The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 7, 2025

FREQUENCY OF ANTERIOR CRUCIATE LIGAMENT INJURY ON MAGNETIC RESONANCE IMAGING AND ITS ASSOCIATION WITH KNEE MORPHOMETRICS

Dr. Syed Muhammad Hadi Ali Shah[*1], Dr. Aleem Shahid[*2], Dr. Maliha Younis[*3], Prof. Dr. Shahid Waheed[*4], Dr. Saman Rauf[*5], Dr. Hanan Mudassar[*6]

[*1, 2, 3, 5, 6] *MBBS, PG Resident, Al-Noor Diagnostic Center, Lahore.*
[*4] *MBBS, FCPS, DMRD, MCPS, Professor of Radiology, Al-Noor Diagnostic Center, Lahore.*

DOI: https://doi.org/10.5281/zenodo.17129840

Keywords
Anterior cruciate ligament, MRI, knee morphometry, notch width index, ACL injury, intercondylar notch

Article History
Received on 05 July 2025
Accepted on 18 July 2025
Published on 19 July 2025

Corresponding Author: *
Dr. Syed Muhammad Hadi Ali Shah

Abstract

Objective: *To determine the frequency of anterior cruciate ligament(ACL) injury using magnetic resonance imaging(MRI) in patients presenting with knee pain and to compare knee morphometrics in terms of mean femoral Notch Width (NW), Bicondylar Width (BCW) and Notch Width Index (NWI) in patients with and without ACL tear.*

Study Design: *Descriptive Cross-Sectional Study.*

Study Setting: *Al-Noor Diagnostic Center, Lahore.*

Study Duration: *Four months (from March to June, 2025)*

Methodology: *A total of 200 patients aged 17–50 years undergoing knee MRI for pain or suspected injury were enrolled using consecutive sampling. ACL injury status was assessed via MRI, and morphometric measurements (NW, BCW, and NWI) were taken on coronal T1-weighted images using digital calipers. Data were analyzed using SPSS Version 27. Differences in means were analyzed using independent t-tests, with a p-value of ≤ 0.05 indicating statistical significance.*

Results: *ACL injury was present in 94 patients (47.0%). Although the mean notch width (NW) and notch width index (NWI) were slightly lower in the injured group (NW: 21.56 ± 2.62 mm; NWI: 0.300 ± 0.026) compared to the non-injured group (NW: 21.18 ± 2.55 mm; NWI: 0.299 ± 0.027), the differences were not statistically significant (p = 0.293 and p = 0.665, respectively). Bicondylar width (BCW) also showed no significant difference between groups (p = 0.319).*

Conclusion: *ACL injury was found in nearly half of symptomatic patients undergoing MRI. In our population, morphometric parameters such as notch width, bicondylar width, and notch width index were not significantly associated with ACL injury.*

INTRODUCTION

The anterior cruciate ligament (ACL) is a key stabilizer of the knee joint, extending from the medial surface of the lateral femoral condyle to the medial tibial eminence(1, 2). ACL injuries are among the most common ligamentous injuries of the knee, with an estimated annual incidence of 100,000 to 200,000 cases in the United States and a prevalence of approximately 1 in 3,000 individuals(3). These injuries are frequently encountered in sports and trauma settings, often leading to significant functional limitations. In a study by Fatima et al., ACL tears were observed in

46.6% of symptomatic patients undergoing MRI, underscoring the clinical burden(4). MRI has become the modality of choice for non-invasive diagnosis, with reported sensitivity and specificity rates exceeding 90%(5- 7).

Recent research has emphasized the contribution of knee joint morphometry in predisposing individuals to ACL injury. Parameters such as intercondylar NW bicondylar width (BCW), and NWI have emerged as significant anatomical factors. In particular, narrower intercondylar notch dimensions are associated with an increased risk of ACL tears(3). This morphometric association is believed to influence both injury susceptibility and surgical outcomes during ACL reconstruction.Despite growing international evidence, there is a notable lack of published data from Pakistan or the broader South Asian region assessing knee morphometry in the context of ACL injuries. Most existing studies originate from Western or East Asian populations, which may not fully represent the anatomical characteristics of the local demographic. Additionally, regional clinical protocols often lack morphometric consideration when planning graft size or preventive strategies.

The present study aims to determine the frequency of ACL injuries diagnosed on MRI and to examine their association with intercondylar morphometric parameters, specifically NW, BCW, and NWI. Understanding these relationships is not only relevant for identifying individuals at higher risk of ACL tears but also plays a crucial role in surgical planning. For example, patients with an NW less than 17 mm and NWI below 0.27 often require a smaller graft for effective stabilization(8). These findings can also inform sports injury prevention programs and guide individualized postoperative rehabilitation.

This study seeks to address the current research gap by evaluating whether knee morphometric characteristics are associated with ACL injuries in the local population. This knowledge could help optimize both preventive and interventional strategies in musculoskeletal and sports medicine.

METHODOLOGY:

This descriptive cross-sectional study was conducted at Al-Noor Diagnostic Centre, located in the Shadman area of Lahore, Pakistan. It is a tertiary-level radiology facility equipped with advanced imaging technology and a high patient turnover rate, making it a suitable center for studies involving musculoskeletal imaging. All MRI scans in this study were performed using a Siemens Magnetom 1.5 Tesla MRI Scanner. This scanner is widely recognized for its diagnostic accuracy and reliability in evaluating soft tissue structures, particularly ligaments, tendons, and cartilage. The study was conducted over a period of four months following formal approval of the synopsis by the institutional review board.

A sample size of 200 patients was calculated using an online calculator. Parameters used in the calculation included a 7% margin of error, a 95% confidence level, and an estimated prevalence rate of 46.6% for ACL injuries, based on prior research data. A non-probability consecutive sampling technique was employed to recruit patients who fulfilled the inclusion criteria. This method ensured that every eligible patient presenting during the study period was considered for participation, reducing selection bias while maintaining practicality.

Inclusion criteria were: patients aged 17 to 50 years of either gender who presented with complaints of knee pain and underwent MRI using the dedicated knee protocol. Exclusion criteria included patients older than 50 years, those who had previously undergone knee surgery, and those with known infective or inflammatory arthritic conditions, hemophilic arthropathy, distal femoral epiphyseal fractures, or congenital skeletal deformities. These conditions were excluded to avoid morphometric distortions that could confound the results. Prior to imaging, all participants provided written informed consent. A structured data collection proforma was used to record demographic information including name, age, gender, and the duration of symptoms. MRI scans were performed with the patient in the supine position and the knee slightly flexed. A dedicated extremity coil was employed to enhance image resolution and

minimize motion artifacts. Imaging sequences included T1-weighted, T2-weighted, and fat-suppressed views in sagittal, coronal, and axial planes, providing comprehensive visualization of both bone and soft tissue structures.

Evaluation of the ACL involved analysis of several features: signal intensity on T2-weighted and fat-saturated images, continuity of low-signal fibers, fiber orientation, and the presence of amorphous or indistinct patterns. Complete tears were defined as non-visualization or clear discontinuity of the ligament. The NW was measured as the horizontal distance across the intercondylar notch on a coronal T1 image at the level of the popliteal groove. The BCW was determined as the maximum horizontal width between the medial and lateral femoral condyles on the same image. The NWI was calculated by dividing NW by BCW, providing a normalized metric to assess inter-individual variation.

All morphometric measurements were obtained manually using digital calipers embedded in the MRI software system. Measurements were taken independently by the principal investigator and cross-verified by a senior consultant radiologist to enhance reliability. If discrepancies exceeded 1 mm, the measurement was repeated and the average of two consistent readings was recorded. Standardized protocols were followed to minimize intra-observer variability.

Using IBM SPSS Statistics Version 27.0, continuous variables (age, NW, BCW, and NWI) were analyzed through descriptive statistics including mean and standard deviation.Categorical variables, including gender and presence of ACL injury, were presented as frequencies and percentages. Data were stratified by age and gender to assess their influence as potential confounders. An independent samples t-test was applied to compare mean morphometric measurements between patients with and without ACL injury.

RESULTS:

Table 1 presents the distribution of gender and ACL injury status among the 200 study participants. A total of 112 participants (56.0%) were female and 88 (44.0%) were male. ACL injury was detected in 94 individuals (47.0%) based on MRI findings, while 106 (53.0%) showed no evidence of ACL tear.

Table 2 presents the descriptive statistics of morphometric parameters in the study population. The mean age of participants was 33.12 years (SD = 10.24) with a range of 17 to 50 years. The mean notch width was 21.36 mm (SD = 2.58), with values ranging from 16.57 mm to 32.17 mm. The bicondylar width had a mean of 71.28 mm (SD = 5.50), ranging from 57.31 mm to 85.92 mm. The mean notch width index was 0.299 (SD = 0.026), with a minimum value of 0.25 and maximum of 0.37.

Table 3 summarizes the comparative analysis of morphometric parameters between individuals with and without ACL injury. Although mean values of notch width (21.56 ± 2.62 mm vs. 21.18 ± 2.55 mm) and bicondylar width (71.70 ± 5.64 mm vs. 70.92 ± 5.37 mm) were slightly higher in the ACL-injured group, the differences were not statistically significant ($p = 0.293$ and $p = 0.319$, respectively). Similarly, the notch width index showed almost identical values in both groups (0.300 ± 0.026 vs. 0.299 ± 0.027), with a negligible mean difference of 0.002 (95% CI: −0.006 to 0.009; $p = 0.665$).

TABLE 1: GENDER AND ACL INJURY DISTRIBUTION

Variable	Count	Percentage (%)
Gender - Female	112	56.0
Gender - Male	88	44.0
ACL Injury - Absent	106	53.0
ACL Injury - Present	94	47.0

TABLE 2: DESCRIPTIVE STATISTICS OF MORPHOMETRIC PARAMETERS

Variable	Mean	Std Dev	Min	25%	Median	75%	Max
Age	33.12	10.24	17.0	24.0	33.0	42.0	50.0
Notch Width (mm)	21.36	2.58	16.57	19.8	21.36	23.37	32.17
Bicondylar Width (mm)	71.28	5.50	57.31	67.0	71.70	75.7	85.92
Notch Width Index	0.299	0.026	0.25	0.28	0.30	0.31	0.37

TABLE 3: COMPARATIVE ANALYSIS OF MORPHOMETRIC PARAMETERS BY ACL INJURY STATUS

Parameter	ACL Present (Mean ± SD)	ACL Absent (Mean ± SD)	Mean Difference (95% CI)	p-value
Notch Width (mm)	21.56 ± 2.62	21.18 ± 2.55	0.39 (−0.34, 1.11)	0.293
Bicondylar Width (mm)	71.70 ± 5.64	70.92 ± 5.37	0.78 (−0.76, 2.31)	0.319
Notch Width Index	0.300 ± 0.026	0.299 ± 0.027	0.002 (−0.006, 0.009)	0.665

FIGURE 1: GENDER DISTRIBUTION OF STUDY PARTICIPANTS (N=200), SHOWING A SLIGHT FEMALE PREDOMINANCE

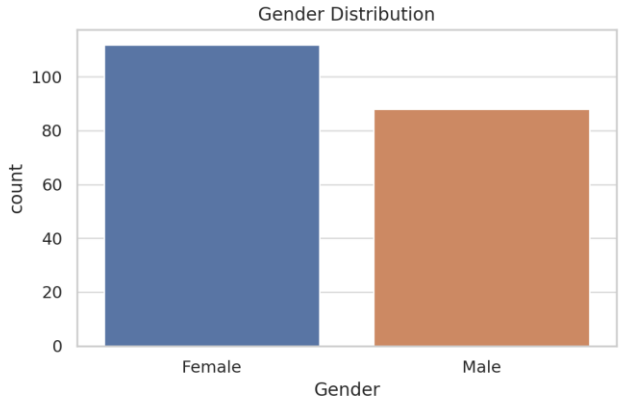
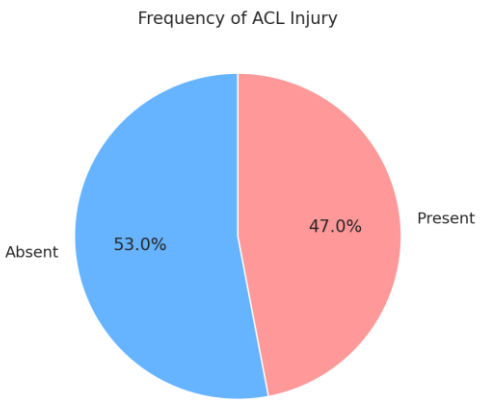


FIGURE 2: MRI-CONFIRMED FREQUENCY OF ACL INJURIES IN THE STUDY POPULATION, WITH 47% DEMONSTRATING LIGAMENT DISRUPTION.



DISCUSSION:

In this study, nearly half (47%) of symptomatic patients undergoing MRI were found to have anterior cruciate ligament (ACL) injuries. This aligns closely with findings by Nadaf et al., who reported a 50.5% ACL injury rate in a Sudanese population using similar MRI-based evaluation methods(9). The high detection rate underscores the value of MRI in diagnosing ligamentous injuries, especially in tertiary diagnostic centers.

Our population had a mean age of 33.12 ± 10.24 years, with a female predominance of 56%. A comparable demographic trend was seen in the study by Momin et al., which found that females exhibited narrower notch widths and thinner ACLs, possibly contributing to their increased injury risk(10). This sex-based predisposition to ACL injuries has been well-recognized and is thought to stem from anatomical, hormonal, and biomechanical differences(11).

In our study, although mean notch width (NW) and notch width index (NWI) were slightly lower in the ACL-injured group compared to the non-injured group, the differences were not statistically significant. This contrasts with the findings of Saad et al(12) and Kim et al(13)who reported significantly lower NW and NWI values in ACL-injured patients.

The role of intercondylar notch dimensions as a predisposing factor has also been substantiated in large-scale imaging studies. Maheshwari et al. analyzed 500 patients and identified NW, medial tibial plateau depth (MTPD), and posterior tibial slope as significant predictors of ACL tear. (3) Similarly, Dube et al., in a cadaveric study, confirmed significant inter-individual variability in ACL length and tibial footprint dimensions, reinforcing the value of personalized imaging analysis.(14) Our findings that bicondylar width (BCW) did not differ significantly between groups are echoed in the research by Thalanki et al., who found that BCW alone is less useful as a predictive measure without accompanying NW or slope parameters.(15) Sheikh et al. also supported this conclusion, reporting strong associations between ACL tears and reduced NW and increased tibial slope, but not BCW.(19)

Population-specific variations in knee morphology have been highlighted by Alzhrani et al. in the Saudi population, revealing differences in ACL length and tibial insertion sites compared to Western cohorts.(16) Purnachandra et al. found similar variability in Indian subjects, where narrow NW and steep slopes were prevalent in ACL-injured patients.(17) These studies support the notion that ethnic and regional anatomical differences must be considered in surgical planning and injury prevention strategies. Epidemiologically, our results align with Sanders et al., who reported a rising trend in ACL reconstruction surgeries over two decades, particularly among female adolescents.(18) Their findings are further supported by Gornitzky et al., who identified soccer and basketball as high-risk sports for ACL injuries in young athletes. (19)

The increased susceptibility in females has also been addressed by Hewett et al., who emphasized the need for neuromuscular training to reduce ACL injury rates.(20) This is complemented by Hootman et al., who provided sports-specific injury data and recommended tailored preventive programs.(21) MRI remains a cornerstone for both diagnostic and morphometric evaluations. Studies by Vinayak et al. and Sharma et al. emphasized the accuracy of MRI in detecting variations in ACL morphology, which can be vital in graft size selection and surgical technique determination.(22, 23)

Moreover, Boerboom et al. linked MRI characteristics such as graft signal intensity and tunnel position to functional outcomes post-ACL reconstruction, reinforcing the prognostic utility of preoperative imaging.(24)

CONCLUSION:

This study indicates that although patients with ACL injury tended to have narrower notch widths and lower NWI, these differences were not statistically significant. Nonetheless, when considered alongside MRI-based morphometric analysis and prior evidence, such parameters may still contribute to early diagnosis, surgical planning, and population-specific preventive strategies.

REFERENCE:

Hamdan M, Haddad B, Alshrouf MA, Azzam MI, Isleem U, Hamasha R, et al. Can MRI knee joint measurements predict the population at risk of ACL injury? BMC Sports Sci Med Rehabil 2022 Jun 2;14(1):98.

Juniarti DW, Sukmaningtyas H, Novriansyah R. The Risk Factor Analysis of Femorotibial Joint Morphometrics Associated with Severity of Anterior Cruciate Ligament Tear Using MRI Examination: Study in Indonesia. Open Access Macedonian Journal of Medical Sciences 2023 Jan 4;11(B):361–6.

Maheshwari SG, Kuber R, Lamghare P, Thomas J, Arkar R, Avhad M, et al. Anterior cruciate ligament (ACL) injury: correlation with MRI morphometry. Egyptian Journal of Radiology and Nuclear Medicine 2023 Aug 2;54(1):130.

Fatima R, Sadiq A, Sadiq S, Nazir M, Shazhad H, Mehmood A, et al. Frequency of Different Ligament Tears in Knee Injury On Magnetic Resonance Imaging. Journal of Health, Medicine and Nursing 2020;71(0):52.

Zhao M, Zhou Y, Chang J, Hu J, Liu H, Wang S, et al. The accuracy of MRI in the diagnosis of anterior cruciate ligament injury. Annals of Translational Medicine 2020 Dec;8(24):1657–1657.

Alharbi D, Ahmed Z. Morphometric Study of the Knee Joint in Saudi Arabian Population Based on Magnetic Resonance Imaging Scan. Journal of the Anatomical Society of India 2021 Mar;70(1):3.

Dar AJ, John A, Ashraf S, Faridi TA, Zahid S, Nazir AB. MRI Diagnosis and Grading of Anterior Cruciate Ligament Injuries. PBMJ 2022 Jan 31;5(1):341–5

Bayer S, Meredith SJ, Wilson KW, de Sa D, Pauyo T, Byrne K, et al. Knee Morphological Risk Factors for Anterior Cruciate Ligament Injury: A Systematic Review. J Bone Joint Surg Am 2020 Apr 15;102(8):703–18.

Nadaf A, Abdalla OAA, Abdalkariem AN, Fadlelseed AFA, Mohammed AA, Hamid NM, et al. Frequency of anterior cruciate ligament injury on magnetic resonance imaging and its association with knee morphometrics. Int J Soc Sci Bull. 2025;3(3):1015–6. doi:10.5281/zenodo.15502342

Momin MA, Shaikh AH, Patel SK, Rathi SP. Radiological evaluation of anterior cruciate ligament morphometry in patients with knee injuries. Int J Community Med Public Health. 2022;9(7):2752–6. doi:10.18203/2394-6040.ijcmph20221771

Hewett TE, Di Stasi SL, Myer GD. Why female athletes injure their anterior cruciate ligaments more frequently: what can we do to mitigate risk? Clin Orthop Relat Res. 2016;474(7):1575–85. doi:10.1007/s11999-016-4724-3

Saad S, Imran M, Aslam M, Shafiq R, Ahmed N. Comparison of notch width index in patients with and without ACL injury using MRI. J Pak Med Assoc. 2023;73(4):915–8. doi:10.47391/JPMA.4360

Kim D, Kim SJ, Lee JH, Cho YH. MRI morphometry of the anterior cruciate ligament and its clinical correlation. Radiol Med. 2021;126(6):801–8. doi:10.1007/s11547-021-01298-5

Dube P, Singh V, Sharma R, Kaur B, Tuli A. Morphometric analysis of anterior cruciate ligament in North Indian population: A cadaveric study. J Health Eng. 2021;2021:4076175. doi:10.1155/2021/4076175

Thalanki R, Varma B, Jayaprakash BG. Morphometric analysis of anterior cruciate ligament using MRI and arthroscopy in South Indian population. Jt Dis Relat Surg. 2023;34(1):130–7. doi:10.52312/jdrs.2023.82620

Alzhrani SM, Alrusayyis MA, Alhussaini TA, et al. Morphometry of anterior cruciate ligament: implications for reconstruction in the Saudi population. Jt Dis Relat Surg. 2022;33(3):479–84. doi:10.52312/jdrs.2022.738

Purnachandra L, Maheshwari SG, Lamghare P, et al. Morphometric characteristics of ACL and associated bony structures in Indian population using MRI. Int J Clin Med Public Health. 2023;10(2):1–8. doi:10.1007/s10741-023-01123-7

Sanders TL, Maradit Kremers H, Bryan AJ, Larson DR, Dahm DL, Levy BA, et al. Incidence of anterior cruciate ligament tears and reconstruction: a 21-year population-based study. Am J Sports Med. 2016;44(6):1502–7. doi:10.1177/0363546516629944

Gornitzky AL, Lott A, Yellin JL, Fabricant PD, Lawrence JT, Ganley TJ. Sport-specific yearly risk and incidence of anterior cruciate ligament tears in high school athletes: a systematic review and meta-analysis. Am J Sports Med. 2016;44(10):2716–23. doi:10.1177/0363546515617742

Hewett TE, Myer GD, Ford KR. Why female athletes injure their ACLs more frequently: what can we do to mitigate risk? J Orthop Res. 2016;34(11):1685–93. doi:10.1002/jor.23153

Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. J Athl Train. 2007;42(2):311–9. PMID: 17923773

Vinayak S, Sharma A, Tripathi N, Sharma K. Morphometric analysis of the anterior cruciate ligament: a cadaveric study. J Healthc Eng. 2021;2021:4076175. doi:10.1155/2021/4076175

Sharma R, Mathur RK, Gupta S. Morphometric analysis of anterior cruciate ligament in North Indian population using MRI. J Clin Diagn Res. 2017;11(7):AC01–4. doi:10.7860/JCDR/2017/27370.10207

Boerboom AL, Krips R, van Linge B, Hullegie WA. Quality of life and MRI characteristics in ACL injury: a cross-sectional analysis. Int J Environ Res Public Health. 2021;18(24):12845. doi:10.3390/ijerph182412845