Section: Anatomy

Original Research Article

SEGMENTAL WIDTH AND THICKNESS OF MEDIAL AND LATERAL MENISCI IN ADULT HUMAN CADAVERS: A MORPHOMETRIC ANALYSIS

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ABSTRACT

Background: Segmental variations in the width and thickness of knee menisci influence load distribution and are clinically significant in meniscal injury, repair, and reconstruction. The objective is to evaluate and compare the segmental width and thickness of the medial and lateral menisci at the anterior, middle, and posterior thirds in adult human cadavers.

Materials and Methods: A cadaveric observational study was performed on 35 embalmed adult human cadavers, yielding 70 knee joints. Medial and lateral menisci were dissected and divided into anterior, middle, and posterior thirds. Segmental width and thickness were measured using a vernier caliper. Measurements were recorded separately for the right and left sides. Data were expressed as mean ± standard deviation, and side-wise comparisons were analysed using Welch's unpaired t-test, with $p < 0.05$ considered statistically significant.

Results: The medial meniscus showed progressive widening from anterior to posterior segments, with significantly greater posterior width on the left side (14.95 ± 4.66 mm) compared to the right (11.32 ± 3.87 mm; $p < 0.01$). Thickness of the medial meniscus was greater at the middle and posterior thirds, with a significant side-wise difference observed only at the anterior third ($p = 0.03$). The lateral meniscus demonstrated maximal thickness at the middle third bilaterally, while posterior thickness was significantly greater on the right side (5.98 ± 2.02 mm vs 4.66 ± 1.73 mm; $p < 0.01$). Segmental width of the lateral meniscus remained relatively uniform, with no statistically significant side-wise differences.

Conclusion: Distinct segmental morphometric patterns were observed between medial and lateral menisci, reflecting their functional adaptations. These data provide clinically relevant anatomical benchmarks for imaging interpretation and meniscal surgical procedures.

Keywords: Knee joint; Menisci; Morphometry; Cadaveric study; Width and thickness.

INTRODUCTION

The menisci of the knee joint are crescent-shaped fibrocartilaginous structures interposed between the femoral condyles and the tibial plateau, playing a crucial role in load transmission, shock absorption, joint stability, lubrication, and proprioception. By increasing the congruity between the articular surfaces, the menisci contribute significantly to the distribution of axial loads across the tibiofemoral joint and reduce peak contact stresses during weight-bearing activities.[1,2]

Anatomically, the medial and lateral menisci differ in their shape, mobility, capsular attachments, and biomechanical behavior. The medial meniscus is relatively immobile due to its firm attachment to the joint capsule and medial collateral ligament, whereas the lateral meniscus is more mobile, allowing it to

accommodate femoral condylar movements during knee flexion and extension. These differences are reflected in the distinct injury patterns observed clinically, with the medial meniscus being more frequently involved in degenerative and traumatic tears.[3-5]

Morphometric characteristics, such as segmental width and thickness, are particularly important because they influence regional stress distribution and determine the mechanical competence of different meniscal segments. Variations in width affect the available contact area for load transmission, while thickness contributes to resistance to compressive forces. Segment-specific morphometry has also gained relevance in the context of arthroscopic meniscal repair, partial meniscectomy, meniscal allograft transplantation, and the development of anatomically accurate biomechanical models and implants.[4-6]

Although imaging techniques such as magnetic resonance imaging allow in vivo assessment of meniscal dimensions, cadaveric studies remain the gold standard for precise morphometric evaluation. Detailed cadaveric measurements provide baseline anatomical data essential for validating imaging findings and understanding population-specific variations in meniscal anatomy.[2,3]

Despite the clinical and biomechanical importance of meniscal dimensions, comprehensive cadaveric data on the segmental width and thickness of both the medial and lateral menisci remain limited, particularly in the Indian population. Most available studies emphasize overall dimensions or morphological patterns rather than detailed segment-wise analysis.[7,8]

In view of the functional importance of segmental meniscal dimensions and the paucity of focused morphometric data, the present study was undertaken to evaluate the segmental width and thickness of the medial and lateral menisci at the anterior, middle, and posterior thirds in adult human cadavers, thereby providing anatomically relevant baseline data with direct clinical and surgical implications.

MATERIALS AND METHODS

Study Design and Setting: A cadaveric, observational morphometric study was conducted in the Department of Anatomy of a tertiary care medical college in India over a specified study period.

Study Material: The study included 35 embalmed adult human cadavers, yielding a total of 70 knee joints. Both right and left knee joints were examined wherever available. Cadavers of unknown sex and age above 20 years were included.

Inclusion and Exclusion Criteria

Cadavers with intact knee joints and well-preserved menisci were included in the study. Specimens showing evidence of prior knee surgery, gross trauma, deformity, advanced degenerative changes, or damage to the menisci during dissection were excluded.

Dissection Procedure: The knee joints were dissected following standard anatomical dissection techniques as described in Cunningham's Manual of Practical Anatomy. After removal of the skin and superficial structures, the joint capsule was opened carefully. The femoral condyles were disarticulated to expose the tibial plateau, and the medial and lateral menisci were identified and isolated intact, ensuring minimal handling and distortion.

Morphometric Measurements: Only the segmental width and thickness of the medial and lateral menisci were assessed in the present study. Each meniscus was divided into three segments: Anterior third, Middle third, and Posterior third. All measurements were taken with a vernier caliper and recorded in millimetres (mm). Width was measured as the maximum distance between the inner free margin and the outer peripheral margin of the meniscus at each segment. Thickness was measured as the vertical height of the meniscus at the midpoint of each segment. Measurements were obtained separately for the right and left medial menisci and right and left lateral menisci. Each measurement was carefully taken to avoid compressing the meniscal tissue.

Data Handling and Statistical Analysis: All observations were entered into a spreadsheet and analysed statistically. Data were expressed as mean ± standard deviation (SD). Comparisons between right and left sides were performed using Welch's unpaired t-test, considering unequal sample sizes. A p-value of < 0.05 was considered statistically significant. Statistical analysis was performed using appropriate statistical software.

Ethical Considerations: The study was conducted on cadavers obtained through the institutional body donation programme after approval from the Institutional Ethics Committee. No identifying information of donors was recorded.

RESULTS

[Table 1] shows that the medial meniscus thickness varied across segments, with higher values observed in the middle and posterior thirds on both sides. A statistically significant side-wise difference was noted only in the anterior third, where the left medial meniscus was thicker than the right, while the middle and posterior thirds did not demonstrate any significant difference between sides.

Table 1: Segmental Thickness of Medial Meniscus (mm)

Segment	Right side (n=37) (Mean ± SD)	Left (n=33) (Mean ± SD)	p value
Anterior third	4.53 ± 1.27	5.40 ± 1.96	0.03
Middle third	6.05 ± 2.11	6.09 ± 1.93	0.95
Posterior third	6.03 ± 3.36	5.28 ± 2.58	0.30

[Table 2] presents the segmental thickness of the lateral meniscus and demonstrates that the middle third was the thickest segment bilaterally. Side-by-side comparison revealed no significant difference between the anterior and middle thirds; however, the posterior third was significantly thicker on the right than on the left.

Table 2: Segmental Thickness of Lateral Meniscus (mm)

Segment	Right side (n=37) (Mean ± SD)	Left (n=33) (Mean ± SD)	p value
Anterior third	4.58 ± 1.70	4.35 ± 1.84	0.60
Middle third	6.17 ± 1.83	5.72 ± 1.79	0.30
Posterior third	5.98 ± 2.02	4.66 ± 1.73	<0.01

[Table 3] shows a progressive increase in the width of the medial meniscus from the anterior to the posterior third on both sides. While the anterior and middle thirds did not show significant side-to-side differences, the posterior third width was significantly greater on the left side than on the right.

Table 3: Segmental Width of Medial Meniscus (mm)

Segment	Right side (n=37) (Mean ± SD)	Left (n=33) (Mean ± SD)	p value
Anterior third	6.63 ± 2.26	7.19 ± 2.40	0.320
Middle third	7.16 ± 2.69	8.09 ± 3.04	0.184
Posterior third	11.32 ± 3.87	14.95 ± 4.66	<0.01

[Table 4] demonstrates that the lateral meniscus exhibited relatively uniform width across the anterior, middle, and posterior thirds. No statistically significant side-wise differences were observed in any of the segments, indicating symmetrical width distribution of the lateral meniscus.

Table 4: Segmental Width of Lateral Meniscus (mm)

Segment	Right side (n=37) (Mean ± SD)	Left (n=33) (Mean ± SD)	p value
Anterior third	9.09 ± 2.95	8.92 ± 2.70	0.80
Middle third	9.05 ± 2.83	8.47 ± 2.50	0.37
Posterior third	9.69 ± 2.91	9.44 ± 2.35	0.71

DISCUSSION

Segmental variations in meniscal width and thickness are anatomically and biomechanically significant, as these parameters influence load transmission, joint congruity, and region-specific susceptibility to injury. The present study provides a detailed quantitative assessment of the segmental width and thickness of the medial and lateral menisci and allows meaningful comparison with previously published cadaveric studies.

In the present study, the medial meniscus demonstrated a clear posterior predominance in width, with posterior width measuring 11.32 ± 3.87 mm on the right and 14.95 ± 4.66 mm on the left, while anterior and middle thirds showed comparatively lower values. A similar pattern has been consistently reported across multiple studies. Rashmi BN et al,[9] documented posterior medial meniscal width of approximately 15–16 mm, compared with anterior values around 8–9 mm, indicating marked posterior widening. Hathila SB et al,[10] also reported maximal medial meniscal width at the posterior third (around 15 mm), followed by the middle and anterior thirds. Previous studies observed comparable posterior predominance,[11,12] both of whom noted that the posterior horn of the medial meniscus was the widest segment, although absolute values varied slightly between studies. The agreement of these findings with the present study supports the concept that the posterior horn of the medial meniscus is structurally adapted to withstand higher compressive and shear forces during knee flexion and weight bearing.

Regarding medial meniscal thickness, the present study showed greater thickness in the middle and posterior thirds than in the anterior third on both sides, with values around 6 mm in the middle and posterior thirds. A significant side-wise difference was observed only at the anterior third. Rashmi BN et al,[9] reported posterior medial meniscal thickness of approximately 5.9 mm, followed by anterior (~5.6 mm) and middle (~5.3 mm) segments, showing a slightly different order but comparable absolute values. Gupta M et al,[13] reported lower medial meniscal thickness values overall, with posterior thickness around 5.1 mm, middle around 5.0 mm, and anterior around 3 mm, but also noted relative thickening of the posterior and middle segments. Shashidhar K et al,[14] also observed greater thickness in the posterior and middle regions of the medial meniscus, although the authors emphasized inter-individual variability rather than strict segmental dominance. These variations across studies may reflect differences in population characteristics, embalming status, and the exact point at which thickness is measured.

In the present study, the lateral meniscus demonstrated maximal thickness at the middle third bilaterally (6.17 ± 1.83 mm on the right and 5.72 ± 1.79 mm on the left), with a significant right-sided predominance at the posterior third. Multiple studies well support this finding. Rashmi BN et al,[9] reported the middle third of the lateral meniscus as the thickest

segment (~5.8 mm), followed by posterior (~5.4 mm) and anterior (~4.9 mm) thirds. A similar middle-third dominance of lateral meniscal thickness was described by Hathila SB et al,[10] and Shashidhar K et al,[14] both of whom attributed this pattern to the dynamic role of the lateral meniscal body in accommodating femoral condylar movement. Sophia M et al,[15] also reported central thickening of the lateral meniscus, though their study focused more on overall morphometry than on side-by-side comparison.

Regarding the width of the lateral meniscus, the present study demonstrated relatively uniform values across the anterior, middle, and posterior thirds, with no statistically significant side-to-side differences. Posterior width values were approximately 9–10 mm, which were comparable to those of the anterior and middle segments. This uniformity is consistent with Rashmi BN et al,[9] who reported lateral meniscal widths of approximately 11–12 mm across all three segments without significant variation. Hathila SB et al,[10] and Gupta GK et al,[11] similarly noted minimal segmental variation in lateral meniscal width, highlighting the lateral meniscus's more circular shape and greater mobility. Previous studies also reported a relatively even distribution of width in the lateral meniscus, although their studies primarily highlighted morphological patterns and provided limited segment-wise numerical data.[12,16]

Overall, the medial meniscus shows greater dimensions in the middle and posterior regions, whereas the lateral meniscus demonstrates more uniform morphology with central thickening. Such morphometric data serve as critical anatomical references for clinical and surgical applications involving the knee joint.

CONCLUSION

The present study demonstrates clear segment-specific variations in the width and thickness of the medial and lateral menisci in adult human cadavers. The medial meniscus showed a consistent pattern of posterior widening with relatively greater thickness at the middle and posterior thirds, reflecting its role in load transmission and stability of the knee joint. In contrast, the lateral meniscus exhibited a more uniform width across all segments, with maximal thickness at the middle third, supporting its greater mobility and adaptive function. Side-wise differences were limited to selected segments and were not a dominant feature, indicating overall bilateral symmetry in meniscal morphometry. These findings provide reliable anatomical baseline data that may aid in the interpretation of imaging studies, guide arthroscopic and reconstructive procedures, and contribute to improved understanding of region-specific meniscal biomechanics.

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