MORPHOMETRIC ANALYSIS OF CONDYLES AND INTERCONDYLAR NOTCH OF FEMUR IN NORTH INDIAN POPULATION AND ITS CLINICAL SIGNIFICANCE

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ABSTRACT

BACKGROUND

Injury of knee is very common in athletes and Anterior Cruciate Ligament (ACL) is the most ruptured ligament. It has been proposed that a narrow intercondylar notch increases risk of ACL injury, but the data are conflicting. This study aimed to analyse morphometry of femoral condyles and intercondylar notch as the literature is sparse in North Indian population and its clinical implications.

MATERIALS AND METHODS

The present investigation was conducted using 100 dry femora. The dimensions studied were condylar width and depth, intercondylar notch width and depth. The shape of notch was also examined. The results were tabulated.

RESULTS

The shape of intercondylar notch was inverted U shape in 75 (75%) cases and inverted V shape in 25 (25%) cases. The mean condylar width and depth, intercondylar notch width and intercondylar notch depth 64 ± 6.34 , 58.16 ± 4.54 , 21.12 ± 2.83 and 26.8 ± 2.88 mm respectively. The notch width index and notch depth index were determined as 0.29 and 0.46 respectively. Statistical Analysis- The morphometric data of the present study was represented as mean $\pm$ SD and then analysed by unpaired 't' test by using SPSS software (version 19). Measurements were compared statistically with respect to left and right sides and were tabulated.

CONCLUSION

Morphometric data contributed by this study will assist orthopaedicians in averting ACL injuries and administer appropriate treatment in knee problems.

KEYWORDS

Anterior Cruciate Ligament, Femur, Intercondylar Notch, Knee Injury, Morphometry.

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BACKGROUND

Distal end of femur is widely expanded as a bearing surface for transmission of weight to the tibia. It has two massive condyles, which are partly articular. Anteriorly condyles unite and continue into the shaft, posteriorly separated by intercondylar notch (fossa) and projecting beyond the popliteal surface. Groove present anteriorly between them is called patellofemoral groove. Notch separating them posteriorly is Intercondylar Notch.¹ The femoral intercondylar notch has been an anatomic site of interest, as it houses the Anterior Cruciate Ligament (ACL).² The cruciate ligaments have intimate embryological and functional relationship to intercondylar notch.³ It has been suggested that a narrow intercondylar notch may increase the risk of ACL injury.⁴ Notch depth index has been used by authors to predict stenosis of intercondylar notch.⁵ Indian study has

shown morphology of intercondylar notch of femur is related to functioning of cruciate ligaments. Abnormally narrow (stenotic) notch has been shown to increase risk of ACL injuries. Space available for cruciate ligament is determined by dimensions of notch including depth, width and shape.⁶ Intercondylar notch stenosis increases incidence of ACL ruptures in patients with degenerative arthritis.⁷ ACL is the most injured ligament in athletes and patients with degenerative osteoarthritis.³ Undoubtedly, morphological data that helps avert ACL injury is very significant.

There have been studies which show that no relation exists between intercondylar notch and ACL pathology.^{8,9,10} As conflicting data was obtained while reviewing literature, therefore it became essential to explore various parameters of intercondylar notch and femoral condyles and subsequently to see its implications on ACL injury.

Morphological knowledge of femoral Intercondylar Notch may assist orthopaedic and arthroscopic surgeons, while inserting femoral tunnel in correct location during ACL reconstruction procedures.¹¹

Since inadequate literature is available on the morphometry of femoral intercondylar notch in North Indians, therefore the present study was conducted to measure various dimensions of the femoral condyles and intercondylar notch in North Indian population and assess its clinical significance.

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MATERIALS AND METHODS

The present study was performed by using 100 dried femurs (51 belonged to the right side and 49 were left sided). Dry bones from the bone bank of Department of Anatomy, University College of Medical Sciences, New Delhi were used in this study. The femora which showed deformities around the intercondylar notch region were excluded from the present study.

The parameters like condylar width and depth, intercondylar notch width and depth and shape of intercondylar notch were measured. The measurements were performed according to the guidelines of Wada et al (1999), Ravichandran et al (2010), Herzog et al (1994) and Ameet KJ et al (2014).^{5,6,9,12}

All the measurements were taken using a digital Vernier caliper. The maximum distance between the two epicondyles was measured as the condylar width (Figure 1). The maximum antero-posterior height of the lateral femoral condyle was measured as the condylar depth (Figure 2). The depth of the intercondylar notch was measured as maximum height of intercondylar notch. The intercondylar notch width represents the breadth of the notch at about 2/3 part of its depth (Figure 3). The notch width index and notch depth index were calculated using these data. The ratio of femoral intercondylar notch width to the condylar width of femur was determined as the notch width index. The ratio of depth of femoral intercondylar notch to the depth of femoral condyle was determined as the notch depth index. The shape of intercondylar notch was examined.

Statistical Analysis

The morphometric data of the present study was represented as mean ± SD. The statistical analysis among right and left femora were performed by using unpaired 't' test by using the SPSS software (Version 19). The difference was considered statistically significant, if p-value was less than 0.05. The measurements were compared statistically with respect to right and left sides and were tabulated.

RESULTS

100 femurs (R= 51, L= 49) were observed and measurements were taken. The shape of intercondylar notch was inverted U shape in 75 (75%) cases and inverted V shape in 25 (25%) cases (Figure 4, 5). The mean condylar width, condylar depth, intercondylar notch width and intercondylar notch depth was 64 ± 6.34, 58.16 ± 4.54, 21.12 ± 2.83 and 26.8 ± 2.88 mm respectively. The notch width index and notch depth index were determined as 0.29 and 0.46 respectively. When the data was compared on left and right sides by unpaired 't' test, the difference was not found to be statistically significant (Table 3).

Parameters	Measurements in mm ± SD
Intercondylar notch width	21.12 ± 2.83
Intercondylar notch depth	26.8 ± 2.88
Condylar width	72.64 ± 6.34
Condylar depth	58.16 ± 4.54

Table 1. Measurements of various Parameters of the Lower End of Femur

Parameter	Index
Notch width index	0.29
Notch depth index	0.46

Table 2. Indices of Femoral Intercondylar Notch Width and Depth

Parameters	Measurements (in mm) Right side (n = 51)	Measurements (in mm) Left side (n = 49)	Statistical Significance
Intercondylar notch width	20.82 ± 2.57	21.03 ± 3.13	0.71 (NS)
Intercondylar notch depth	26.58 ± 2.84	26.5 ± 2.92	0.88 (NS)
Condylar width	73.11 ± 6.14	72.16 ± 6.58	0.45 (NS)
Condylar depth	57.84 ± 5.07	57.52 ± 4.10	0.72 (NS)

Table 3. Comparison of Dimensions of Intercondylar Notch of Femur on Right and Left Sides

NS: Not Significant

Figure 1. Measurement of Condylar Width

Figure 2. Measurement of Condylar Depth

Figure 3. AB: Measurement of Intercondylar Depth. CD: Measurement of Intercondylar Width

Figure 4. Inverted "U" shaped Intercondylar Notch

Figure 5. Inverted "V" shaped Intercondylar Notch

DISCUSSION

Anterior cruciate ligament injuries are most common injuries, especially among athletes. ACL comes at an angle of 40 degrees from its tibial attachment to femoral attachment. Roof of intercondylar notch is inclined at 40 degrees to long axis of femur, so that when the knee is in full extension roof is near anterior surface of ACL.³ Morphology of ACL therefore plays an important role in injuries of ACL.⁶ Morphology of intercondylar notch of femur may be clinically relevant in relation to ACL pathologies.¹³ Size of ACL is related to size of intercondylar notch of femur.¹⁴

It has been found that there is correlation between stenosis of femoral intercondylar notch and tears of ACL.^{15,16} Intercondylar notch was found to be stenotic in knees with severe osteoarthritis due to osteophytic growth in notch,⁵ thus increasing incidence of ACL ruptures in patients with degenerative arthritis.⁷

The shape of the intercondylar notch plays an important role in knee injuries. Triangular shaped notches with straight edges cause damage to the ligaments.⁶ The shapes of the intercondylar notches were observed by many investigators.^{8,16,17}

Shepstone et al concluded that the shape of the notch may be of some significance (in relation to ACL damage). The notch shape may be of importance, because femora could be of equal notch width (or notch width index), but have different shapes. Differently shaped notches could provide

very different volumes of space for the cruciate ligaments. Alternatively, the shape of the notch may have a more direct impact on the functioning of the ACL.¹³ The shape of intercondylar width in this study was found to be inverted U shape in 75 (75%) cases and inverted V shape in 25 (25%) cases, which is consistent with those found by Ameet KJ et al (inverted U shaped in 73.2% and inverted V shape in 26.8%) and inconsistent with those found by Ravichandran et al (inverted U shaped in 67% cases and inverted V shape in 33% cases).^{6,12} The present study was not consistent with study of Ravichandran et al, probably because their study population was South Indian and ours being North Indian.

The intercondylar notch width according to Ameet KJ et al,¹² Wada et al⁵ and Ravichandran et al⁶ was 11.9 ± 2.7 mm, 17.0 ± 5.0 mm and 18.65 ± 0.27 mm respectively. In the present study, it was found to be 21.12 ± 2.83 mm. It is not consistent with the study of Ameet KJ et al, Wada et al and Ravichandran et al.^{5,6,12} This was probably because of regional differences.

The intercondylar notch depth according to Ameet KJ et al, Wada et al and Ravichandran et al was 26.3 ± 2.4 mm, 29.5 ± 4.5 mm and 27.27 ± 0.29 respectively.^{5,6,12} The depth in present study was found to be 26.8 ± 2.88 , which is similar to these studies.

The condylar width in this study was 72.64 ± 6.34 , which is consistent with findings of Indian authors Ameet KJ et al¹² (72.9 ± 5.3 mm) and Ravichandran et al⁶ (73.97 ± 0.61) and inconsistent with foreign author Wada et al⁵ (80 ± 10.5 mm). This dissimilarity in dimension of condylar width between Indian and foreign authors could be due to racial differences.

Condylar depth in the present study was 58.16 ± 4.54 mm. Condylar depth found by Ameet KJ et al, Ravichandran et al and Wada et al 56 ± 8 mm, 57.3 ± 4.3 mm and 58.38 ± 0.51 respectively.^{5,6,12} The condylar depth obtained in the present study was more or less similar to what was seen by these authors.

Notch Width Index (NWI) has been used as a criterion to estimate risk of ACL injury.¹⁸ Notch width index has been traditionally used as an indicator of stenosis ($NWI < 0.20$) of intercondylar notch.^{8,16,17} Notch width index in this study was found to be 0.29, which is very similar to what was obtained by Ameet KJ et al,¹² Ravichandran et al,⁶ Wada et al⁵ and Lombardo et al¹⁰ was 0.25, 0.22, 0.22 and 0.29 respectively.

Since there is a strong correlation between stenosis of femoral intercondylar notch and tears of ACL,^{15,16} it can be inferred from our study that chances of ACL injury is less in North Indians, NWI being 0.29.

Notch depth index in present study was found to be 0.46, which is same as that found by in other Indian studies by Ameet KJ et al and Ravichandran et al, and dissimilar from foreign authors Wada et al (0.51)^{5,6,12} probably due to ethnic differences.

The current study analyses the normal range of parameters like Intercondylar notch width and depth, condylar width and depth in North Indian population. It has also provided additional data, which will assist orthopaedic surgeons in diagnosis and reconstruction procedures during ACL injuries. Considering the fact that there have been no similar studies conducted in north Indian Population in the past.

CONCLUSION

Morphometric data contributed by this study will assist orthopaedicians in averting ACL injuries and administer appropriate treatment in knee problems.

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