

MORPHOMETRIC STUDY OF MENISCI OF KNEE JOINTS IN ADULT CADAVERS

Rashmi B.N ^{*1}, Dakshayani K.R ², Vadiraja N ³.

^{*1} Assistant professor, Department of anatomy, Mysore Medical College and Research Institute, Mysore, Karnataka, India.

² Professor and HOD, Department of anatomy, Mysore Medical College and Research Institute, Mysore, Karnataka, India.

³ Assistant professor, Department of Community Medicine³, Mysore Medical College and Research Institute, Mysore, Karnataka, India.

ABSTRACT

Background: The menisci of knee joint are important functional units able to improve joint congruence and load distribution thereby reducing the stress on the knee joint, a function that is considered primordial to protect the articular cartilage and prevent osteoarthritis. Variations of form and in particular of thickness and width of menisci can determine the possibility and kind of injury. The study of morphology of menisci of the knee joint will provide support to meniscal anatomy which is necessary for various surgical procedures and also for arthroscopy of the knee joint. The knowledge of exact size and shape is essential for meniscal transplantation in meniscal injuries.

Materials and Methods: The study is done on 50 menisci (32 right and 18 left sides) of adult cadavers preserved with formaldehyde solution obtained from department of Anatomy, MMC&RI. To measure the length of each menisci, a cotton thread is placed across the outer edge of the meniscus from the apex of the anterior horn to the apex of the posterior horn. Next the thread length is measured using vernier calipers. Width is measured at three points-anterior third, middle third and posterior third. From each point, distance between outer edge to inner edge is measured using vernier calipers. The thickness of the meniscus is also measured at three points- anterior third, middle third and posterior third. The data was analysed using the student t-test for independent samples.

Results: The individual analysis of each meniscus showed that posterior third of medial meniscus was the widest part (16.68 ± 0.60 mm) ($p < 0.05$) followed by middle third (12.09 ± 0.22 mm) and anterior third (8.88 ± 0.19 mm). Related to the thickness of outer circumference of meniscus, posterior third (5.90 ± 0.12 mm) of medial meniscus was the thickest part followed by anterior third (5.58 ± 0.18 mm) and middle third (5.28 ± 0.12 mm). However, in the lateral menisci, middle third was the thickest part ($p < 0.05$) (table I). In the present study, the peripheral length of medial meniscus (10.38 ± 0.33 cm) was significantly more than the lateral meniscus (9.61 ± 0.2 cm). Discoid medial and lateral menisci were not observed in the present study (0%).

Conclusion: The result of this study showed that there is an important relationship between the morphometric data of the menisci and the data found in the clinic, which would explain the incidence of injuries in specific points of each meniscus.

KEY WORDS: Meniscus, Morphometry, Knee, Discoid meniscus.

Address for Correspondence: Dr. Rashmi B.N, Assistant professor, Department of Anatomy, Mysore Medical College and Research Institute, Mysore, Karnataka, India.

E-Mail: dr.rashmimanju@gmail.com

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INTRODUCTION

The menisci are crescent shaped fibrocartilaginous structures that partly divides a joint cavity. These lamellae serve to deepen the surfaces of articular fossae of the head of tibia for reception of the condyles of the femur. The functions of the meniscus include load transmission, shock absorption, stress reduction, increase joint congruence, improve joint stability, limit extreme flexion and extension, proprioception, and joint lubrication and nutrition [1].

The medial meniscus is C shaped and it is wider anteriorly than posteriorly [2]. Its covers 50% of the medial tibial plateau and is connected firmly to the joint capsule (coronary, meniscotibial and deep medial collateral ligament). Its anterior insertion is fan shaped, and is attached to the tibial plateau and to the intercondylar notch above anterior cruciate ligament [3]. Its posterior insertion attaches to posterior intercondylar area of the tibia between posterior insertion of the lateral meniscus and anterior to posterior cruciate ligament. The firm bony insertion of the anterior and posterior horn is considered crucial to the meniscus function of load distribution [4].

The lateral meniscus is almost circular and more freely movable than the medial meniscus. It covers 70% of the lateral tibial plateau and has firm anterior and posterior attachments (augmented posteriorly by meniscofemoral ligament), while its lateral joint capsule attachment is loose. Thus, the average excursion of meniscus during flexion and extension is greater laterally, a feature that protects against incidence of lateral meniscal tear. The anterior insertion of lateral meniscus is attached to anterior intercondylar fossa of the tibia, anterior to the lateral eminence of tibia and part of the its fibers blend with anterior cruciate ligament. The insertion of posterior lateral meniscus is fixed in the tibia posterior to the insertion of medial meniscus [3,4].

The menisci of knee joint are important functional units able to improve joint congruence and load distribution, thereby reducing the stress on the knee joint, a function that is considered primordial to protect the articular cartilage and prevent osteoarthritis [4].

The menisci has several roles that contribute to the successful function of the knee. Injuries to the meniscus are common in work, sports and everyday activities, and can be disabling [4].

Variations of form and in particular of thickness and width of menisci can determine the possibility and kind of injury. There are many differences in the anatomical features and insertion between the lateral and medial menisci and also the contour of the menisci changes from C- shaped to circular (discoid) which are important in relation to the injury mechanism. Other meniscal variants such as hypoplastic meniscus, absent menisci and anomalous insertion of medial meniscus are less frequent, with an incidence of 0.3%. Such variants are more prevalent in the population of Asian countries, in the lateral meniscus and are frequently asymptomatic. Discoid meniscus may be unstable and therefore more susceptible to injury. The knowledge of these variants menisci of the knee joint will provide support to meniscal anatomy which is necessary for various surgical procedures and also for arthroscopy of the knee joint. The knowledge of exact size and shape is essential for meniscal transplantation in meniscal injuries [5,6].

Discoid lateral and medial menisci were first described in cadaver specimens by Young [7] in 1889 and Watson Jones 1930. Smillie [8] believed that discoid meniscus was the result from an incomplete breakdown of the central meniscus, but this is now disputed, as at no time in development does the meniscus have discoid appearance. Kaplan [9] hypothesized that the knee develops from the mesenchymal mass that differentiates into tibia, femur and intrarticular structures at 8 week of gestation. This mesenchymal tissue persists only at the edges, where differentiation into menisci occurs. It is believed that discoid menisci develop from this mesenchymal tissue in a site where this tissue does not normally occur [7].

MATERIALS AND METHODS

The study was done on 50 menisci of 25 knees of adult cadavers preserved with formaldehyde solution obtained from department of Anatomy, MMC&RI. All menisci that showed injuries and

any structural changes which prevent its morphometric analysis such as injuries and advanced degenerative changes, will be excluded. After the removal of skin and muscles, the menisci were approached anteriorly by a longitudinal incision on each side of the joint capsule, cutting the patellar ligament and the collateral ligament transversely. In order to expose the menisci clearly, the joint capsule and the intra articular ligaments were cut, and the condyles were circumferentially detached from their soft tissue attachments, exposing the tibial plateau. All dissections were performed in a systematic fashion and data were recorded on a standardized collection sheet.

To measure the peripheral length of each menisci, a non elastic cotton thread was placed along the outer edge of the meniscus from the apex of the anterior horn to the apex of the posterior horn (figure 1 A). The length of the thread was measured using vernier calipers. Width was measured at three points-anterior third, middle third and posterior third (Figure 1B). From each point, distance between outer edge to inner edge (Figure 2B) was measured using Vernier calipers. The thickness of the meniscus was determined using the same width points, and then the caliper was placed between the top and bottom edge (Figure 2A) in the outer circumference only. The data were statically analysed by the T test of student for independent samples, considering the level of significance of 0,05. Data were presented as mean±SD.

Fig. 1 A: showing the method of measurements of peripheral length of the meniscus along the red dotted line. **B.** showing the measurement of width of the meniscus by establishing three points: one anterior, one medium and one posterior.

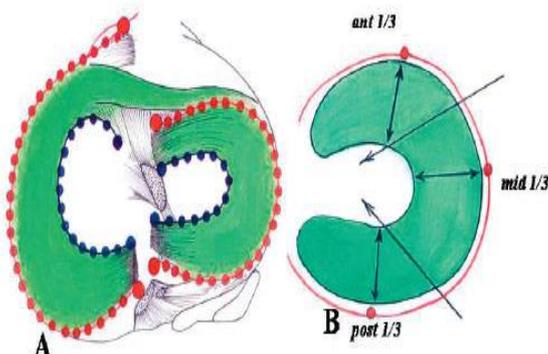


Fig. 2: A: showing the method of measurement of the thickness of outer circumference of the meniscus.



B. Showing the method of measurement of the width of the meniscus.



RESULTS

The individual analysis of each meniscus (Table 1) showed that posterior third of medial meniscus was the widest part ($16.68 \pm 0.60 \text{ mm}$) ($p < 0.05$) followed by middle third ($12.09 \pm 0.22 \text{ mm}$) and anterior third ($8.88 \pm 0.19 \text{ mm}$). In the lateral meniscus, there was no significant ($p > 0.05$) difference between the anterior ($11.52 \pm 0.23 \text{ mm}$), middle ($11.87 \pm 0.29 \text{ mm}$) and posterior third ($11.46 \pm 0.12 \text{ mm}$). Comparing the average width of medial menisci (12.55 mm) with that of lateral menisci (11.6 mm), a statically significant difference ($p < 0.05$) in the three points were found (figure 3).

Related to the thickness of outer circumference of meniscus (Table 2), posterior third ($5.90 \pm 0.12 \text{ mm}$) of medial meniscus was the thickest part followed by anterior third ($5.58 \pm 0.18 \text{ mm}$) and middle third ($5.28 \pm 0.12 \text{ mm}$). A statically significant difference was not observed ($p > 0.05$) among the anterior, middle and

posterior third of medial meniscus. However, in the lateral menisci, middle third was the thickest part ($p < 0.05$). The average thickness of the medial and lateral menisci were 5.58mm and 4.9mm respectively. Comparing the average thickness value of medial meniscus with the value of lateral meniscus it was observed that in anterior and posterior thirds, medial menisci was significantly more thick ($p < 0.05$) compared to lateral menisci (figure-4).

In the present study, the peripheral length (Table 3) of medial meniscus (10.38 ± 0.33 cm) was significantly more than the lateral meniscus (9.61 ± 0.2 cm). The range of outer circumference of medial menisci is from 9-10.5cm and for lateral menisci is 9.4-10.2cm. The shape of the menisci showed variations in shape from semilunar to circular. Discoid medial and lateral menisci were not observed in the present study (0%).

Table 1: Width of medial and lateral menisci (mm).

	Anterior third	Middle third	Posterior third
Medial menisci	8.88±0.19	12.09±0.22	16.68±0.60
Lateral menisci	11.52±0.23	11.87±0.29	11.46±0.12

Table 2: Thickness of medial and lateral menisci (mm).

	Anterior third	Middle third	Posterior third
Medial menisci	5.58±0.18	5.28±0.12	5.90±0.12
Lateral menisci	3.78±0.15	5.94±0.15	5.27±0.13

Table 3: Length of outer circumference of the menisci (cm).

	Medial menisci	Lateral menisci
Length of outer circumference	10.38±0.33	9.61±0.20

Fig. 3: average values of width of menisci.

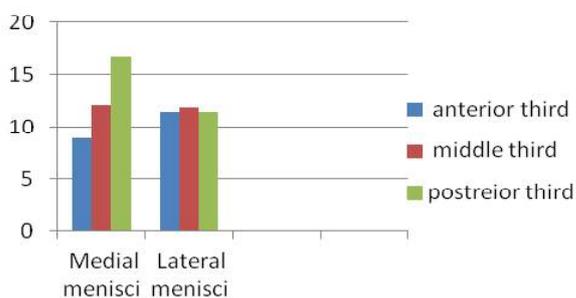
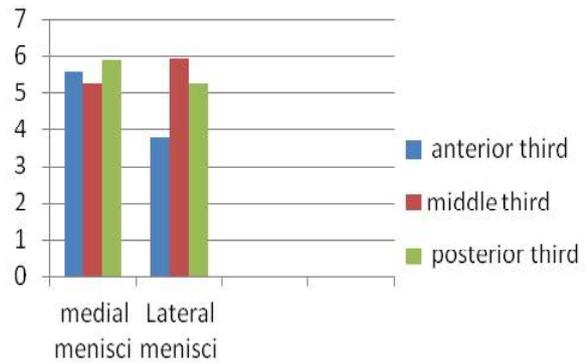


Fig. 4: average values of thickness of menisci.



DISCUSSION

The data related to the morphology of the menisci are scarce; therefore the main objective of this study was to analyse the morphometric variations present in the human meniscus, enriching the literature on this subject, and correlating these variations with the possibility, location and type of lesion as shown in the literature review.

In a study conducted by Almeida et al. (2004) [6], on 44 menisci of 22 adult knee, the individual analysis of each meniscus showed that the posterior 3rd was the widest part of medial meniscus ($p < 0.05$); while in the lateral meniscus, no statistically significant ($p < 0.05$) difference was observed among the three examined points. The average width for medial meniscus was 12.85mm and for lateral meniscus was 11.76mm. In our study we found the average width for medial meniscus and lateral meniscus were 12.55mm and 11.61mm respectively. This description is also in accordance with Moore and Dalley (2001) [2], who described that the medial meniscus is larger posteriorly than anteriorly. According to Smillie the lateral meniscus shows a width higher and more uniform than the medial meniscus. However, Testut & Latarjet and Didio [11], mention that it is common the medial meniscus be a little wider than the lateral meniscus. In another study conducted by Bras and Silva (2010) [10] on 40 menisci there was no significant difference in the width between the anterior (11.32 ± 1.46 mm), medium (11.16 ± 1.64 mm) and posterior third of lateral meniscus. However in the medial meniscus, the posterior third was the widest part (14.96 ± 2.66 mm) followed by the mid

(9.32 ± 2.24 mm) and anterior third (7.68 ± 1.36 mm). Comparing the width of medial and lateral menisci, a statistically significant difference ($p < 0.05$) in three points was found. Relating to the thickness which was also measured at the three points anterior, middle and posterior third, middle third of medial menisci was the thinnest (5.28 ± 0.12 mm) followed by posterior (5.90 ± 0.12 mm) and anterior (5.58 ± 0.18 mm) thirds showing an average value of 5.58mm. This is in correlation with the study conducted by Almeida et. al., [6] De Moraes, Tashimiro et al whose study also showed the middle third being the smallest. In a study on the location of meniscal ruptures, Rico and Ayala (1997) observed that the medial meniscus is more commonly affected and topographically lesions were frequent at the middle third (51%) followed by posterior third (39%) and the anterior third (10%). With regard to the lateral meniscus, it was noted that lesions of the middle third appear more frequently, either alone or associated with other locations. According to Smillie [5] the morphological differences of menisci, in particular, in the thickness and width can determine not only the possibility of an injury, but also the location and the kind of injury. This author also suggests that the narrow meniscus is less prone to ruptures than the wide. This is justified because the narrow meniscus is liable to a less action of femoral condyle. A higher evidence of this context is suggested by the rarity of injuries of the anterior third of medial meniscus as related by Alonso et al (1996) and Rico and Ayala (1997). Kohn and Moreno (1995) [3] reports that, if bony fixation of a meniscal substitute should be attempted, the entire circumferential length of the meniscus plus both the insertion ligaments must be known. In the present study, the peripheral length of the medial meniscus (10.38 ± 0.33 cm) was more than the lateral menisci (9.61 ± 0.20 cm).

A discoid lateral meniscus is a relatively uncommon developmental variant of the meniscus. It affects 4% to 5% of the patient population, with a much higher incidence, upto 13% in the Asian patient population. Cadaver studies have reported the prevalence of lateral discoid meniscus to be 0 and 7% whereas arthroscopic

studies have demonstrated ranges from 0.4% to 16.6%, but the racial differences do exist among the incidence rates [13-15]. Normal variants of the meniscus are relatively uncommon and are frequently asymptomatic, although there is greater propensity for discoid menisci to tear. In the meniscus allograft transplantation, it has been stated that providing a meniscal allograft that matches the size and shape of the meniscus to the recipient's knee is the responsibility of the tissue bank providing the graft. In both anatomical and orthopedic literature, attention to the form of the menisci of the knee joint has been directed for the most part to the occurrence of a discoid type of lateral meniscus [16].

CONCLUSION

There are marked differences between the contour and insertion of the medial and lateral menisci that are important concerning the mechanism of injury. Thus based on general anatomy, the thickness of the outer circumference, width and the peripheral length of the menisci of knee joint were topics that guided this study. The morphometric findings of the meniscus demonstrate accordance with studies regarding the location of meniscal injuries. The anterior third of the medial meniscus presented smaller width, which explains the lower incidence of injuries at this point of the meniscus due to the weaker action of the femoral condyles. Similarly, measures of the middle third confirmed that it is the point of greatest tension, and also that it is the most frequently injured region in both menisci. Normal variants of the meniscus are relatively uncommon and are frequently asymptomatic, although there is greater propensity for discoid menisci to tear. However recognizing these variants is important, as they can be misinterpreted for more significant pathology on MRI. Therefore, health professionals who work with the treatment of meniscal injuries should be aware of the possible anatomical variations that may exist in the meniscus facilitating the rehabilitation process.

Conflicts of Interests: None

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