

Morphologic Variation of Patellofemoral Joint in Nepalese Patients with Recurrent Patellar Instability: A Case-Control Study

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Abstract

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Background: Recurrent patellar instability (RPI) is strongly influenced by osseous morphology of the patellofemoral joint, yet population-specific data from South Asia remain scarce. This study evaluated magnetic resonance imaging (MRI) parameters of trochlear and patellar geometry in Nepalese patients with RPI compared with matched controls.

Methods: In this hospital-based case-control study, 72 patients with clinically confirmed RPI and 72 age- and sex-matched controls without patellofemoral pathology underwent standardized knee MRI at 15–20° flexion. Patellar tilt angle (PTA), sulcus angle (SA), and lateral trochlear inclination (LTI) were measured independently by two blinded orthopedic surgeons, and mean values were compared using independent-sample t-tests ($p < 0.05$).

Results: Patients with RPI demonstrated significantly greater PTA ($25.8 \pm 5.7^\circ$ vs. $14.3 \pm 4.8^\circ$), larger SA ($143.6 \pm 6.5^\circ$ vs. $135.1 \pm 5.3^\circ$), and smaller LTI ($9.2 \pm 3.3^\circ$ vs. $15.6 \pm 4.1^\circ$) than controls ($p < 0.001$ for all). These morphologic deviations indicate a shallow trochlear groove and increased lateral patellar tilt, both predisposing to recurrent lateral displacement.

Conclusion: MRI assessment confirmed that increased patellar tilt and sulcus angle with reduced lateral trochlear inclination are key morphologic correlates of recurrent patellar instability in the Nepalese population. Integrating these quantitative MRI parameters into diagnostic and preoperative planning may improve risk stratification and guide surgical decision-making, particularly in resource-limited settings where population-specific normative data are essential.

Keywords: Patellofemoral joint, Recurrent patellar instability, Lateral trochlear inclination, Sulcus angle, Patellar tilt, Magnetic resonance imaging, Nepalese population

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Introduction

Patellar instability encompasses a spectrum of conditions ranging from subluxation to dislocation of the patella from its normal articulation within the trochlear groove. With an incidence of 5.8 to 29 per 100,000 person-years, it significantly impacts knee function and quality of life, particularly affecting adolescents and young adults.^{1,2}

The anatomic variation in the patellofemoral joint is crucial in determining its biomechanics and contributes to patellar instability, early onset patellofemoral osteoarthritis, and decline in functional status of the patients. These include trochlear dysplasia, patella alta, increased tibial tubercle-trochlear groove distance, and abnormal patellar tilt.³ Radiographic assessment of these parameters has become instrumental in diagnosing structural predispositions and guiding treatment decisions. Among these, patellar tilt angle, sulcus angle, and lateral trochlear inclination are important in evaluating the patellofemoral relationship and trochlear morphology.^{4,5} These measurements can objectively quantify the degree of anatomical variation and aid surgical planning.⁶

While extensive research exists on patellofemoral morphology in Western populations, studies specific to Asian populations, particularly from Nepal, remain scarce. Ethnic variations in knee anatomy and biomechanics have been reported, suggesting potential differences in predisposing factors and clinical presentation of patellar instability across populations.⁷

This study aims to investigate the morphologic variations of the patellofemoral joint in Nepalese patients with recurrent patellar instability compared to controls, focusing on key radiographic parameters.

Methods

Study Design

This hospital-based case-control study was conducted at the Department of Orthopedics, B&B Hospital, Gwarko, Lalitpur, Nepal. The study enrolled patients from December 2022 to December 2024, using a matched sampling technique to assess morphologic differences in the patellofemoral joint between patients with recurrent patellar instability and controls without patellofemoral pathology. A total of 144 participants were enrolled with 1:1 case to control ratio.

Ethical approval and patient consent

Ethical clearance was obtained from the B&B Hospital IRC. Written informed consent was obtained from all participants. Data confidentiality was strictly maintained.

Participants

Inclusion Criteria

Cases: Patients aged 10–55 years with ≥ 2 clinically documented episodes of lateral patellar dislocation or subluxation, undergoing knee MRI on a 1.5T scanner.

Controls: Age-matched (± 5 years) patients with MRI scans of the knee performed for unrelated pathology (e.g., ACL tear, meniscal injury), with no history or clinical evidence of patellar instability.

Exclusion Criteria

- Prior surgery involving the patellofemoral joint
- Congenital limb deformities
- Inflammatory arthropathies
- Poor-quality or incomplete MRI

Imaging and Measurement

All MRI scans were performed in axial and sagittal planes with the knee in 15–20° flexion. Three morphologic variables were assessed:

Patellar tilt angle: Angle between the posterior condylar line and maximal patellar width line.

Sulcus angle: Angle formed by lines connecting the highest points of the medial and lateral femoral condyles to the deepest point of the trochlear groove.

Lateral trochlear inclination: Angle between the lateral facet and posterior condylar line.

Two blinded orthopedic surgeons independently measured each parameter. Final values were averaged for analysis.

Statistical analysis

Normality of data was assessed using the Shapiro-Wilk test. Continuous variables were compared using independent t-tests or Mann-Whitney U-tests. A p-value < 0.05 was considered statistically significant. Analyses were conducted using SPSS v26.

Results

Demographics

The study included a total of 144 participants: 72 cases with recurrent patellar instability and 72 age-matched controls. The mean age was comparable between groups (cases: 24.7 ± 6.2 years, controls: 25.1 ± 5.8 years; $p = 0.68$).

Table 1. Demographic Characteristics

Variable	Case (n=72)	Control (n=72)	p-value
Mean Age (years)	24.7 \pm 6.2	25.1 \pm 5.8	0.68
Sex (M/F)	28 / 44	32 / 40	0.42
Side (Left/Right/Bilateral)	26 / 38 / 8	29 / 37 / 6	0.76

The distribution by sex showed no statistically significant difference ($p = 0.42$), with females being more represented in both groups. (Table 1)

Morphological Measurements

Significant differences were observed in all three patellofemoral parameters assessed via MRI. (Table 2)

Table 2. Comparison of patellofemoral parameters assessed via MRI

Measurement	Case (Mean ± SD)	Control (Mean ± SD)	Mean Difference	p-value (t-test)
Patellar Tilt Angle (°)	25.8 ± 5.7	14.3 ± 4.8	+11.5	<0.001
Sulcus Angle (°)	143.6 ± 6.5	135.1 ± 5.3	+8.5	<0.001
Lateral Trochlear Inclination (°)	9.2 ± 3.3	15.6 ± 4.1	-6.4	<0.001

Discussion

This study demonstrates that patients with recurrent patellar instability in the Nepalese population exhibit distinct morphologic deviations of the patellofemoral joint on MRI when compared to age-matched controls. A greater patellar tilt, increased sulcus angle, and decreased lateral trochlear inclination were significantly associated with instability.

Our findings align with prior investigations indicating that increased patellar tilt and sulcus angle, along with decreased LTI, are morphologic hallmarks of patellofemoral instability.^{3,8-11} Gobbi et al. identified patellar tilt as the most reliable MRI biomarker in differentiating instability, reporting similar effect sizes and statistical significance.⁸ Carrillon et al. emphasized LTI <11° as a critical threshold associated with lateral dislocation predisposition.¹⁰ The observed sulcus angle difference (-8.5°) in our study mirrors findings by Osman and Ebrahim, who noted that a shallow trochlear groove (angle >140°) strongly correlates with instability.¹¹ Furthermore, the normative LTI value observed in our control group (15.6°) corresponds well to established thresholds in global studies.¹²

These findings implicate that reduced LTI and increased PTA lead to lateral displacement, abnormal pressure distribution and symptomatic patellar maltracking which is also shown by dynamic studies.¹³⁻¹⁵ Mechanistically, a shallow trochlear groove (increased sulcus angle) and reduced lateral trochlear height (low LTI) reduce bony containment of the patella during early flexion, allowing lateral translation and increasing the reliance on soft-tissue stabilizers (notably the medial patellofemoral ligament).¹⁶⁻¹⁸ Clinically, these radiographic and MRI metrics have implications for management. First, precise MRI assessment of trochlear shape, sulcus angle, LTI, and patellar tilt should be integrated into the standard workup for recurrent instability to inform indication and selection of interventions (MPFL reconstruction, trochleoplasty, tibial tubercle realignment).^{6,12,19,20} Second, absolute thresholds (e.g., LTI ≤11–14° or sulcus angle >145°) can guide surgeons toward bony procedures in addition to soft-tissue reconstruction when the osseous geometry provides insufficient containment.⁶

However, strict numeric cutoffs should be employed alongside clinical examination, patient symptoms, and

dynamic assessment because measurement technique and knee flexion angle at imaging can affect values.²¹ The study has certain limitations. Selection bias is possible due to hospital-based recruitment. Lack of dynamic imaging might underestimate functional instability patterns. Interobserver variability was minimized using averaged values but could still influence measurement reliability.

Conclusion

This case-control MRI-based study confirms that morphologic abnormalities specifically increased patellar tilt and sulcus angle and decreased lateral trochlear inclination are significantly associated with recurrent patellar instability in the Nepalese population. These findings underscore the importance of pre-operative morphologic assessment in patients with recurrent dislocations.

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References

- Hawkins RJ, Bell RH, Anisette G. Acute patellar dislocations. *Am J Sports Med* 1986; 14: 117–120 <https://doi.org/10.1177/036354658601400204>
- Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and Natural History of Acute Patellar Dislocation. *Am J Sports Med* 2004; 32: 1114–1121 <https://doi.org/10.1177/0363546503260788>
- Koh JL, Stewart C. Patellar Instability. *Orthopedic Clinics of North America* 2015; 46: 147–157 <https://doi.org/10.1016/j.jocl.2014.09.011>
- Rhee S-J, Pavlou G, Oakley J, et al. Modern management of patellar instability. *International Orthopaedics (SICOT)* 2012; 36: 2447–2456 <https://doi.org/10.1007/s00264-012-1669-4>

5. McConnell J. Rehabilitation and Nonoperative Treatment of Patellar Instability. *Sports Medicine and Arthroscopy Review* 2007; 15: 95–104 <https://doi.org/10.1097/JSA.0b013e318054e35c>
6. Dejour DH, Mesnard G, Giovannetti De Sanctis E. Updated treatment guidelines for patellar instability: “un menu à la carte”. *J exp orthop* 2021; 8: 109 <https://doi.org/10.1186/s40634-021-00430-2>
7. Adhikari K, Kumar Gupta M, Devkota K, et al. Magnetic Resonance Imaging Evaluation of Patellofemoral Joint. *J Nepal Health Res Counc* 2021; 19: 122–126 <https://doi.org/10.33314/jnhrc.v19i1.3063>
8. Gobbi RG, Cavalheiro CM, Giglio PN, et al. Patellar Tilt and Patellar Tendon–Trochlear Groove Angle Present the Optimum Magnetic Resonance Imaging Diagnostic Reliability for Patients With Patellar Instability. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 2023; 39: 2339–2351 <https://doi.org/10.1016/j.arthro.2023.04.005>
9. Dejour H, Walch G, Nove-Josserand L, et al. Factors of patellar instability: An anatomic radiographic study. *Knee surg sports traumatol arthrosc* 1994; 2: 19–26 <https://doi.org/10.1007/BF01552649>
10. Carrillon Y, Abidi H, Dejour D, et al. Patellar instability: assessment on MR images by measuring the lateral trochlear inclination-initial experience. *Radiology* 2000; 216: 582–585 <https://doi.org/10.1148/radiology.216.2.r00au07582>
11. Osman NM, Ebrahim SMB. Patellofemoral instability: Quantitative evaluation of predisposing factors by MRI. *The Egyptian Journal of Radiology and Nuclear Medicine* 2016; 47: 1529–1538 <https://doi.org/10.1016/j.ejrnm.2016.09.020>
12. Barbosa RM, Da Silva MV, Macedo CS, et al. Imaging evaluation of patellofemoral joint instability: a review. *Knee Surg & Relat Res* 2023; 35: 7 <https://doi.org/10.1186/s43019-023-00180-8>
13. Watts RE, Gorbachova T, Fritz RC, et al. Patellar Tracking: An Old Problem with New Insights. *RadioGraphics* 2023; 43: e220177 <https://doi.org/10.1148/rg.220177>
14. Thouvenin C, Erard J, Abu Mukh A, et al. Patellar morphology is different in patellofemoral instability: An MRI comparative case-control study. *The Knee* 2024; 51: 199–205 <https://doi.org/10.1016/j.knee.2024.09.007>
15. Eysturoy NH, Husum H-C, Mortensen ES, et al. High prevalence of patellar dislocation and trochlear dysplasia in a geographically and genetically isolated society: an observational national cohort study from the Faroese Knee Cohort. *Acta O* 2024; 95: 14–19 <https://doi.org/10.2340/17453674.2024.35229>
16. Friedman MV, Hillen TJ, Misra S, et al. Quantitative Variable Assessment of Patellar Instability: An MRI-Based Study. *American Journal of Roentgenology* 2020; 215: 1163–1170 <https://doi.org/10.2214/AJR.19.22556>
17. Joseph SM, Cheng C, Solomito MJ, et al. Lateral Trochlear Inclination Angle: Measurement via a 2-Image Technique to Reliably Characterize and Quantify Trochlear Dysplasia. *Orthopaedic Journal of Sports Medicine* 2020; 8: 2325967120958415 <https://doi.org/10.1177/2325967120958415>
18. Nelitz M, Lippacher S, Reichel H, et al. Evaluation of trochlear dysplasia using MRI: correlation between the classification system of Dejour and objective parameters of trochlear dysplasia. *Knee surg sports traumatol arthrosc* 2014; 22: 120–127 <https://doi.org/10.1007/s00167-012-2321-y>
19. Ali SA, Helmer R, Terk MR. Analysis of the Patellofemoral Region on MRI: Association of Abnormal Trochlear Morphology With Severe Cartilage Defects. *American Journal of Roentgenology* 2010; 194: 721–727 <https://doi.org/10.2214/AJR.09.3008>
20. Trivellas M, Kelley B, West N, et al. Trochlear Morphology Development: Study of Normal Pediatric Knee MRIs. *Journal of Pediatric Orthopaedics* 2021; 41: 77–82 <https://doi.org/10.1097/BPO.0000000000001697>
21. Anand BS, Ho S, Kambhampati S. Recent advances and future trends in patellofemoral instability. *JASSM* 2020; 1: 110–117 https://doi.org/10.25259/JASSM_19_2020