

# Morphological Variations of Distal End of Femur: A Cross-sectional Study

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## ABSTRACT

**Introduction:** Apart from intercondylar notch and trochlear groove, the intercondylar line also contributes to knee joint instability. Knowledge of morphological variations of these anatomical landmarks can help in diagnosis as well as planning the treatment. As of now, very limited data is available on morphological variations of trochlear groove and intercondylar line.

**Aim:** To find out normal morphological patterns of shapes of intercondylar notch, depth of trochlear groove and intercondylar line and also to finding out the prevalence of different patterns.

**Materials and Methods:** In this cross-sectional study, 68 dried human femurs were examined grossly for five months (December 2020 to April 2021) by naked eye from the collection of Anatomy Department, Dr. ND Desai Faculty of Medical Science and Research Gujarat, India, for the shape of intercondylar notch, depth of trochlear groove and intercondylar line. All morphological

patterns were tabulated and prevalence of each was calculated using excel worksheet.

**Results:** Morphological patterns noted in shapes of intercondylar notch were A-shaped (35.29%), inverted V-shaped (5.88%), M-shaped (2.94%) and inverted U-shaped (55.88%) with highest prevalence of inverted U shape. Three forms of trochlear groove noted were as follows: shallow (29.41%), intermediate (58.82%) and deep (11.76%) with highest prevalence being intermediate type. Intercondylar line was found in straight (36.76%), oblique (50%) and convex (13.23%) forms with highest prevalence of oblique form.

**Conclusion:** The results of the study show that there are considerable variations in the morphology of distal end of femur. Knowledge of these morphological variations may help in making knee prosthesis, diagnosis of osteoarthritis and cruciate ligament surgeries.

**Keywords:** Intercondylar line, Intercondylar notch, Trochlear groove

## INTRODUCTION

The distal end of femur is widely expanded to form two large condyles. Posteriorly they are separated by a deep gap called intercondylar fossa/intercondylar notch [1]. Shape of intercondylar notch assumes great importance as edge of the medial condyle tends to be straight in osteoarthritis patients [2]. Intercondylar fossa is limited from behind by an intercondylar line. On the floor of the fossa near the intercondylar line, there is a flat posterosuperior impression for the proximal attachment of the anterior cruciate ligament. The trochlear groove is transversely concave, vertically convex and bears a groove for the posterior surface of patella. It extends anteriorly on both condyles, more on the lateral. The trochlear groove helps to stabilise the patella. An abnormally shallow groove predisposes to instability [3]. Knee joint includes both tibio-femoral and femoro-patellar articulations. Any deviation in normal morphology of lower end of femur may increase the chances of ligament injury and knee joint instability.

Majority of researches on lower end of femur are largely focused on knee joint instability based on intercondylar notch shapes, morphology and anterior cruciate ligament tear but trochlear groove and intercondylar line are rarely studied [4,5]. As the intercondylar line serves as attachment landmark for anterior cruciate ligament and trochlear groove lodges the patella in femoropatellar articulation, variations in their anatomy may disturb the knee joint mechanics [6,7]. Nowadays majority of the studies are done based on imaging but that may not be suitable for surface studies due to poor resolution [8,9]. So, we conducted this study on dry human femur to estimate the prevalence of different morphological variations of intercondylar notch, trochlear groove and intercondylar line. To the best of our knowledge, this is the first attempt to establish morphological patterns of lower end of femur in Gujarat.

## MATERIALS AND METHODS

In this cross-sectional study, 68 dry human femurs from Department of Anatomy, Dr. ND Desai Faculty of Medical Science and Research Nadiad, Gujarat, India, were examined from December 2020 to April 2021 by naked eye for the following parameters:

1. Shape of intercondylar notch
2. Depth of trochlear groove
3. Intercondylar line

**Inclusion criteria:** Only intact femur without any damage and femur with complete skeletal growth were included in this study.

**Exclusion criteria:** Damaged and distorted femur and femur with incomplete skeletal growth were excluded in this study.

### Study Procedure

Posterior surfaces of femoral condyles were placed on the flat surface to examine the shape of intercondylar notch. Patellar groove and intercondylar lines were examined by placing the inferior surface of femoral condyles on the flat surface [Table/Fig-1-3].

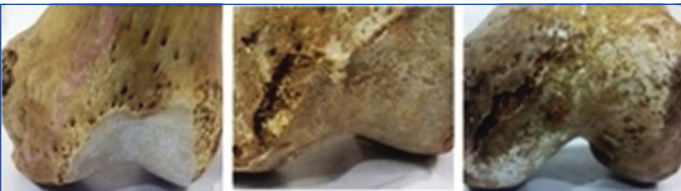
Patellar groove was considered shallow when deepest point of the groove located towards distal end of lateral margins of patellar articular surface, intermediate when deepest point of groove located at the level between distal and mid points of lateral margins of patellar articular surface and deep when deepest point of groove located at the level of midpoint of lateral margins of patellar articular surface or higher [Table/Fig-2]. Intercondylar line was considered straight when extends uniformly from one condyle to other without a bend, oblique when form a slope and convex when curved upwards [Table/Fig-3].

## STATISTICAL ANALYSIS

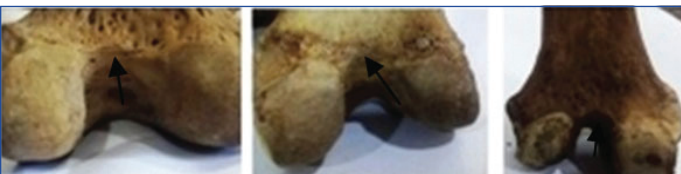
All morphological patterns were tabulated and prevalence of each was calculated using excel worksheet.



**[Table/Fig-1]:** Shapes of intercondylar notches: In upper row, inverted U-shaped and A-shaped, In lower row, Inverted V-shaped and M-shaped from left to right.



**[Table/Fig-2]:** Trochlear groove: shallow, intermediate and deep from left to right.



**[Table/Fig-3]:** Intercondylar line: straight, oblique and convex from left to right.

## RESULTS

Morphological patterns noted in shapes of intercondylar notch were A-shaped (35.29%), Inverted V-shaped (5.88%), M-shaped (2.94%) and inverted U-shaped (55.88%) with highest prevalence of inverted U shape. Three forms of trochlear groove noted were shallow (29.41%), intermediate (58.82%) and deep (11.76%) with highest prevalence being intermediate type. Intercondylar lines were found in straight (36.76%), oblique (50%) and convex (13.23%) forms with highest prevalence of oblique form [Table/Fig-4].

Parameter	Variations, n (%)			
	Intercondylar notch	A-Shaped 24 (35.29%)	Inverted V-shaped 4 (5.88%)	M-Shaped 2 (2.94%)
Trochlear groove	Shallow 20 (29.41%)	Intermediate 40 (58.82%)	Deep 8 (11.76%)	
Intercondylar line	Straight 25 (36.76%)	Oblique 34 (68%)	Convex 9 (13.23%)	

**[Table/Fig-4]:** Morphological variations of intercondylar notch, trochlear groove and intercondylar line with their prevalence (N=68).

## DISCUSSION

In the present study, four different shapes of intercondylar notch noted were, A-shaped, Inverted V-shaped, M-shaped and inverted U-shaped with their prevalence being 35.29%, 5.88%, 2.94% and 55.88%, respectively. van Eck CF et al., found three varieties

of intercondylar notches in his arthroscopic study, which were A (54%), U (41%) and W (5%) with higher prevalence of A shape [10]. Lena H et al., found two varieties of intercondylar notches which were A and  $\Omega$  shapes [11]. Higher prevalence of inverted U-shaped notch in present study is in line with Hirtler's finding that notch is A-shaped in early stages of life and turns  $\Omega$  shaped in later stages of life because most of the femur in present study were derived from donated cadavers which were of individuals in mid or later stages of life. Other shapes found in the present study i.e., inverted V and M shape are associated with narrow intercondylar width. Narrow intercondylar width is associated with anterior cruciate ligament tears [12].

Three varieties of trochlear groove were found in present studies which were shallow, intermediate and deep with high prevalence of intermediate variety. Depth of trochlear groove is important because flattened trochlear groove offers protection against degenerative patellofemoral conditions, whereas shallow groove predisposes to knee instability [3,13]. Three varieties of intercondylar lines found in the present study which were straight, oblique and convex with their prevalence being 36.76%, 50% and 13.23%, respectively. Convex intercondylar line leads to deepening of intercondylar fossa with no visible groove for posterior cruciate ligament suggesting of squatting person with bulky ligament [14]. Low prevalence of convex intercondylar line correlates with decreasing trend of squatting habits. High prevalence of oblique intercondylar line which have elevated lateral end suggests well developed anterior cruciate ligament which produces a ridge at lateral end. This ridge can serve as a guide in femoral tunnel placement during anterior cruciate ligament repair surgeries [15].

## Limitation(s)

The present study is also limited by certain factors. As intercondylar line and trochlear groove have been studied less, limited data is available for comparison.

## CONCLUSION(S)

The lower end of femur possesses significant variations. Each variation is having its own clinical implications. Knowledge of these variations may help in making knee prosthesis, diagnosis of osteoarthritis and cruciate ligament surgeries. As there are significant morphological variations in various ethnic groups, separate normograms should be prepared for each ethnic group.

## REFERENCES

- [1] BD Chaurasia's. Human Anatomy. 6<sup>th</sup> edition, CBS Publishers, vol. 2, 15.
- [2] Shepstone L, Rogers J, Kirwan JR, Silverman BW. Shape of the intercondylar notch of the human femur: A comparison of osteoarthritic and non-osteoarthritic bones from a skeletal sample. *Ann Rheum Dis.* 2001;60:968-73.
- [3] Gray's Anatomy. The Anatomical Basis of clinical Practice. 40<sup>th</sup> Edition, Elsevier Churchill Livingstone. 2008;4029-30.
- [4] Eldan K, Anel D, Edinela G, Maida S. Intercondylar notch morphology in regard to anterior cruciate ligament injuries. *Homospoticus.* 2018;1:20-24.
- [5] Huang M, Li Y, Li H, Liao C, Xu H, Luo X. Predictive effects of the intercondylar notch morphology on anterior cruciate ligament injury in males: A magnetic resonance imaging analysis. *Medicine.* 2020;99:10(e19411).
- [6] Amir ARA, Soheil S, Sebastian I, Tom C, Freddie HF. Anatomical individualized ACL reconstruction. *Arch Bone Jt Surg.* 2016;4(4):291-97.
- [7] Janice KL. Biomechanics and pathomechanics of the patellofemoral joint. *The International Journal of Sports Physical Therapy.* 2016;11(6):820-30.
- [8] Osama AS, Mary B, Reji A, Mehraj S. Association of femoral intercondylar notch morphology, width index and the risk of anterior cruciate ligament injury. *Knee Surg Sports Traumatol Arthrosc.* 2013;21:678-82.
- [9] Minkyung Y, Sung HH, Ja-young C, Hye JY, Yusuhn K, Jina P, Heung SK. Femoral trochlear groove morphology assessed on oblique coronal MR images. *American Journal of Roentgenology.* 2015;205(6):1260-68.
- [10] van Eck CF, Martins CA, Vyas SM, Celentano U, van Dijk CN, Fu FH. Femoral intercondylar notch shape and dimensions in ACL-injured patients. *Knee Surg Sports Traumatol Arthrosc.* 2010;18(9):1257-62. DOI: 10.1007/s00167-010-1135-z.
- [11] Lena H, Sebastian R, Franz K. The femoral intercondylar notch during life: An anatomic redefinition with patterns predisposing to cruciate ligament impingement. *AJR.* 2016;207:836-45.

- [12] Tomas FJ, Juan MLA, Elena RI, Fabian C, Juan CH, Pedro GG. The importance of the intercondylar notch in anterior cruciate ligament tears. *The Orthopaedic Journal of Sports Medicine*. 2015;3(8):2325967115597882.
- [13] Teichtahl AJ, Parkins K, Hanna F, Wluka AE, Urquhart DM, English DR, et al. The relationship between the angle of the trochlear groove and patella cartilage and bone morphology: A cross-sectional study of healthy adults. *Osteo Arthritis and Cartilage*. 2007;15(10):1158-62.
- [14] Martin CP. Some variations in the lower end of the femur which are especially prevalent in the bones of primitive people. *J Anat*. 1932;66(pt 3):371-83.
- [15] Rahul B, Andrew K, Quentin F, Simon JS, Jibu J. Lateral Intercondylar Ridge: Is it a reliable landmark for femoral ACL insertion?: An anatomical study. *Int J Surg*. 2018;50:55-59.

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**PLAGIARISM CHECKING METHODS:** [\[Jain H et al.\]](#)

- Plagiarism X-checker: May 14, 2021
- Manual Googling: Oct 21, 2021
- iThenticate Software: Feb 12, 2022 (4%)

**ETYMOLOGY:** Author Origin**AUTHOR DECLARATION:**

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval Obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **May 13, 2021**Date of Peer Review: **Aug 12, 2021**Date of Acceptance: **Oct 21, 2021**Date of Publishing: **Apr 01, 2022**