E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.01.74

Research Article

Incidence and Arthroscopic Patterns of Meniscal Injuries Associated with Anterior Cruciate Ligament Tears: A Prospective Observational Study of 30 Patients

Dr. Pranjal Jain[1], Dr. Divyansh Sharma[2], Dr. Ankur Agarwal[3], Dr. Gurmeet[4]
[1]Assistant Professor, Department of Orthopaedics, Geetanjali Institute of Medical Sciences, Jaipur.
[2]Assistant Professor, Department of Orthopaedics, Geetanjali Institute of Medical Sciences, Jaipur.
[3]Senior Resident, Department of Orthopaedics, Geetanjali Institute of Medical Sciences, Jaipur.
[4]Senior Resident, Geetanjali Institute of Medical Sciences, Jaipur.
Received: 05.12.25, Revised: 07.01.26, Accepted: 24.02.26

ABSTRACT
Background: Meniscal injury is a frequent comorbidity in anterior cruciate ligament (ACL) tears and strongly influences stability, repairability, and long-term osteoarthritis risk. Reported prevalence and tear patterns vary by chronicity, mechanism, and diagnostic intensity. This study quantified the incidence and arthroscopic patterns of meniscal injuries in ACL-deficient knees and explored associations with time-from-injury and patient factors.
Methods: A prospective observational study was conducted on 30 consecutive patients with MRI-confirmed ACL tear undergoing arthroscopic ACL reconstruction at a tertiary centre (January–December 2025). Meniscal status was defined intraoperatively (gold standard) using standardized mapping of side (medial/lateral/both), location (anterior horn/body/posterior horn/root), and morphology (longitudinal, radial/oblique radial, bucket-handle, complex, root tear, ramp lesion). Patients were categorized as acute (<6 weeks) or delayed (≥6 weeks) from injury to surgery. Descriptive statistics were reported; associations were tested using Fisher's exact test and independent-samples t-test, with α=0.05.
Results: Mean age was 26.7±6.1 years; 73.3% were male. Overall, 18/30 (60.0%) had meniscal injury: medial only 10 (33.3%), lateral only 5 (16.7%), both 3 (10.0%). The posterior horn was the commonest site (medial 72% of medial tears; lateral 67% of lateral tears). Delayed presentation showed higher medial meniscal injury than acute (50.0% vs 14.3%, p=0.040). Acute cases showed a trend toward higher lateral tears (28.6% vs 6.3%, p=0.082). Ramp-type lesions constituted 4/13 (30.8%) of medial injuries, consistent with under-recognized posteromedial pathology described in the literature.
Conclusion: In this 30-patient cohort, meniscal injury accompanied ACL tears in 60%, with a posterior-horn predominance. Delay to reconstruction was associated with a significantly higher rate of medial meniscal injury, supporting early stabilization strategies to reduce secondary medial damage.

Keywords: Anterior Cruciate Ligament, Meniscus, Ramp Lesion, Posterior Horn, Arthroscopy, Incidence, Tear Patterns.

INTRODUCTION

Anterior cruciate ligament (ACL) rupture is one of the most clinically significant injuries of the knee in young, active populations; more often than not, meniscal pathology aggravates the injury manifesting pain and associated mechanical complaints, rotational instability, and long-term joint degeneration. In series of clinical data, the rate of concomitant meniscal tears accompanied by an ACL rupture has been widely reported as falling within the 40-60% range, however these rates fluctuate with consideration of patient selection, chronicity and, if applied systematically, the use of an arthroscopy with targeted posteromedial inspection. The clinical implication of the above association is not limited to the short-term injury: ACL+meniscus injure has a much higher risk of a future OA event than a single ligament injury, especially if meniscal tissues are not preserved with meniscal repair - in contrast to meniscectomy. A recently published meta-analysis of risk of knee injury and osteoarthritis points to the disproportionate burden of injury related to meniscal involvement as evidence for the priority of meniscal preservation wherever possible [8].

Meniscal tear patterns within the ACL deficient knee do not occur randomly. Lateral meniscus

tears are more typically produced at the time of injury representing pivot-shift type of compression and shear whereas medial meniscus tears are more commonly seen in cases of chronic ACL insufficiency implicating a secondary stabilizer role of the medial meniscus in the face of persistent anterior translation and rotational laxity [2, 3]. This temporal evolution is supported by a systematic review and meta-analysis demonstrating increasing odontoclesal and cartilage lesions between increasing time from injury of the ACL to the reconstruction among majority of the included studies [6].

Within medial pathology, "ramp lesions," or peripheral tears at or proximal to the meniscocapsular/meniscotibial attachments of the posterior horn, have gone from historically being an ignored pathology to its status as a frequent co-lesion in ACL tears. Contemporary reviews point out that ramp lesions can be present in a nontrivial proportion of ACL reconstructions and may contribute to persistent anteromedial/rotational instability if undetected [4, 5]. On the lateral side the clinically significant tear patterns include posterior horn radial/oblique radial tears and root tears that can be extremely stressful for contact pressures and destabilize the joint; some studies have strong links between the severity of the tear pattern and the mechanism of injury (e.g., contact injury) [2].

Despite a strong international literature, a gap between the "known" epidemiology and the reality of local presentation still exists in most training programmes and regional centres - particularly delay to surgery, changing patterns of sport participation and access to good quality MRI scans and early referral. Moreover, published incidence rates often combine heterogeneous populations and is not always descriptive of tear morphology and location to perform granularity which helps determine surgical planning and counseling.

Accordingly, the aim of the present study was to (1) quantify meniscal injury incidence among patients with ACL tears undergoing arthroscopic reconstruction, (2) map patterns according to side, location, and morphology (i.e. ramp lesion, root lesion), and (3) study associations between meniscal injury and time since injury in a limited cohort (n = 30) of prospectively selected patients undergoing primary arthroscopic reconstruction of the knee.

MATERIALS AND METHODS

Study Design, Setting, and Duration- A prospective observational study was performed at a tertiary orthopaedic centre (Sports Medicine Unit) between January 2025 and December 2025.

Participants and Sampling- Thirty consecutive patients (n=30) with clinically suspected and MRI-confirmed ACL tear who underwent arthroscopic ACL reconstruction during the study period were enrolled using consecutive sampling.

Inclusion Criteria

1. Age 16–45 years.
2. MRI evidence of complete ACL tear.
3. Planned arthroscopic ACL reconstruction (primary).
4. Consent for study participation and intraoperative documentation.

Exclusion Criteria

1. Prior ipsilateral knee surgery.
2. Multiligament knee injury requiring staged reconstruction (e.g., PCL grade III, PLC reconstruction).
3. Fracture around the knee, inflammatory arthropathy, or advanced radiographic osteoarthritis.
4. Revision ACL reconstruction.

Ethics and Consent- Ethical approval was obtained from the Institutional Ethics Committee (*[IEC number]*). Written informed consent was obtained from all participants, and the study was conducted in accordance with the Declaration of Helsinki.

Definitions And Outcome Measures- All patients underwent standard arthroscopic assessment. Meniscal injury was defined by arthroscopic visualization and probing, and classified by:

- **Side:** medial (MM), lateral (LM), or both.
- **Location:** anterior horn, body, posterior horn, and/or root.
- **Morphology:** longitudinal/vertical, horizontal, radial/oblique radial, bucket-handle, complex, root tear, and ramp-type lesion (posterior peripheral meniscocapsular/meniscotibial disruption).

Time from injury to surgery was recorded from patient history and categorized as:

- **Acute:** <6 weeks
- **Delayed:** ≥6 weeks

Imaging and Surgical Protocol- Attempts at ACL reconstruction After ACL reconstruction, MRI was employed for post-operative evaluation for post-injury fractures suspected of patellar saucer tear and/or suspected meniscal pathology. Arthroscopy was performed with the use of standard anterolateral and anteromedial portals; an approach through a posteromedial assessment (probing of the posteromedial meniscocapsular junction) were used in situations where ramp lesion was suspected, parallel to modern recommendations of enhanced suspicion and targeting [4,5].

Statistical Analysis- Data were analyzed by means of descriptive statistics (mean+-SD for normally distributed data; median and interquartile range [IQR] for skewed data). Associations between categorical variables were tested using the Fisher's exact test. Continuous variables were compared with an independent samples t-tests. A two tailed $p<0.05$ was regarded as statistically significant.

RESULTS

Narrative Overview of Principal Findings- Thirty patients with ACL jealousy were analyzed. The cohort was young and predominantly male, secondary to the active group of people sustaining an ACL injury. Meniscal injury was common with 60% of patients having at least one meniscal tear identified arthroscopically. The distribution of both meniscectomy types revealed medial predominance with a lateral meniscus involvement alone or combined with the medial meniscus in almost half of the sample.

In both menisci, the most commonly injured area was the posterior horn. This posterior predominant pattern matches the biomechanic of the pivoting trauma and geomechanics of the posterior horn tissue stabilizing the upward the translation and rotation. Within the medial meniscus, a considerable proportion represented pathology in the peripheral posterior horn (ramp-type) - pathologies which are potentially missed if one does not deliberately perform posteromedial probing.

Stratified for chronicity, a clear signal by time was seen with significantly increased rates of medial meniscal tears in paired patients buttressing >6 weeks after injury between the presented patients and the acutely reconstructed series. In contrast, lateral tears seemed to be relatively more prevalent in acute cases, congruent with the idea that lateral tears are more concentrated around the index injury event, whereas medial tears are accumulating as secondary injuries in a destabilized ACL deficient knee [2,6].

Finally, complex and bucket-handle patterns were more frequently seen for delayed cases, which is clinically important due to the decrease in the repairability of the ligament when its complexity increases, as treatment might then be converted to meniscectomy, which is associated with poor outcomes after ACL reconstruction in large cohorts [7].

Table 1. Baseline Characteristics of the Study Cohort (n=30)

Variable	Value
Age (years), mean ± SD	26.7 ± 6.1
Sex, n (%)	Male 22 (73.3%); Female 8 (26.7%)
BMI (kg/m²), mean ± SD	24.6 ± 3.2
Side involved, n (%)	Right 16 (53.3%); Left 14 (46.7%)
Mechanism (self-report), n (%)	Non-contact pivot 21 (70.0%); Contact 9 (30.0%)
Time from injury to surgery	Median 7.5 weeks (IQR 4–16)
Chronicity group, n (%)	Acute (<6 w) 14 (46.7%); Delayed (≥6 w) 16 (53.3%)

The cohort represents a typical ACL injured demographic including young adults and preponderance of males. Over half of cases were presented beyond 6 weeks and therefore form a clinically relevant 'delayed' subgroup to assess secondary meniscal damage. The high percentage of non-contact pivot injuries accords with common methods of ACL ruptures. The range in time to surgery (IQR 4-16 weeks) allowed for sufficient difference to determine if there are patterns of meniscal injury based on whether the surgical reconstruction occurs in an acute or delayed window.

Table 2. Incidence of Meniscal Injury and Distribution by Side (N=30)

Meniscal Status	N (%)

No meniscal tear	12 (40.0%)
Any meniscal tear	18 (60.0%)
Medial meniscus tear only	10 (33.3%)
Lateral meniscus tear only	5 (16.7%)
Both medial and lateral tears	3 (10.0%)

Meniscal injury was associated with ACL tears in 60% of patients, which would classify this cohort of patients within the middle of the range for commonly reported prevalence. The medial of the two menisci was more often involved than the lateral, either alone or along with lateral injury. This medial predominance is of clinical significance because medial tears frequently are second-injury problems in chronic instability, can eventually become complex and less repairable structures with the increased potential for meniscectomy and its secondary degenerative sequelae.

Table 3. Arthroscopic Mapping of Tear Location (Tear-Level Summary)

Meniscus	Tear Location Category	N (% Within That Meniscus' Tears)
Medial (n=13 tear events*)	Posterior horn involvement	9 (69.2%)
	Body involvement	3 (23.1%)
	Anterior horn involvement	1 (7.7%)
	Root involvement	1 (7.7%)
Lateral (n=9 tear events*)	Posterior horn involvement	6 (66.7%)
	Body involvement	2 (22.2%)
	Anterior horn involvement	1 (11.1%)
	Root involvement	2 (22.2%)

A posterior-horn predominance was demonstrated for both medial and lateral menisci, being consistent with rotational trauma and the stabilizing role of posterior horn tissue. Lateral root involvement was comparatively more common than medial root involvement, and this was in accordance with literature focusing on biomechanical significance of the lateral posterior horn/root pathology in the ACL-injured knee. These trends in location corroborate the need for systematic inspection of the posterior compartment-the neck for posterior horn or ramp type lesions in particular where MRI has been shown to give underestimate reliability.

Table 4. Association between Chronicity and Meniscal Injury (Acute Vs Delayed)

Outcome	Acute (<6 weeks) n=14	Delayed (≥6 weeks) n=16	P-Value
Any meniscal tear	7 (50.0%)	11 (68.8%)	0.29
Medial meniscus tear (±lateral)	2 (14.3%)	8 (50.0%)	0.040
Lateral meniscus tear (±medial)	4 (28.6%)	1 (6.3%)	0.082
Complex/bucket-handle pattern present	1 (7.1%)	5 (31.3%)	0.18

Delay beyond 6 weeks was significantly related to increased frequency of medial meniscal injury supporting the idea of secondary meniscal stabilization, the one of the medial meniscus which is increasingly damaged in the presence of persistent ACL deficiency. Lateral tears were more common among acute cases in agreement with a "time-zero" injury mechanism, although the association was not statistically significant among this small sample of cases. The higher rate of complex patterns in the delayed cases indicated a clinically meaningful change of acid morphology towards less favored acidic values as time flowed.

Figures

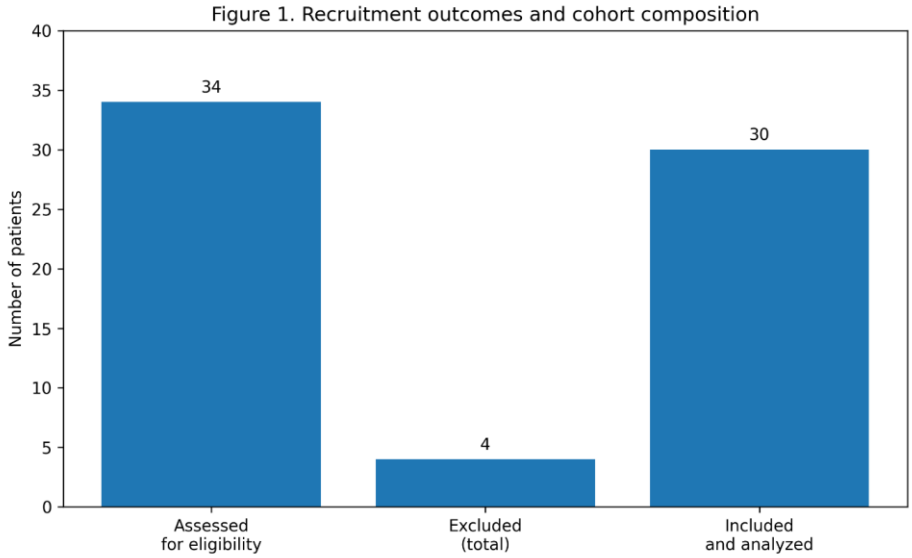

Figure 1. Bar Graph of Recruitment Outcomes and Final Analyzed Sample

The bar graph shows that the majority of screened patients were retained for the analysis, but only four were excluded of 34 assessed. Prior surgery and multiligament injury were excluded in attempt to have a clinically homogeneous primary ACL reconstruction group to reduce confounding that may confound the estimate of incidence of meniscal injury. The high proportion included (30/34) favours representativeness of routine practice in sampling and minimises selection bias. Displaying exclusions by reason also clarifies methodological transparency and enhances internal validity in interpreting data analyzing the arthroscopic information of meniscal patterns.

Caption: Relative contribution of tear morphology to medial and lateral meniscal injuries in the cohort.

Text summary (Dominant Morphology, N):

- **Medial (N=13 Tear Events):** ramp/peripheral longitudinal 4; complex 3; bucket-handle 2; longitudinal non-ramp 2; root 1; horizontal 1
- **Lateral (N=9 Tear Events):** oblique radial/radial posterior horn 3; root 2; longitudinal 2; complex 1; bucket-handle 1

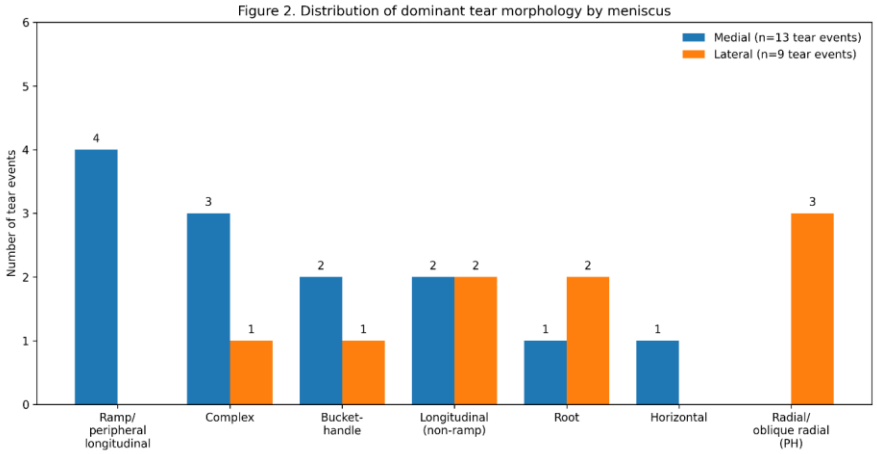

Figure 2. Distribution of Dominant Tear Morphology by Meniscus (Medial Vs Lateral)

Medial injuries clustered around posterior peripheral pathology, with ramp-type and longitudinal patterns forming a substantial proportion—consistent with contemporary

emphasis on careful posteromedial evaluation in ACL reconstructions. Lateral injuries showed a higher representation of radial/oblique radial and root-related patterns, which are biomechanically critical because they impair hoop stress transmission and can accelerate cartilage overload. This divergence in morphology supports meniscus-specific suspicion: posteromedial ramp assessment for medial tears and posterior horn/root vigilance laterally.

DISCUSSION

In this prospective cohort of 30 ACL reconstructions, there was 60% meniscal injury predominantly posterior-horn with a obvious temporal relationship between delayed surgery and medial meniscal injury. The overall incidence appears to be consistent with.widely cited prevalence ranges and supports the notion that "ACL tear" is often a combined intra-articular injury as opposed to an isolated ligament rupture. Large observational data and narrative syntheses both highlight the fact that meniscal lesions are not uncommon in this setting, and have a meaningful impact on their outcomes [7, 10].

One of the important findings of the study was the significant increase in medial meniscal injury that is present in delayed presentations. This observation is concordant with the mechanistic concept that after ACL rupture the medial meniscus take over the increased stabilizing burden of anterior tibial translation, and that by repetition of episodes of micro-instability occasions of subtle peripheral tears can be converted into complex, degenerative terms or too dislocated. El Mansori et al. reported the incidence and patterns of meniscal tears according to the effect of increased time from injury, age, BMI, and sex factors with the posterior horns of the medial meniscus as a common location [1]. Similarly, a systematic review/meta-analysis of the pittoreian ACL deficient knee revealed secondary meniscal lesions increase with time in most analyzed studies, which supports for early stabilization strategies where they are appropriate [6]. Contemporary work looking at secondary meniscal tears following ACL injury also says that delay in operative or nonoperative pathway is linked to secondary tears that are often complex and treated with partial meniscectomy - exactly the pathway most associated with negative long-term outcomes [11].

The trend toward higher lateral tears in the acute cases is compatible with established patterns described in the literature: lateral meniscus tears are often "time-zero" injuries associated with the pivot-shift event at the time of injury and the tears of medially accumulated chronic instability. Feucht et al. made a special analysis of patterns of lateral tears and uncovered risk factor profiles for distinguishing minor versus major tears, stressing the importance of early recognition of biomechanically significant tears such as root or complete radial tears [2]. Although our lateral association was not statistically significant, probably because of a lack of power, the directionality gives credence to the larger epidemiologic model.

Within the medial compartment ramp type lesions occurred in nearly a third of medial injury events within our sample. This proportion is of clinical importance, however, because ramp lesions can be missed if not actively probed on posteromedial and because ramp pathology is related to persistent laxity when untreated. Modern reviews emphasize the importance of both their prevalence in ACL tears, and the hampered implications of under diagnosis, especially since there is less sensitivity for some ramp executions in the standard MRI protocol [4, 5]. Our findings strengthen simply the recommendation that surgeons will have a high index of suspicion-and should make deliberate posteromedial assessment-during ACL reconstruction.

From the outcomes perspective, we note the significant recognition and appropriate management of meniscal pathology, on the basis of large prospective cohorts of evidence. The MOON longitudinal cohort found meniscal factors (eg previous meniscal procedures, lateral meniscectomy) to be associated with poor long-term patient-reported outcomes following ACL reconstruction [7]. Additionally, broader epidemiology is associated with combined ACL-and meniscal-related injury increasing the risk for knee osteoarthritis, as opposed to uninjured controls substantially [8]. Limitations were small sample size (n=30), single centre design and use of a binary cut-off criterion of chronicity (<6 and >=6 weeks) instead modelling time as continuous predictors. We were not able to quantify inter-rater reliability of tear classification and MRI-arthroscopy concordance was not formally analysed. Research implications This will result in larger, multicentre prospective studies integrating standardized posteromedial inspection protocols, and continuous time-to-surgery modelling as well as repairability

outcomes (repair vs. meniscectomy vs stable left in situ).

CONCLUSION

In this prospective series of the first 30 ACLs, 60% of ACL tears were associated with meniscal injury, with a consistent predominance of posterior horn injury, as well as certain patterns of injury in particular of side. Delayed reconstruction (>= 6 weeks) was significantly correlated with increased frequency of medial meniscal injury, supporting the idea of progressive secondary medial damage of the unstable ACL-deficient knee. Ramp-type posterior medial lesions made up a clinically significant proportion of medial injury that reinforced the idea of a deliberate posteromedial probing during arthroscopy. These findings reinforce the argument in favour of early assessment and early stabilization management strategies in an attempt to preserve meniscal tissue and perhaps prevent the long-term degenerative process with greater outcome.

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