BS Structured Summary

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Original Article: Combined Root and Body Lateral Meniscus Tears in the Adolescent Population — An Underrecognized and Underreported Tear Pattern

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Introduction / Background

Meniscus root tears were historically labeled the "silent epidemic" of knee arthroscopy — under-recognized and under-treated for decades. In recent years, however, this picture has begun to change: diagnostic difficulty, inconsistent clinical presentation, and the strong association with anterior cruciate ligament (ACL) injuries have placed root tears at the center of the sports medicine research agenda. A meniscus root tear is defined as a radial tear within 1 cm of the meniscal root attachment — anterior or posterior — or as a complete bony or soft-tissue avulsion of that attachment from the tibial plateau.

While posterior medial meniscus root tears are typically associated with degenerative disease, lateral meniscus posterior root tears (LMPRTs) are usually traumatic and present in 7% to 14% of patients with ACL injuries. Biomechanical studies have shown that LMPRTs significantly increase tibiofemoral contact pressures — particularly when there is concomitant disruption of the meniscofemoral ligaments (MFLs) of Humphrey and Wrisberg, which provide additional support to the lateral root.

Despite advances in morphological classifications of root tears — with LaPrade's five-type system being the most widely used — specific patterns continue to escape traditional classification. In 2016, Shen et al. described in adults a combination that proved to be more common than isolated LMPRT alone: a simultaneous tear of the posterior root and the body of the lateral meniscus, termed CRAB tear (combined root and body) — named for its claw-like appearance reminiscent of a stone crab. Preoperative diagnosis is particularly challenging: isolated LMPRTs are missed on up to 66% of preoperative MRIs, and it is reasonable to assume that the CRAB pattern is even more underdiagnosed.

No prior literature had described this injury pattern in the adolescent population. The present study is the first to characterize the incidence, clinical associations, and diagnostic miss rate of CRAB tears in adolescents undergoing primary ACL reconstruction.

Objective

(1) To describe the incidence of CRAB tears of the lateral meniscus in adolescents undergoing primary ACL reconstruction; (2) to retrospectively analyze demographic, MRI, and intraoperative findings of patients with CRAB tears; and (3) to determine the rate at which this injury pattern is missed by the radiologist on preoperative imaging.

Methods

A retrospective chart review was performed of all patients undergoing primary ACL reconstruction between January 2021 and December 2022 by a single fellowship-trained pediatric sports medicine surgeon (A.T.P.) at a large metropolitan children's hospital. Patients of all ages were included. Exclusion criteria: multiligamentous knee injury requiring reconstruction beyond the ACL, congenital absence of the ACL, revision reconstruction, discoid meniscus, and unavailability of preoperative MRI or intraoperative imaging.

Operative notes, imaging findings, and arthroscopic images were retrospectively reviewed to characterize lateral meniscus pathology, including LMPRTs, CRAB tears, or other patterns. After identifying the CRAB cohort, a randomly selected control cohort with a 2:1 ratio was generated from the larger ACL group. Demographic variables collected: time between MRI and surgery, age at injury, BMI, height, weight, and mechanism of injury (contact vs. noncontact).

Imaging variables included: physeal status, presence of meniscal extrusion (>3 mm beyond the lateral tibial plateau margin), atypical bone bruising, Segond fracture, cartilage damage, and concomitant injuries to the posterolateral corner (PLC), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and medial meniscus. Bone bruising was classified as nonclassic when the T2 signal was located outside the conventional posterolateral tibial plateau or middle third of the lateral femoral condyle — the classic patterns described in acute ACL tears.

Preoperative MRIs were performed on a 1.5-T scanner with coronal, sagittal, and axial sequences in T1, T2, and fat-suppressed T2 weightings. Imaging variables were collected by a board-certified attending surgeon and a PGY-3 resident. A CRAB tear was classified as "missed" by the radiologist if either the posterior root tear, the radial body tear, or both were absent from the preoperative MRI report yet observed intraoperatively.

Main Results

Of 227 primary ACL reconstructions, 122 (54%) involved a lateral meniscus tear, and 38 (17%) involved the posterior root. A total of 23 CRAB tears were identified, representing 10.1% (23/227) of all ACL tears and 60.5% (23/38) of all LMPRTs. In other words, among adolescents with LMPRTs, the CRAB pattern was MORE common than isolated root tears (60.5% vs. 39.5%).

The mean age of CRAB patients was 16.0 ± 1.3 years, with 78% (18/23) male. Most — 65% (15/23) — had a noncontact mechanism. There was no difference in the time interval between MRI and surgery between groups with and without CRAB.

Patients with CRAB tears were 3.7 times more likely to have nonclassic bone bruising (43% vs. 17%; p=0.039) and had a higher BMI (26.6 ± 5.8 vs. 23.9 ± 4.9; p=0.048) compared with ACL patients without CRAB. Mean weight was also higher (80.9 vs. 68.4 kg; p=0.012). Lateral meniscus extrusion was more frequent in the CRAB group (22% vs. 9%) but did not reach statistical significance (p=0.148).

Associated injuries: deep MCL injury in 57% (13/23), medial meniscus tear in 43% (10/23), and PLC injury in 26% (6/23) — none statistically different from controls. There were no differences in superficial MCL or in proximal/distal MCL distribution.

The most striking finding: 74% (17/23) of CRAB tears were missed by the radiologist on preoperative MRI. Detailed analysis of missed cases revealed that 58.8% (10/17) were due to omission of the radial body tear, 23.5% (4/17) due to omission of the posterior root tear, and 17.6% (3/17) due to omission of both components.

Authors' Conclusion

CRAB tears are underdiagnosed preoperatively and represent a relatively common injury pattern, particularly in adolescents undergoing primary ACL reconstruction with higher BMI and nonclassic bone bruising. When a radial tear of the lateral meniscus body is identified arthroscopically, the surgeon must carefully evaluate the posterior root of the meniscus to ensure no second lesion is overlooked.

BS Discussion

This study brings to light an injury pattern that most of us have likely encountered in the operating room but which has lacked formal description in the pediatric literature. An incidence of 10.1% across all adolescent ACL reconstructions — and the fact that the CRAB pattern is MORE common than isolated LMPRT (60.5% vs. 39.5%) — is a number that deserves attention. We are not talking about a rarity.

The central message of this paper is, first and foremost, intraoperative: when a radial tear of the lateral meniscus body is identified during arthroscopy, careful inspection of the posterior root is mandatory. This inspection requires proper knee positioning — figure-of-four with varus stress — and active use of a probe. The literature has consistently shown that the lateral root is a blind spot in standard arthroscopy, and this study reinforces that, in the presence of a radial body tear, the likelihood of a second root lesion is high. Intraoperative recognition completely changes the treatment strategy — from isolated root repair to combined management of both components.

On the preoperative side, the 74% miss rate by radiologists is alarming and merits reflection. Notably, 59% of missed cases stemmed from omission of the radial body tear — not the root tear itself. This suggests that even musculoskeletal radiologists trained to look for the classic LMPRT may overlook the body component, particularly on 1.5-T scans. For BS, this translates into a two-pronged practical recommendation: first, in our dialogue with radiologists, we should highlight this pattern so that active search for the radial body tear is incorporated into systematic MRI reading in ACL patients. Second, whenever feasible, we should prioritize 3-T MRI in the setting of acute adolescent ACL injury.

The associated factors — higher BMI, nonclassic bone bruising, and noncontact mechanism in young patients — are valuable clinical clues. Atypical bone bruising in particular suggests that the CRAB tear represents a higher-energy mechanism, with energy dispersion from the posterior root to the body of the meniscus. This biomechanical concept is coherent and clinically useful: atypical bone bruise patterns should prompt us to actively search for less obvious meniscal lesions.

Limitations are honestly disclosed and typical of retrospective designs: single-center, single-surgeon sample, no PROMs collected, and no data on fixation technique or treatment of the body tear component. Prospective long-term studies are still needed to determine whether recognition and proper

treatment of the CRAB components reduce post-traumatic lateral compartment arthropathy — a biologically plausible but still unproven hypothesis. For BS Papers, this is essential reading for any surgeon operating on adolescents with ACL injuries: it adds an item to our intraoperative checklist and improves the precision of our communication with both radiology colleagues and patient families.

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