

## Morphometric study of medial menisci of the adult knee joint

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### Abstract

**Introduction:** Knee joint is the largest articulation in the body. The condyles of the femur rest in unequal manner on the shallow concave surface of the tibia. The menisci are firmly attached to the intercondylar area of tibia and their outer edges are attached to fibrous capsule of the knee joint. Variation in thickness and width of menisci can determine the possibility and kind of injury. The size of the meniscus is related to its function, any procedure like meniscal replacement and regeneration techniques adopted in orthosurgeries must be accompanied by measurement techniques to determine meniscal size.

**Objective:** To analyze thickness, width, peripheral and inner border lengths, distance between anterior and posterior horns of adult medial menisci of right and left knee joints and to compare with that of meniscal parameters which are available in the literature.

**Materials and Method:** For this study, 120 medial menisci from 60 adult human knees available in the Department of Anatomy, Jawaharlal Nehru Medical College, Belgaum were studied and analyzed.

**Results:** Paired t-test with  $p < 0.05$  significance was applied for values expressed as Mean  $\pm$  SD, Mean values of all parameters were high for left sided menisci but statistically significant higher difference was observed only for peripheral length values.

**Conclusion:** Peripheral length of medial menisci was more on the left sided knees. Other morphometric parameters of the medial menisci between right and left knees did not show any significant difference.

**Keywords:** Medial menisci, Peripheral length, Thickness, Width, Inner border length

### Introduction

One of the major articulation in the body is the knee joint. It is a type of double condyloid joint which gives 20° of freedom of motion to the joint. Tibia has shallow concave articulating surface which receives the condyles of the femur, this approximation of bones is unequal at the knee joint. So knee joint has to depend on soft tissue structures like the anterior and posterior cruciate ligaments, medial and lateral collateral ligaments, the capsule, the menisci and the muscles across the joint for static and dynamic stability.<sup>(1,2)</sup>

Intercondylar area of tibia provides stable attachment to menisci and their outer edges are fastened to the fibrous capsule of the knee joint. The capsular fibers of coronary ligaments fix the borders of the menisci to the tibial condyles.<sup>(3)</sup>

The medial meniscus is C-shaped and it is wider posteriorly than anteriorly.<sup>(4)</sup> Its anterior insertion is fan-shaped and it is attached above to the tibial plateau and intercondylar notch, near and anterior to the insertion of the crossed anterior ligament.<sup>(5)</sup> Posterior insertion of the medial menisci is to the posterior intercondylar area of tibia and anteriorly to the attachment of the posterior crossed ligament. The lateral meniscus is smaller, almost circular in shape, and more freely mobile than the inner non fixed edges of the menisci.

Menisci is made up of collagen, glycoproteins, proteoglycans, elastin and cells like fibroblasts and chondrocytes. The principal function of menisci in knee joint is to augment joint congruence and load

distribution, therefore reducing the stress on the knee joint. This function helps to protect the articular cartilage and prevent osteoarthritis.<sup>(6)</sup> The obvious disparity in the insertion, shape and form among the lateral and the medial menisci are crucial in understanding the mechanisms of injury.<sup>(7)</sup>

The knowledge of variations in width and thickness of the menisci can decide the kind of injury and the possibility of injury.<sup>(8)</sup> Width of the menisci plays a vital role in determining the contact pressure distribution. The firm bony insertion of the anterior and posterior horns is considered vital to the meniscus function of loads distribution. The functions of the meniscus include stress reduction, load transmission, shock absorption, joint lubrication, enhance joint stability, restrict extreme flexion and extension and nutrition.

With the introduction of new techniques such as computed tomography (CT), arthroscopy and magnetic resonance imaging (MRI), the intraarticular structures of the knee joint are studied better and the anatomical variations and abnormalities of these structures have become significant.

Different approaches to meniscus replacement were undertaken, such as allografts, autografts, biodegradable collagenous scaffolds and permanent prosthesis.<sup>(5)</sup> Adequate size, appropriate replacement material and anatomically correct position must be identified as crucial factors that determine the success rates of procedures like meniscus replacement and to avoid changes as degenerative arthritis which might

develop after total meniscectomy.<sup>(5)</sup> Hence there is a need for more knowledge about morphometry and its variations of medial menisci in people of North Karnataka.

### Objectives

To analyze the peripheral and inner border lengths, thickness, width and distance between anterior and posterior horns of the adult medial menisci of left and right knee joints and to correlate and compare with the data available in the literature.

### Materials and Method

To carry out this study, embalmed human adult limbs of the cadavers available in the Anatomy Department, Jawaharlal Nehru Medical College, Belgaum were used. For this study, 120 menisci from 60 human knees, 31 left and 29 right which were dissected previously and preserved with 10% formalin solution were used. Since the knee joints were isolated and separated from its cadaver it was not possible to assess whether they were from same or different specimen. Factors that may influence certain anatomical variations like weight, sex and height were also not studied.

**Study design:** Cross sectional study.

**Inclusion criteria:** During the study period all the cadaveric limbs available in the Department of Anatomy of J. N. Medical College.

**Exclusion criteria:** Cadavers whose lower limbs had abnormal knee joints like exostosis, any deformity, traumatic injury or fractures. Menisci that showed advanced degenerative changes in the structure which prevented its morphometric analysis were also excluded.

Firstly skin and muscles were dissected at the knee joint, then route to menisci was planned. On each side of joint capsule a longitudinal incision was made anteriorly then collateral ligaments and patellar ligament were cut transversely to open the joint cavity. To visualise the menisci clearly intraarticular ligaments and joint capsule were cut, condyles were separated from soft tissue attachments around the edges exposing the tibial plateau. After the methodical dissection data were entered on a standardized data collection sheet.

The peripheral length of menisci was determined first to measure the thickness of outer circumference of menisci. A cotton non-elastic thread was placed along the periphery of the meniscus and with small pins the tibial insertion ligaments of meniscus were held in place. Peripheral length is measured as the length of thread from the most anterior part of the anterior

insertion area to the most posterior part of the posterior insertion area. In the same manner, by keeping the thread at the inner free edge the inner free border length was measured.<sup>(9)</sup>

Then the thread with peripheral circumference length is divided into 3 equal parts by using scale & colour marker pens. The thread is placed again over the meniscus and the meniscus were divided into 3 equal parts anterior 1/3(ant 1/3), middle 1/3(mid 1/3) and posterior 1/3(post 1/3) respectively. Then the width and the thickness of the meniscus were measured at the above mentioned parts at their midpoint. The distance between (b/w) the anterior horn (AH) & posterior horn (PH) was also measured.<sup>(9)</sup>



**Fig. 1: Showing the division of meniscus into ant1/3, mid1/3 & post 1/3**

A Vernier caliper of 0.10 mm accuracy was used for taking measurements. Using these parameters dimensions of the normal medial menisci were determined. Statistical analysis included mean and standard variations of each variable calculated and their difference between right and left knee menisci was compared by using Student's unpaired t-test, where significance value was  $p < 0.05$ .

### Result

Study involved 60 knee joints. Table 1 showed comparison of medial menisci parameters on left and right side, mean peripheral length of left sided medial menisci were higher with statistically significant difference ( $p < 0.05$ ). Mean inner border length was also high on left medial menisci but the difference was not significant. Mean values of width and thickness of medial menisci at anterior1/3, middle1/3 and posterior 1/3 were more in left sided menisci with no significant difference. Mean of distance between anterior and posterior horns of menisci were high on left side.

**Table 1: Medial meniscal parameters in adults (n = 60)**

Parameters		Right Side (mm)	Left Side(mm)	t value	p value
Peripheral Length		97.4 ± 8.53	102.1 ± 8.56	2.136	0.037 *
Inner Border Length		55 58.4 ± 8.59	62.1 ± 8.04	1.753	0.085
Width	Ant 1/3	6.9 ± 1.24	7.3 ± 1.70	1.012	0.311
	Mid 1/3	7.2 ± 1.53	7.4 ± 1.58	0.707	0.482
	Post 1/3	12.1 ± 2.20	12.2 ± 2.65	0.186	0.853
Thickness	Ant 1/3	4 ± 0.69	4.2 ± 0.80	0.730	0.469
	Mid 1/3	4.2 ± 1.08	4.2 ± 0.94	0.149	0.882
	Post 1/3	4.4 ± 0.73	4.6 ± 0.71	0.703	0.485
Distance b/w AH & PH		27.8 ± 5.65	28.7 ± 5.31	0.647	0.520

Values are Mean ± SD, Statistical significance (Paired t-test) \*p<0.05

### Discussion

In the present study among the medial menisci mean peripheral length of left sided menisci (102.1 ± 8.56 mm) were higher than right (97.4 ± 8.53 mm) with statistically significant difference. Inner border length for Medial menisci was greater for left sided menisci than right sided with no significant difference. These findings were consistent with a study done in Germany on 92 knees with left sided values for length being higher.<sup>5</sup> Report of the study suggests that if meniscal transplant is tried to fix to the bone then it's important that the entire circumferential length of the meniscus and both the insertion ligaments is known.<sup>(5)</sup>

In a similar study done on Punjab population the mean of inner circumference of medial menisci of left knee was 6.4 cm. and right knee was 6.2 cm. Mean outer circumference of 9.7 cm in left side and 9.2 cm on right side was observed. The width range of anterior segment of medial menisci of both left knee and right knee was from 0.5-1.5 cm with mean width of 1.00 cm and 0.9 cm respectively. The width range of middle segment of medial menisci of left knee and right knee was from 0.7-1.6 cm with mean width of 1.10 cm. and 1.0 cm. The width range of posterior segment of medial menisci of left knee and right knee was from 1.0-2.0 cm with mean width of 1.50 cm and 1.40cm. When analyzing the thickness of the outer circumference of the medial meniscus, the posterior third (5.18±1.55 mm) appeared thinner compared to the anterior (6.17±1.68 mm) and medium thirds (6.31±1.73 mm).<sup>(10)</sup>

In a study, conducted by Almeida *et al.* (2004), on 44 menisci of 22 knee of adult male cadavers it was observed that thickness of medial menisci in anterior 3rd was 5.92±1.337 mm, in middle 3<sup>rd</sup> was 5.31±1.06 mm, in posterior 3rd was 5.91±1.13 mm. Width of medial menisci in anterior 3rd was 9.02±1.59 mm, in middle 3rd was 12.16±2.58 mm, in posterior 3rd was 17.37±2.22 mm. The distance between the anterior and posterior horns of medial meniscus was (29.70±4.12 mm).<sup>(8)</sup>

In the study conducted by Murlimanju *et al.* (2010), the individual analysis of each fetal medial meniscus showed that the posterior 1/3 (3.28±0.62 mm) was the widest part of the medial meniscus than the anterior (2.94±0.61 mm) and middle 1/3 (2.88±0.61 mm). The distance between the anterior and posterior horns of the medial meniscus (3.79±0.89 mm).<sup>(9)</sup>

In another study conducted by Braz and Silva (2010) on 40 menisci from 20 knees, it was observed that the peripheral length of medial menisci was 91.85±5.66 mm. The distance between the anterior and posterior horn of the medial meniscus (25.88±3.33 mm). Regarding the width of medial meniscus, the posterior 3rd was the widest (14.96±2.66 mm) followed by the middle thirds (9.32±2.24 mm) and anterior 3rd (7.68±1.36 mm). With regard to the thickness of the meniscus, the posterior 3rd of the medial meniscus was the smallest (5.18 mm) followed by anterior (6.17 mm) and medium thirds (6.31 mm).<sup>(11)</sup>

From 28 pairs of knees, the peripheral length of the menisci in the right knee was correlated with the peripheral length of the medial menisci in the left knee (110.86 ± 13.18, and 111.09 ± 15.78).<sup>(5)</sup>

A study done to determine dimensions of the normal menisci in 174 healthy subjects by using MRI in vivo the measurements of width for the medial meniscus were (7.78 mm) anterior horn, (7.37 mm) mid-body and the (11.71 mm) posterior horn. Medial meniscus thickness at anterior horn, mid body and posterior horn were 5.32 mm, 5.03 mm and 5.53 mm respectively.<sup>(12)</sup>

It is presumed that the wider the meniscus, the more susceptible it is to meniscal injuries as it is exposed to the actions of the femoral condyles. The anterior third of the MM presented with narrow width explains the lower incidence of injuries at this region due to the weaker action of the femoral condyle.<sup>(9,2)</sup> Since proper function of menisci depends on its size any procedure to replace the cartilage must be done along with techniques which determine meniscal size.

Precise measurement would be helpful as a clinical assessment tool for meniscal replacement and regeneration procedures taken up in orthosurgeries.

From our study we can conclude that morphometric parameters of the medial menisci between right and left knees did not show any significant difference ( $p>0.05$ ), except for the peripheral length of the medial menisci which was more on the left side ( $p<0.05$ ). The present study offers added information on measurements of the medial menisci of right and left knee with contribution to a better description of meniscal anatomy and implications in regard to allograft meniscus transplantation. This study is useful for the health experts who are involved with the management of meniscal injuries to understand anatomical variations that may exist in the menisci, thereby assisting the rehabilitation process. With the above findings, present study proposes that future studies should be undertaken involving the measurement of volume of the meniscus and to assess any gender differences in the morphometry of menisci.

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