.5 at the time of diagnosis (Table 1). Mean BMI at the time of injury was 26.0 \pm 5.3. The most common mechanism of injury was sport related (88), followed by falls (6) and jumping (5). 16% (17) of injuries were non-sports related. The most frequent sports involved in injury were basketball (25%), soccer (23%) and football (23%) (Table 1, Graph 1). Injury in these activities was often due to cutting or twisting motions.

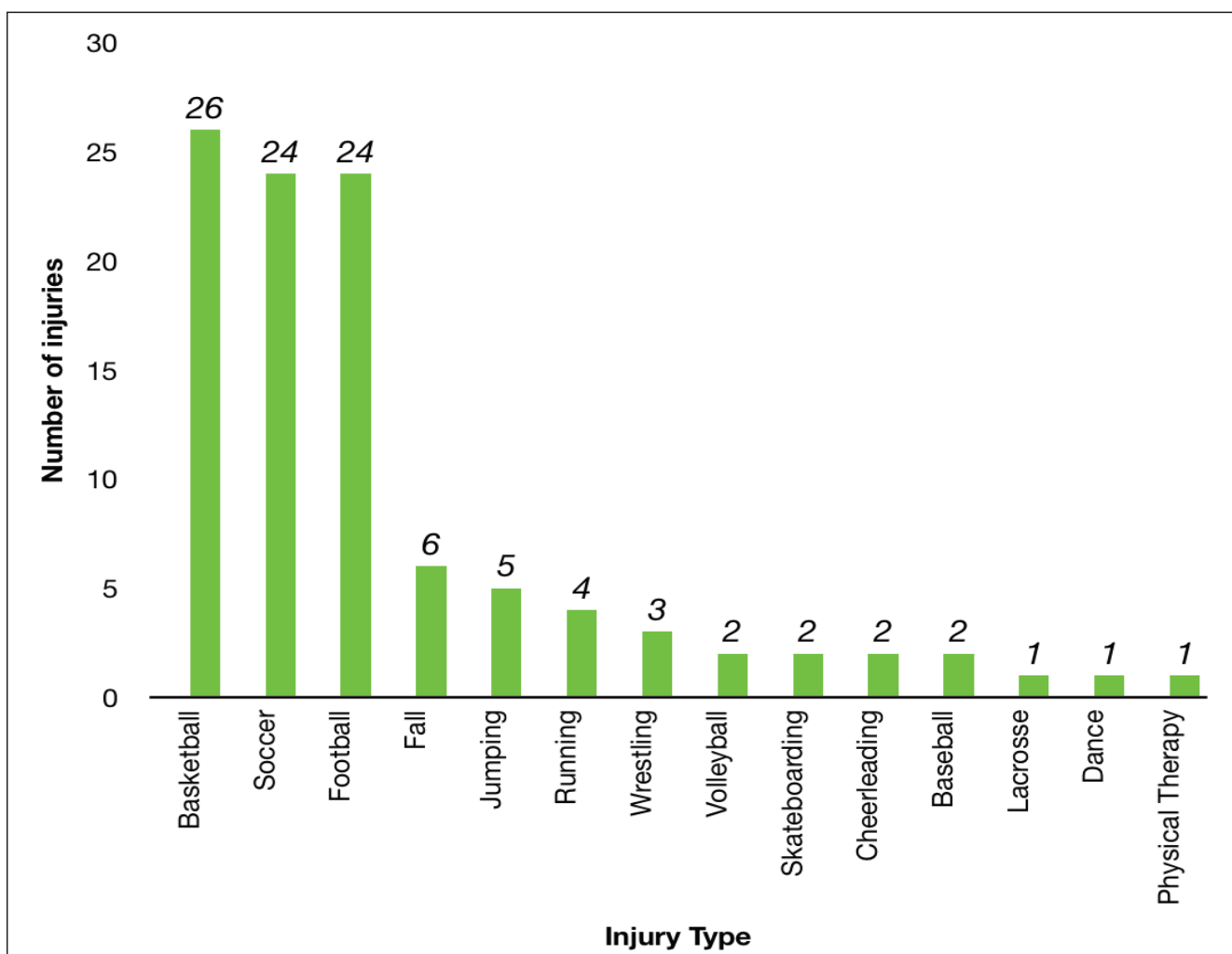
57% (60) of patients presented with tenderness to palpation, 67% (70) had swelling, and on physical exam 50% (53) had a limited range of motion. Referring to MRI reports the associated injury locations were more likely to be in medial compartment (59%) than both medial and lateral compartments (36%) and lateral compartment only (4%). Only three patients had underlying musculoskeletal history pathologies including one with genu varum, one with a history of arthroscopy reduction and internal stabilization procedure for a type I tibial spine fracture 4 years prior to ACLR, and one with avulsion tibial tuberosity 2 years prior to ACLR. All injured were isolated, except one patient with a concomitant ankle sprain.

All cases in our cohort were confirmed ramp lesions through arthroscopy. All patient Ramp lesions were associated with ACL tears. The sensitivity of an MRI in our cohort was 66% (69) There was no significant difference between sex, age, BMI, injury location, tenderness to palpation, swelling, or range of motion between patients that had lesions detected on MRI and patients whose lesions were not detected.

Variables	Counts and Percentages
Sex	Male (62), Female (43)
Race	White (49), Black (42), Asian (4), unable to obtain (10)
Age at Diagnosis (mean)	15.3 ± 1.5
BMI* (mean)	26.0 ± 5.3
Mechanism of Injury	Sports (88), falls (6), jumping (5), running (4), dance (1), PT* (1)
Injury Location (medial vs lateral)	medial and lateral (38), medial only (62), lateral only (4)
Tender to palpation	60 (57%)
Swelling	70 (67%)
Decreased range of motion	53 (50%)
MRI* ramp lesion detection	detected (69, 66%), not detected (32, 30%), suspected (4,4%)
Underlying MSK* pathologies or history	1x acquired genu varum, 1x arthroscopy + ORIF* 4 years prior to diagnosis, 1x idiopathic thoracic scoliosis

*BMI - body mass index; PT - physical therapy, MRI - magnetic resonance imaging; MSK - musculoskeletal; ORIF - open reduction internal fixation.

Table 1. Demographics and Characteristics



Graph 1. Etiology of injury

	Detected on MRI (69)	Not detected on MRI (32)	p
Sex	30 female, 39 male	12 female, 20 male	0.66
Age at Diagnosis (mean)	15.5 ± 1.4	15.0 ± 1.5	0.12
BMI	25.8 ± 5.5	26.2 ± 4.9	0.74
Injury location	medial and lateral (27), medial only (40), lateral only (2)	medial and lateral (10), medial only (19), lateral only (2)	0.61
Tender to palpation	58% (40)	53% (17)	0.67
Swelling	68% (47)	63% (20)	0.65
Range of motion	52% (36)	44% (14)	0.52

Table 2. Lesions Detected Versus not Detected on MRI

Discussion

The diagnosis and treatment of Ramp lesion has been well established in adult populations, but has not been studied as extensively in pediatric populations. In this series of 105 pediatric patients with ACL ruptures, we found ramp lesions in 15% of them. none of our measured patient variables were associated with preoperative MRI diagnosis.[12]

Causes and activities

ACL ruptures, and by extension Ramp lesions, often occur during sporting activities. (cite)

In our cohort, pivoting sports such as basketball, soccer, and football, were most prevalent.

Willinger *et al.* [14] found a 16% incidence of ramp lesions in ACL-injured knees at surgery in professional athletes (mean age of 22.3 years old).

Other studies have shown rates of 9 to 34%. [9, 16-22]

Only 3 studies have reviewed Ramp lesions in a pediatric population after ACL injury; *Nguyen et al.* [11] with a 41% rate in patients aged 10-20 years, *Malatray et al.* [13] with a 23% rate in patients aged 12-18 years, and *Liu et al.* [16] with a 21% rate in patients aged 10-20 years. These incidences are higher than our cohort (15%), but similar to non-pediatric studies.

Diagnosis

A specific test or physical exam finding to detect Ramp lesions does not exist. Further, isolated ramp lesions with no ACL rupture association is rare and not often looked for. [15]

A typical history includes localized pain, with or without swelling that begins directly after trauma and progresses over 2-3 weeks if the patients do not stay in rest. In the context of our study, physical exam findings were not necessarily specific to the Ramp lesions as any findings were confounded by history of ACL rupture.

Our physical exam findings tended to include tenderness to palpation (57%), swelling (67%), and painful or limited range of motion (50%). *Jiang et al.* described a series of

17 isolated Ramp lesions where patients had posteromedial knee pain, limited flexion, medial joint line tenderness, and positive McMurray's tests.[15]

Ramp lesions occur at the attachments of the meniscocapsular ligament and meniscotibial ligament at the middle level of the posterior horn meniscus length.[1] Anatomically, the posterior capsule does not attach directly to the superior portion of the PHMM, providing evidence for the potential location of hidden meniscal ramp lesions when the knee is near full extension.[4]

This hidden area may be responsible for missed diagnoses of ramp tears during preoperative MRI scans, and it further supports the utility of checking this area with a probe and/or viewing the PHMM posteromedially during arthroscopy to confirm or disprove the presence of a ramp lesion at the time of ACL surgery.[13]

In our cohort, MRI sensitivity was 66%. Other reports analyzing the accuracy of MRI for these lesions have ranged from 48-85%, and subsequent arthroscopy for confirmation of diagnosis and treatment is necessary. [1, 9, 11, 12, 14, 17, 19, 20, 23]

Arner et al. [17] had one reviewer out of three with an 84% MRI sensitivity in 90 patients, but had low inter-rater reliability (0.56), while *Kim et al.* [19] had 85% sensitivity in a series of 95 patients.

Because of the difficulty in identifying ramp lesions on standard arthroscopic approaches and defining the level of lesion during arthroscopy, if it is capsular or peripheral menisci, the classification often remains as a general Ramp lesion. [5] There was no documentation of classification in surgery notes in any of our cases.

Treatment

All the patients were treated by arthroscopy with the all inside suture technique [24, 25]

Some reports show good outcomes with trephination and abrasion only, but with a longer return to sport. [12, 26] Most recommend surgical treatment due to risk of osteoarthritis, instability, and a higher chance of ACL re-rupture.[10, 12]

In our series all lesions were treated arthroscopically and tested for stability. Additionally, stabilization carries a theoretical benefit of preventing tear propagation.

Limitations

The study was descriptive. There was no comparison group for the cohort. While this is the largest series on prevalence in pediatric ramp lesions, it is relatively small in comparison to some all-inclusive studies.[2, 16]

There were no MRI scans post-operatively to evaluate healing, nor is this a clinical outcome study.

Conclusion

Ramp lesions had an incidence rate of 15% in children and adolescents with ACL rupture undergoing surgical treatment. Only 66% of lesions were detected on preoperative MRI. Diligent exploration of the posteromedial compartment is necessary during ACL reconstruction to accurately diagnose and repair Ramp lesions in the pediatric population. Lack of treatment may lead to continued instability and risk of complications in these patients.

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