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ORIGINAL ARTICLE

A Morphometric Analysis of Intercondylar Notch of Femur with Emphasis on Its Clinical Implications

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ABSTRAK

Takuk interkondil adalah tapak anatomi yang menarik kerana ia terbenam di ligament krusiat anterior. Objektif kajian ini ialah untuk mengkaji morfologi dan morfometri takuk interkondil femur pada tulang kering cadaver dengan penekanan pada implikasi klinikalnya. Kajian dilakukan ke atas 97 femur kering. Parameter yang diukur adalah lebar takuk interkondil, kedalaman takuk interkondil, lebar kondil dan kedalaman kondil. Bentuk interkondil juga dianalisa. Ukuran dibandingkan secara statistic merujuk kepada sebelah kanan dan sisi dan dibuat dalam bentuk jadual. Pemerhatian mendapati secara morfologi takuk interkondil adalah berbentuk 'U' terbalik pada 71 (73.2%) specimen dan berbentuk 'V' terbalik pada 26 (26.8%) spesimen. Min lebar takuk interkondil, kedalaman takuk interkondil, lebar kondil dan kedalamanan kondil adalah 11.9 ± 2.7 mm, 26.3 ± 2.4 mm, 72.9 ± 5.3 mm dan 57.3 ± 4.3 mm masing-masing. Pemerhatian mendapati tiada perbezaan statistik yang signifikan (p > 0.05) antara sebelah kanan dan kiri. Indeks lebar dan kedalamanan lekuk didapati sebagai 0.25 dan 0.46 masing-masing. Data morfometri kajian ini adalah penting kepada pakar ortopedik bagi menghalang dan menguruskan kes kecederaan lutut. Kami percaya kajian ini telah menambah maklumat atas subjek berkaitan dan data ini boleh digunakan oleh pakar klinikal yang terlibat dalam membuat diagnosis dan mengurus masalah lutut.

Kata kunci: ligament krusiat anterior, femur, takuk interkondil, lutut, morfologi, morfometri

ABSTRACT

The intercondylar notch has been an anatomic site of interest as it lodges the anterior cruciate ligament. The objectives of the present study were to study the

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morphology and morphometry of femoral intercondylar notch in cadaveric dry bones with emphasis on its clinical implications.The present investigation was performed by using 97 dry femora. The parameters like intercondylar notch width, intercondylar notch depth, condylar width and condylar depth were measured. The shapes of intercondylar notch were also analyzed. The measurements were compared statistically with respect to right and sides and were tabulated. It was observed that the intercondylar notch was having inverted 'U' shape morphology in 71 (73.2%) specimens and it was inverted 'V' shaped in 26 (26.8%) cases. The mean intercondylar notch width, intercondylar notch depth, condylar width and condylar depth were 11.9 ± 2.7 mm, 26.3 ± 2.4 mm, 72.9 ± 5.3 mm and 57.3 ± 4.3 mm, respectively. It was observed that there was no statistical significance difference observed ($p > 0.05$) between the right and left sides. The notch width index and notch depth index were determined as 0.25 and 0.46, respectively. The morphometry data of the present study could provide importance to the orthopedicians in prevention and management of knee injuries. We believe that the present study has provided additional information on this subject and these data might be of use to the clinicians who are involved in the diagnosis and management of knee problems.

Keywords: anterior cruciate ligament, femur, intercondylar notch, knee, morphology, morphometry

INTRODUCTION

The lower end of the femur presents two rounded and eccentrically curved condyles. The groove which is present anteriorly between them is called the patello-femoral groove. The notch separating them posteriorly is called as the intercondylar notch (Williams et al. 1995). The intercondylar notch has been an anatomic site of interest as it lodges the anterior cruciate ligament (ACL) (van Eck et al. 2010). The cruciate ligaments have intimate embryological and functional relationship to the intercondylar notch (Miller 2008). The roof of intercondylar notch has an inclination of 40 degrees to the longitudinal axis of femur so that when the knee is in full extension, the roof is near the anterior surface of the ACL (Miller 2008).

Palmer (2007) reported for the first time that a narrow intercondylar notch would lead to increased risk of ACL tears. This concept was supported by Souryal et al. (1988) who reported the notch width index as the criteria to estimate risk of ACL injury. It is also reported that the morphology of the intercondylar notch of femur may be clinically relevant in relation to ACL pathologies (Shepstone et al. 2001). There are few articles which have reported about the existence of correlation among the stenosis of femoral intercondylar notch and tears of the ACL (Good et al. 1991; Souryal & Freeman 1993; Davis et al. 1999). The accepted hypothesis is that the size of ACL is related to the size of

intercondylar notch of femur (Davis et al. 1999). However there are also some authors who opine that there is no such relation exists (Schickendantz & Weiker 1993; Herzog et al. 1994; Lombardo et al. 2005). Inspite of its clinical interest, there are only a very few study available in the literature about this subject. This was the stimulus to conduct this investigation; the objectives of the present investigation were to study the femoral intercondylar notch morphology and morphometry in cadaver dry bones.

MATERIALS AND METHODS

The present investigation was performed by using 97 dried cadaveric femora (45 belonged to the right side and 52 were left sided). The femora which exhibited damages and pathological changes around the intercondylar notch region were excluded from the present study. The present study has been approved by the ethics committee of our institution. The parameters like intercondylar notch width, intercondylar notch depth, condylar width and condylar depth were measured (Figure 1). The shapes of intercondylar notch were also analyzed. The intercondylar notch was starting at the inferior point of the femoral lateral condyle and continuing medially until the inferior point of the medial condyle of femur. In the present study, the femora were kept on a flat surface of the table and they were resting on their posterior aspects of the condyles and the morphology was macroscopically observed. The shape of intercondylar notches were classified as inverted 'U'shape and inverted 'V' shape.

The measurements were performed according to the guidelines of Anderson et al. (1987), Herzog et al. (1994), Wada et al. (1999) and Ravichandran and Melanie (2010). All the measurements of the present study were performed using a digital vernier caliper. The notch width represents the breadth of the notch at about 2/3 part of its depth (Figure 1- CD). The depth of the intercondylar notch was identified as its height at the maximum (Figure 1-AB). The inter epicondylar width was measured as the condylar width (Figure 1-EF) and the maximum antero-posterior height of the lateral femoral condyle was measured (Wada et al. 1999) as the condylar depth (Figure

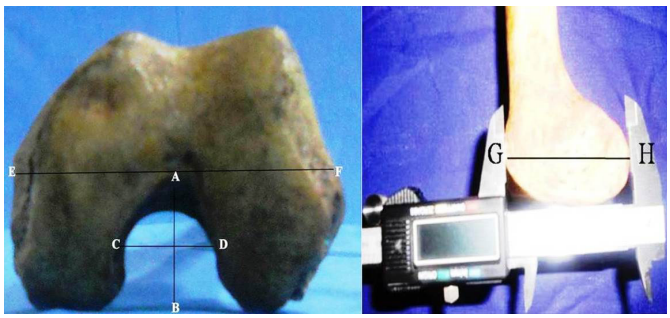

Figure 1: Photographs showing the measurement of the parameters (AB-intercondylar notch depth; CD-intercondylar notch width; EF-condylar width; GH-condylar depth)

Figure 2: Photographs showing 2A-inverted 'U' shaped and 2B-inverted 'V' shaped intercondylar notches.

1-GH). The notch width index and notch depth index were calculated with these data. The width of the intercondylar notch was estimated as the distance between the medial prominence of the lateral condyle to the lateral prominence of the medial condyle. 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. All measurements were were performed by the same person and was observed by the other authors of the present study on each time the measurement was taken. The statistical analysis among the right femora and left femora were performed by the independent t-test, the difference was considered statistically significant if the p-value is less than 0.05. The statistical analysis was performed with the SPSS 15.0 version. The morphometric data of the present study were represented as mean ± SD. The measurements were compared statistically with respect to right and sides and were tabulated.

RESULTS

It was observed that the intercondylar notch was having inverted 'U' shape morphology in 71 (73.2%) specimens (Figure 2A) and it was inverted 'V' shaped in 26 (26.8%) cases (Figure 2B). The mean intercondylar notch width, intercondylar notch depth, condylar width and condylar depth were 11.9 ± 2.7 mm, 26.3 2.4 mm, 72.9 ± 5.3 mm and 57.3 ± 4.3 mm, respectively (Table 1). The data were compared on the right and left sides by the independent 't' test. It was observed that there was no statistical significance difference observed ($p > 0.05$) between the right and left sides (Table 2). The notch width index and notch depth index were determined as 0.25 and 0.46 respectively.

Table 1: The morphometric analysis of the femoral intercondylar notch (n=97)

Values in mm	Total (n=97)
Intercondylar notch width	17.9 ± 2.7
Intercondylar notch depth	26.3 ± 2.4
Condylar width	72.9 ± 5.3
Condylar depth	57.3 ± 4.3

Values are Mean ± SD

Table 2: Comparison of the morphometric data on right and left sides (n=97)

Values in mm ± SD	Right Side (n=45)	Left Side (n=52)	Statistical significance
Intercondylar notch width	18 ± 3	17.9 ± 2.5	0.8 (P< 0.05, SNS)
Intercondylar notch depth	26.3 ± 2.3	26.3 ± 2.6	0.9 (P< 0.05, SNS)
Condylar width	72.5 ± 5.3	73.3 ± 5.3	0.4 (P< 0.05, SNS)
Condylar depth	56.9 ± 4.8	57.6 ± 3.9	0.4 (P< 0.05, SNS)

SNS: statistically not significant

DISCUSSION

There are many human and animal studies which reported the correlation between the femoral intercondylar notch width and ACL injury. Since the ACL passes inside the femoral intercondylar notch it is sensible to believe that the morphology of intercondylar notch may influence the function of ACL and the risk of its injury (Shepstone et al. 2001). The morphology of intercondylar notch may be important since the femora with equal intercondylar notch width (or notch width index) can have various shapes. The different shapes of intercondylar notches can give variant quantities of space to the ACL and it is reported that the function of ACL is directly related to the morphology of the intercondylar notch (Shepstone et al. 2001). The space available for the ACL is determined by the dimensions of notch including the depth, width and shape (Ravichandran & Melanie 2010). Notch depth index has been used by some authors to predict the stenosis of intercondylar notch (Wada et al. 1999).

According to an Indian study by Ravichandran and Melanie (2010), the average notch width index was found to be 0.252 and the average notch depth index was found to be 0.467 in cadaver dry bones. Our observations are almost similar to Ravichandran and Melanie (2010) findings with respect to mean intercondylar notch width and depth, condylar width and depth, notch width index and notch depth index. Ravichandran and Melanie (2010) observed inverted 'U' and inverted 'V' shaped notches in 67% and 33% of their specimens.

In the present study, the inverted 'U' shape was found in 73.2% of cases and inverted 'V' shaped in 26.8% cases. These are almost similar to Ravichandran and Melanie (2010) findings.

It was reported that the intercondylar notch was found to be smaller in knees with severe osteoarthritis because of osteophytic growth in the notch (Wada et al. 1999), thus increasing the incidence of ACL ruptures in patients with degenerative arthritis (Leon et al. 2005). Alizadeh & Kiavash (2008) reported that in their study, there was no observed relationship between the narrow femoral intercondylar notch width and the tears of ACL. They also opined that the knee MRI is not recommended to check the chance of ACL tear.

The limitation of this study is the gender based comparison, which has not been done in the present study. The future implications of this study include

studying the intercondylar notch by using the radiological techniques like plain X ray of the knee joint, CT scan and nuclear magnetic resonance of the knee joint.

The morphological knowledge of the femoral intercondylar notch may assist the orthopedic and arthroscopic surgeon while inserting the femoral tunnel in the correct location during the ACL reconstruction procedure (Farrow et al. 2007). The morphometry data of the present study could provide of importance to the orthopedicians in the prevention and management of knee injuries. We believe that the present study has provided additional information on this subject and these data might be of use to the clinicians who are involved in the diagnosis and management of knee problems.

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