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ORIGINAL RESEARCH

Morphometric Study of Menisci of the knee Joint: A Cadaveric Study

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ABSTRACT

Introduction: The sports activities often lead to joint injuries, particularly in the knees. The knee menisci, two crescent-shaped cartilaginous structures, are essential for load distribution, reducing stress on the joint and maintaining knee health. Examining the menisci's morphological characteristics—dimensions, shape, width, and thickness—provides critical information for meniscal transplantation, especially after damage. This study aims to investigate variations in meniscal shape and specific measurements, enhancing understanding of meniscal anatomy and its treatment implications. **Methods**: 60 menisci were taken from 30 adult cadaver knee joints available in the dissection hall. **Results**: The distance between the anterior and posterior horn medial and lateral of both the right and left knee and observed medial distance between the anterior and posterior horn right knee was 28.9±1.3 which was significantly higher than the medial distance between the anterior and posterior horn left knee were 28.2±1.5. The thickness of meniscus medial and lateral of both right and left knee and observed and medial anterior 1/3, middle 1/3 and posterior 1/3 thickness of meniscus left knee (3.1±1.0, 5.1±0.9 and 5.1±0.9). The length between the anterior and posterior horn medial and lateral of both right and left knee and observed medial outer and inner length between the anterior and posterior horn right knee 80.4±1.4 and 46.6±0.9 respectively. **Conclusion:** The findings of this study enhance our understanding of meniscal anatomy, particularly regarding surgical techniques and arthroscopy of the knee joint. Additionally, the results contribute to a better comprehension of meniscal structure and transplantation. Consequently, healthcare professionals who treat meniscal injuries should be aware of the potential anatomical variations.

Keywords: Knee joint; meniscal anatomy; meniscal injuries.

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INTRODUCTION

The menisci are unique, crescent-shaped structures of fibrocartilage that play a crucial role in the knee joint. These specialized discs partially divide the joint cavity, creating distinct compartments within the knee. They deepen the surfaces of the tibia, allowing for a better fit with the rounded condyles of the femur, which helps distribute weight more evenly during movement.[1]

The menisci serve several essential functions: they assist in load transmission across the joint, effectively absorbing shocks during activities like running or jumping. By doing so, they significantly reduce the stress placed on the knee structures. Additionally, they enhance joint stability by preventing excessive movements that could lead to injuries.[2]

The medial meniscus is characterized by its C-shaped appearance (Figure 1), being wider at the anterior aspect than the posterior. It covers approximately 50% of the medial tibial plateau and is firmly anchored to the joint capsule through structures such as the coronary, meniscotibial, and deep medial collateral ligaments. [2,3]

The anterior insertion exhibits a fan-shaped configuration, connecting to both the tibial plateau and the intercondylar notch superior to the anterior cruciate ligament. In contrast, the posterior insertion secures the meniscus to the posterior intercondylar area of the tibia, situated between the posterior insertion of the lateral meniscus and anterior to the posterior cruciate ligament. These robust bony attachments at the anterior and posterior horns are integral to the meniscus's load distribution within the knee joint. [4].

The menisci in the knee joint are crucial for enhancing joint stability and distributing load, which helps protect articular cartilage and prevent osteoarthritis. They play several vital roles in knee function, and

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meniscus injuries are common in various activities, often leading to disability. [2,3,4]

Variations in menisci's form, thickness, and width can influence injury risk. Differences between the lateral and medial menisci, including their C-shaped to circular (discoid) contours, are significant for understanding injury mechanisms. Less common variants, such as hypoplastic menisci and anomalous insertions, occur in about 0.3% of the population, particularly in Asia, and are often asymptomatic. Discoid menisci may be unstable and more prone to injuries. Understanding these meniscal variants is crucial for surgical procedures, knee arthroscopy, and meniscal transplantation in injuries.[5]

The discoid lateral and medial menisci were first documented by researchers Young in 1889 and Watson Jones in 1930. Smillie proposed that the formation of the discoid meniscus arises from an incomplete breakdown of the central meniscus. However, this theory has come under scrutiny, as the meniscus does not exhibit a discoid shape during its developmental stages. Kaplan contributed to the understanding of knee development by suggesting that the knee emerges from mesenchymal tissue, which differentiates into the tibia, femur, and intra-articular structures by the eighth week of gestation. Consequently, discoid menisci are thought to arise from mesenchymal tissue in knee regions where such tissue typically does not form. [6,7,8]

MATERIALS & METHODS

This study was conducted after obtaining permission from the Institutional Ethical Committee at Index Medical College, Hospital & Research Centers, Indore (MP). The specimens used for this investigation initially consisted of parts of the proximal parts of the tibia and fibula, the femur, and all knee joint structures. A total of 30 Cadavers were included in this study.

PROCEDURE METHODOLOGY

1. The preparations where the knee joints of the adults had no gross pathologies of the osteoarticular system of lower limbs or from the lower limbs amputated because of pathologies of the lower limb area other than the knee region.
2. The knee joints were fixed in a formaldehyde solution.
3. The capsuloligamentous structures of the knee joint were removed, excluding the posterior cruciate ligament, lateral meniscus, and possible meniscofemoral ligaments.
4. Osteoligamentous blocks were cut; the blocks contained the medial condyle of the femur and a wedge-shaped section from the proximal end of the tibia.
5. An incision was made along the knee joint, and the skin, soft tissues, and muscles were removed to clean it properly.
6. A black ink marker was used to outline all the attachments.
7. The distances between the anterior and posterior horns were measured using a digital caliper, which was placed between the apex of the anterior horn and the apex of the posterior horn.
8. The width was measured at three points - the anterior third, middle third, and posterior third.
9. The meniscus thickness was determined using the same width points, and then the caliper was placed between the top and bottom edge in the outer circumference only.
10. A digital caliper took all the measurements.

Figure 2: A digital caliper

STATISTICAL ANALYSIS

Microsoft Excel was utilized to create the database and generate graphs, while data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 23. Mean and standard deviation (±SD) were employed to describe quantitative data that met standard distribution criteria. A parametric unpaired t-test was used to compare two continuous groups. Bivariate analysis was conducted to determine the Pearson correlation coefficient and assess the association of the studied variables. P-values less than 0.05 were considered statistically significant.

RESULTS

The table below demonstrates the average measurement of the studied specimen with their minimum and maximum measurements.

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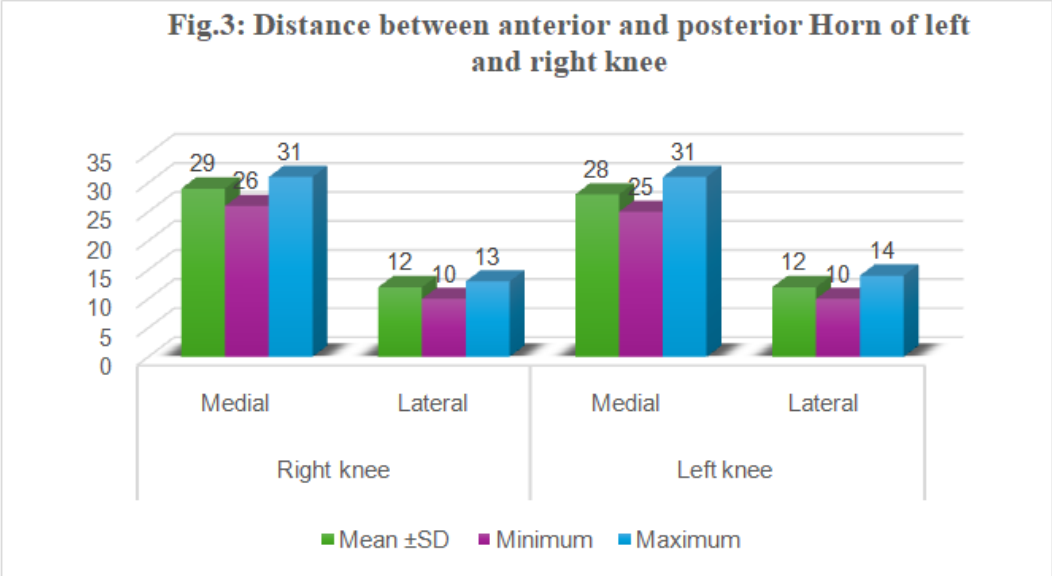

Figure 3: distance between anterior and posterior Horn of left and right knee

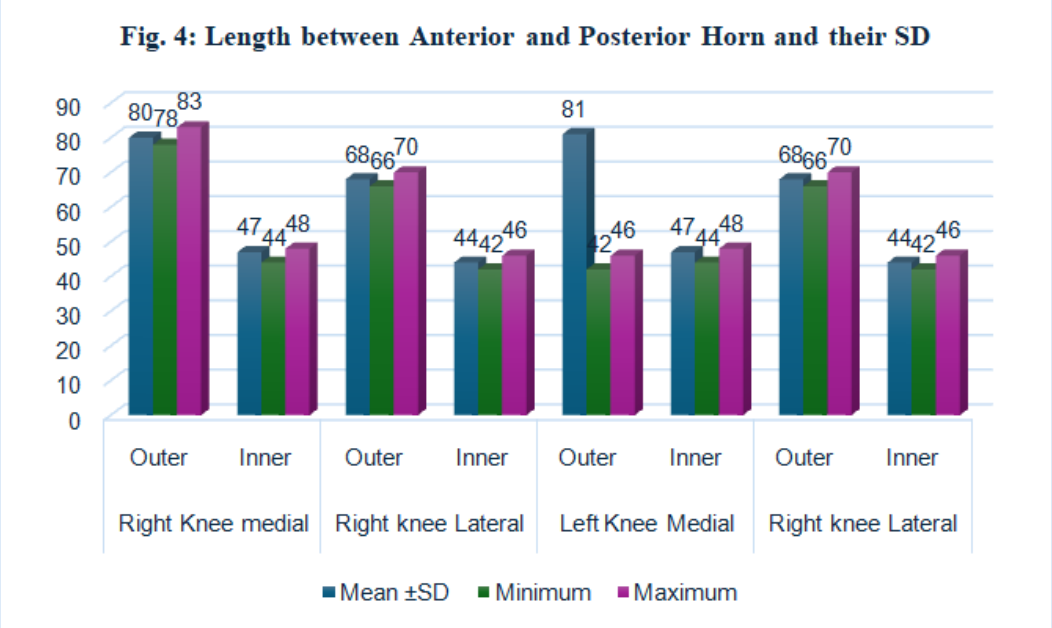

Figure 4: Length between Anterior and Posterior Horn (mm)

Table 1: Width of meniscus

Width of Meniscus (mm)			Mean ±SD	Minimum	Maximum
	Right Knee medial	Ant.1/3	5±0.6	3	6
		Mid. 1/3	6.1±0.8	5	9
		Post. 1/3	10±1.5	6	14
	Right knee Lateral	Ant.1/3	5.7±0.5	4	7
		Mid. 1/3	8.2±0.9	6	10
		Post. 1/3	8.9±0.8	8	11
	Left Knee Medial	Ant.1/3	5.2±0.9	4	8
		Mid. 1/3	6.4±0.9	5	9
		Post. 1/3	9.8±1.2	6	12
	Left knee Lateral	Ant.1/3	5.9±0.6	5	7
		Mid. 1/3	8.3±0.9	6	11
		Post. 1/3	9.2±0.8	7	11

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Table 2: Thickness of meniscus (mm)

Width of Meniscus (mm)			Mean ±SD	Minimum	Maximum
	Right Knee medial	Ant.1/3	2.4±0.4	1	3
		Mid. 1/3	4.4±0.9	2	6
		Post. 1/3	4.5±0.7	3	6
	Right knee Lateral	Ant.1/3	2.4±0.6	1	4
		Mid. 1/3	5.1±0.8	3	7
		Post. 1/3	5.8±o.8	4	7
	Left Knee Medial	Ant.1/3	3.1±1.02	2	6
		Mid. 1/3	5.1±0.94	4	8
		Post. 1/3	5.1±0.9	3	8
	Left knee Lateral	Ant.1/3	2.9±0.8	2	6
		Mid. 1/3	5.1±0.8	3	7
		Post. 1/3	5.9±0.72	4	8

Table 3: Length of Femur and Tibia (cm): This table represents a comparison of the length of the femur and tibia of the right knee with the left knee

		Mean ±SD	Minimum	Maximum
Length of femur(cm)	Right Knee	44.3±2.3	39	48
	Left Knee	44.3±2.3	39	48
Length of Tabia (cm)	Right knee	38.4±2.2	33	43
	Left knee	38.4±2.2	33	43

The table below shows the lengths between the anterior and posterior horns of both knees' medial and lateral aspects. The medial outer and inner lengths for the right knee were 80.4±1.4 and 46.6±0.9, significantly lower than the left knee's 80.8±1.3 and 47.05±0.96 ($P < 0.05$). The lateral inner length for the right knee was 43.6±1.00, also considerably lower than the left knee's 43.9±0.9 ($P < 0.05$). However, the lateral outer lengths were similar, with the right knee at 67.7±0.9 and the left knee at 67.7±0.9 ($P > 0.05$). (Table 4 & 5)

Table 4: Compare the length between anterior and posterior horn medial and lateral of both right and left knee

		Length between anterior and posterior horn (mm)		P value
		Outer	Inner	
medial	Right Knee	80.4±1.4	46.6±0.9	
	Left knee	80.8±1.3	47.1±0.9	<0.001
Lateral	Right Knee	67.7±0.9	43.6±1.0	<0.001
	Left Knee	67.7±0.9	43.9±0.9	

Table 5: Compare the length between anterior and posterior horn medial and lateral of both right and left knee

				P value
		Right knee	Left Knee	
medial	Outer	80.4±1.4	80.8±1.3	
	Inner	46.6±0.9	47.1±0.9	<0.001
Lateral	Outer	67.7±0.9	67.7±0.9	>0.005
	Inner	43.6±1.0	43.9±0.9	

DISCUSSION

Meniscus injuries are expected not only in sports but also in everyday life. These injuries often occur due to rotational trauma, bending, degenerative joint processes, or even spontaneously. Losing a meniscus significantly increases the risk of developing arthritis in the knee. To help reduce knee degeneration following a meniscectomy, meniscus allograft transplantation has been considered a preferred option.[9]

This cross-sectional study was conducted on 30 cadavers in the Department of Anatomy at Index Medical College, Hospital & Research Centers in Indore, Madhya Pradesh. Various authors have examined the morphological parameters of the menisci in the knee joint over time. Farias Filho et al. [10] and Rao N et al. conducted comprehensive studies on the menisci.[11], Rohila J et al. [12], Hathila SB et al. [13], Rashmi BN et al. [14], Itagi V et al. [15], and Kaur A et al. [16] This study compared the morphological parameters of the knee joint

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menisci with those reported by other authors who followed similar research methodologies.

Table 6: Compare the distance between the anterior and posterior horn in the present study to another previous study

Table 6: Distance between anterior and posterior horn		
Authors	**Medial (mm)**	**Lateral (mm)**
Braz PRP et al	25.8	12.6
Almeida SKS et al	29.7	12.7
Rao N et al	31.8	12.6
Murli Manju et al	26.7±4.7	14.7 ±4.1
Present study	28.6 ±1.3	11.6 ±0.6

The present study found that the medial distance between the anterior and posterior horns of the right knee was 28.9 ± 1.3 mm, significantly more significant than the medial distance for the left knee, measured at 28.18 ± 1.46 mm ($P < 0.05$). In contrast, the lateral distance between the anterior and posterior horns of the right knee was 11.5 ± 0.6 mm, which was not significantly different from that of the left knee, which measured 11.7 ± 0.8 mm ($P > 0.005$).

The average distances (in mm) between the anterior and posterior horns are as follows: medial right knee 28.9 ± 1.3, lateral right knee 11.5 ± 0.6, medial left knee 28.18 ± 1.46, and lateral left knee 11.7 ± 0.8. When calculating the overall averages for the left and right medial and lateral distances between the anterior and posterior horns, the values were 28.6 ± 1.3 mm and 11.6 ± 0.6 mm, respectively.

Braz PRP and Silva WG [17], along with **Ashwini C et al.** [18], reported that the distance between the two horns of the medial meniscus is significantly greater than that of the lateral meniscus. Our study's findings support these previous studies. The closer proximity of the lateral meniscus horns may explain why they are less susceptible to injury.

In this study, the lengths between the anterior and posterior horns were measured as follows: right knee medial outer and inner were 28.92±1.33mm and 11.51±0.63mm; right knee lateral outer and inner were 67.65±0.98mm and 43.64±1.00mm. For the left knee, medial outer and inner lengths were 80.77±1.33mm and 47.05±0.96mm, while lateral outer and inner were 67.69±0.96mm and 43.98±0.99mm. In comparison, **Murlimanju BV et al.** [19] reported medial meniscus length as 75.2±0.7mm and lateral meniscus as 68.0±1.2mm. **Panigrahi M** & **Kumar SS** [20,21] found medial menisci were longer (right: 78.0mm, left: 75.0mm) than lateral menisci (right: 58.3mm, left: 50.0mm). **Hathila SB et al.** [13] noted the outer circumference length of the medial menisci as 102.8±7.7mm and lateral as 96.4±3.3mm.

This study also demonstrated that the length of the femur and length of the tibia of both the right and left knee and observed that the length of the femur and length of the right and left knee were comparable ($P>0.05$).

This study found no significant correlation between the distances of the anterior and posterior horns in both knees. However, the right medial middle 1/3 significantly correlated with the left medial distance ($p<0.05$). The right lateral posterior 1/3 and left medial middle 1/3 were significantly linked to the right lateral distance ($p<0.05$). Additionally, the right lateral anterior 1/3 was significantly associated with the medial distances in both knees ($p<0.05$). The left lateral middle and posterior 1/3 meniscus thicknesses were also significantly associated with the lateral distances ($p<0.05$).

The right medial posterior 1/3 and left lateral anterior 1/3 were significantly associated with the left lateral inner length between the anterior and posterior horn ($p<0.05$). However, no significant correlations were found between the distance between the anterior and posterior horn and the lengths of the left and right femur and tibia ($p>0.05$). Notably, the left medial middle 1/3 showed a significant association with both femurs ($p<0.05$), while the left lateral posterior 1/3 was significantly associated with both tibias ($p<0.05$).

CONCLUSION

Understanding the morphology of menisci is vital for a range of medical professionals, including surgeons, orthopedic specialists, radiologists, and interventionists. This knowledge is essential when performing advanced orthopedic surgeries such as arthroscopy, knee transplants, meniscal transplants, and meniscectomies. An in-depth grasp of meniscal anatomy and its variations significantly ensures accurate diagnoses and effective treatment strategies, improving patient outcomes in complex knee-related interventions.

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