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Original Article

A cadaveric study of tibial meniscal dimensions and its clinical implication

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ABSTRACT

Introduction: The knee-joint consists of three articulations in one joint. There are two condyloid joints between condyles of femur and tibia, and third joint is between patella and femur. It is a complex joint because the articular surfaces of the femoral and tibial condyles are not congruent to each other. The tibial menisci play important role in articulation by providing congruent articulating surfaces to tibia and femur.

There is very few data related to the morphometric parameters of tibial menisci. Aim of this study was to measure and analyse the dimensions of tibial meniscus in cadavers.

Methods: In the present study, different parameters of tibial meniscus were measured after exposure of knee joint. These measurements were done with the help of digital Vernier calliper.

Results and discussion: Mean length, width and circumference of medial meniscus were 42.28 ± 3.71 mm, 31.67 ± 3.40 mm and 101.46 ± 6.89 mm respectively. Mean widths of anterior horn, body and posterior horn of medial meniscus were 6.48 ± 1.21 mm, 8.37 ± 1.54 mm, 14.34 ± 2.59 mm respectively. Mean thicknesses of anterior horn, body and posterior horn of medial meniscus were 4.81 ± 1.34 mm, 5.80 ± 1.25 mm and 5.28 ± 1.22 mm respectively. Mean length, width and circumference of lateral meniscus were 32.73 ± 3.08 mm, 33.22 ± 3.37 mm and 97.61± 7.32 mm respectively. Mean widths of anterior, body and posterior parts of lateral meniscus were 8.57 ± 1.6 mm, 9.79 ± 1.71 mm, 9.21 ± 1.28 mm. Mean thicknesses of anterior horn, body and posterior horn of lateral meniscus were 3.03 ± 0.94 mm, 6.53 ± 1.07 mm and 4.76 ± 1.00 mm respectively.

Discussion: These dimensions of the menisci might be the major factors that determine the location and the kind of injury to menisci.

1. Introduction

Knee joint consists of three articulations in one joint, firstly two condyloid joints between condyles of femur and corresponding condyles of tibia and secondly a joint between the patella and the femur. The knee-joint is much complicated joint as compared to other condyloid joint in the body. Owing to the incongruency of the articular surfaces of femur and the tibia, this joint does not carry out the simple gliding movement.[1] The semilunar cartilages known as tibial menisci are extensions of tibial articulation of knee. Menisci help in tibial articulation with the femur by providing the congruent articular surfaces.[2]

Meniscal injuries are common in young athletically active persons aged <25 years. They are common in players involved in sports that involve frequent pivoting, such as soccer, American football and racket sports like badminton.[3] Meniscal injury was the most common lesion in knee injuries, in these types of sports as diagnosed by arthroscopy.[4]

Osteoarthritis of knee is degenerative joint disease, which results from tibio-femoral cartilage loss. The cartilage loss may be due to many factors that are related to menisci, namely damage to the menisci, extrusion of the menisci from its normal anatomical position, malalignment of the menisci, and laxity of the meniscus etc.[5] Thus integrity and the proper functioning of tibial meniscus are very important for the normal working of the knee joint.[6]

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Meniscal repair is recommended when technically and anatomically feasible to preserve meniscal function.[7] Allograft or synthetic meniscal implant has been suggested as means to restore contact pressure following meniscectomy.

Many differences have been found in the shapes, dimensions and the insertion points between the medial and the lateral menisci, in previous studies. Study of dimensions of the menisci is very important, as it will help in understanding the various injury mechanisms causing the damage to the menisci. Hence this study was conducted to throw light on the morphometric parameters of the tibial menisci of knee joint. Objectives of present study were to measure the dimensions of both the medial, lateral menisci as well as to analyse the results and make clinical inferences.

2. Materials and methods

The present study entitled "A cadaveric study of tibial meniscal dimensions and its clinical implication" was carried out at Anatomy Department of T.N. Medical College, Mumbai. The permission of the Head of Department of Anatomy was taken prior to beginning of the study. Consent was not required being a cadaveric study.

We studied 50 specimens of adult Indian cadaveric knee joints.

Skeletally mature normal human cadaveric knees of either sex were included in study. Cadaveric knees with evidence of meniscal tear, knees with evidence of any previous surgery were excluded from the study.

In this study, different parameters of tibial menisci were measured after exposure of knee joint. The present study required the adult human knee joints which were made available in the dissection hall of Anatomy Department. We included 50 intact tibial menisci of 50 knee joints in the study, out of which, 25 were from the right side and the rest 25 were from the left side of human cadavers. Skin and muscles around the knee joints were dissected. Ligamentum patellae and collateral ligaments were cut transversely. After giving the vertical incisions on the either sides of joint capsule, the knee Joint was opened anteriorly. The intra-articular ligaments and the joint capsule were removed. Condyles were properly dissected by removing the surrounding soft tissues and muscles. All dissections were performed systematically and the data was recorded on a standardised data recording sheet.

The measurements of different parameters were done with the help of digital Vernier calliper and a measuring scale. Different parameters of menisci were measured using the following method:

(1) The medial meniscal length (MML) and the lateral meniscal length (LML) were measured from the antero-posterior parts of the respective meniscus as shown in Fig. 1.
(2) The distances between the antero-posterior horns of medial and lateral meniscus (MdAP&LdAP) were measured between the apices of the antero-posterior parts of the respective menisci.
(3) The medial meniscal width (MMW) and the lateral meniscal width (LMW) were measured from the attachment of the posterior horn on tibia to the outer most edge of the respective meniscus as shown in Fig. 1.
(4) Medial meniscal and lateral meniscal circumference (MMC&LMC) were measured with the help of a non-elastic cotton thread as shown in Fig. 2. The thread was placed against the outer margin of the meniscus and it was fixed to the ends of the menisci with the help of metallic pins. The length of thread between the pins was measured with the help of a measuring scale. This length is the outer circumference of the meniscus. When the thread is placed against the inner border of the meniscus, the length so found is the inner circumference of respective meniscus.
(5) When this outer and inner circumference of the meniscus so calculated is divided into three equal parts and the respective division points joined, the meniscus can be divided into three equal parts, i.e. anterior, body (middle) and posterior parts as shown in Fig. 2.
(6) Width of the three parts of the medial and lateral meniscus (MAW, MBW, MPW & LAW, LBW, LPW) was measured along the mid points of three parts of the respective meniscus as shown in Fig. 2, i.e. from the outer edge to inner edge.
(7) Similarly the thickness of the three parts of the medial and lateral meniscus (MAT, MBT, MPT&LAT, LBT, LPT) was taken along the mid points of the three parts of respective meniscus. Only the outer margin was considered while measuring the thickness using a digital Vernier calliper.

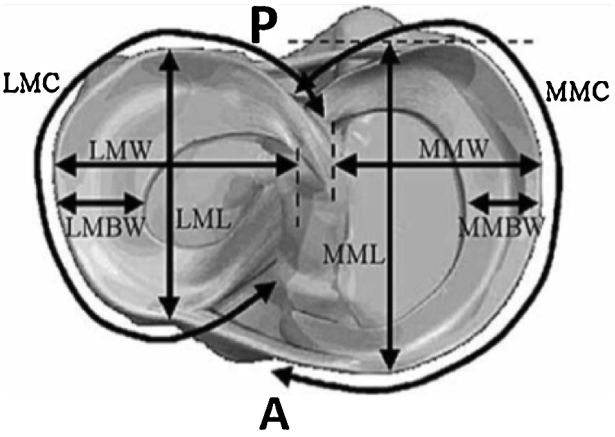

Fig. 1. Showing measurement of meniscal dimensions.[8]

The data were tabulated and analysed for various parameters described subsequently. Mean, standard deviation and standard error of mean was calculated for each parameter. Unpaired *t*-test and One Way ANOVA test were used to compare the data of various parameters. Statistical analysis was done using spss-15 and Microsoft excel software (Fig. 3).

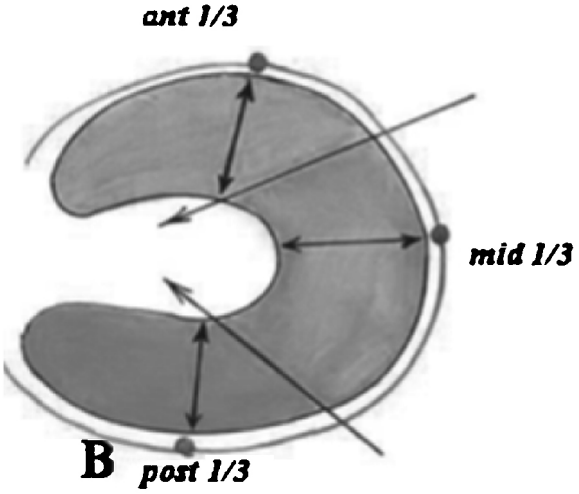

Fig. 2. Showing the measurement of circumference and width of anterior, middle and posterior parts of meniscus.[9]

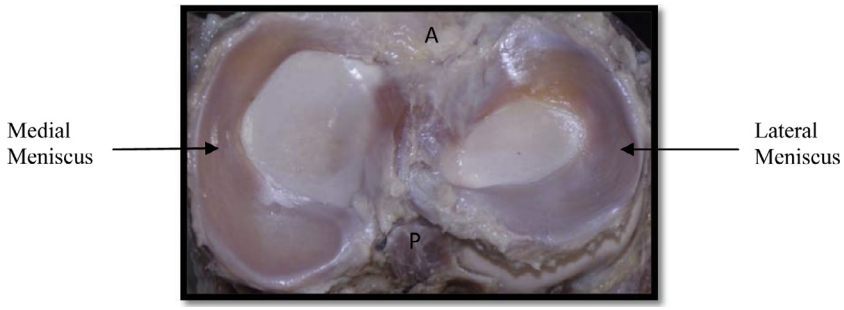

Fig. 3. Diagram showing normal alignment and position of meniscus in the knee joint.

3. Results

Mean and standard deviation of length, width and circumference of both (medial and lateral) the menisci are displayed in Table 1. Width and thickness of three parts of medial and lateral menisci in the form of respective mean and standard deviation are presented in Table 2.

It was found that there is difference between the mean values of medial and lateral meniscal length at 5% level of significance with p value of <0.001,using unpaired t-test. Similarly, observations were made for the difference of width amongst the medial and lateral meniscal width at 5% level of significance with p value of 0.024 (Table 3).

In the same way, it has been observed that circumference of the medial meniscus was greater than that of the lateral meniscus at 5% level of significance with p value of 0.008. Similarly, mean values of distance between anterior and posterior horn show greater distance in medial meniscus as compared to the lateral meniscus at 5% level of significance with p value of <0.001 (Table 3). These findings were made using unpaired t-test.

While performing comparison between three (anterior, body and posterior) parts of medial and lateral menisci for the mean values of width, significant difference was found at 5% level of significance with p value of <0.001 for each of the pair (Table 4). Similarly, there was significant difference between the mean values of thickness of anterior, body and posterior parts of medial and lateral menisci at 5% level of significance with p values of <0.001 for anterior part, 0.002 for middle part and 0.02 for posterior part (Table 4).

Unpaired t-test was used for abovementioned comparisons.

Comparison for width and thickness among three parts (anterior, middle and posterior) of medial meniscus was performed using One Way ANOVA test. It was found significant with p value of 0.001 for both width and thickness. The medial meniscus had maximum width in the posterior part and minimum width in the anterior part, whereas the middle (body) part had the maximum thickness followed by posterior part and the anterior part (Table 5).

Width and thickness among three parts of lateral meniscus were compared using One Way ANOVA test and found to be significant with p value of 0.001 for width and <0.001 for thickness. The lateral meniscus had maximum width in the body part and the minimum width in the anterior part, whereas the

Table 1
Showing medial and lateral meniscal dimensions.

Medial meniscal dimensions				Lateral meniscal dimensions			
Variable	*N*	Mean (mm)	Std. Dev. (mm)	Variable	*N*	Mean (mm)	Std. Dev. (mm)
MML	50	42.28	3.71	LML	50	32.73	3.08
MMW	50	31.67	3.40	LMW	50	33.22	3.37
MMC	50	101.46	6.89	LMC	50	97.61	7.32

Table 2
Showing the width and thickness of three parts of medial and lateral meniscus.

Width and thickness of three parts of medial menisci				Width and thickness of three parts of lateral menisci			
Variable	*N*	Mean (mm)	SD (mm)	Variable	*N*	Mean (mm)	SD (mm)
MAW	50	6.48	1.21	LAW	50	8.57	1.61
MBW	50	8.37	1.54	LBW	50	9.79	1.71
MPW	50	14.34	2.59	LPW	50	9.20	1.28
MAT	50	4.81	1.34	LAT	50	3.03	0.93
MBT	50	5.80	1.25	LBT	50	6.52	1.05
MPT	50	5.28	1.22	LPT	50	4.75	1.00
MdAP[a]	50	30.15	2.19	LdAP[a]	50	12.79	2.21

[a] Distance between anterior and posterior horn.

Table 3
Showing comparison between medial and lateral meniscal variables using unpaired t test.

Variable	Medial meniscus (N=50)		Lateral meniscus (N=50)		p value	Significance
	Mean (mm)	SD (mm)	Mean (mm)	SD (mm)		
Length	42.28	3.71	32.73	3.09	<0.001	Highly significant
Width	31.67	3.40	33.22	3.38	0.024	Significant
Circumference	101.46	6.88	97.61	7.32	0.008	Significant
Distance between A-P horn	30.15	2.19	12.79	2.21	<0.001	Highly significant

Table 4
Comparison between the respective three parts (anterior, body and posterior) of medial and lateral meniscus using unpaired *t* test.

Width and thickness	Medial meniscus		Lateral meniscus		*p* value	Significance
	Mean (mm)	SD (mm)	Mean (mm)	SD (mm)		
Anterior width	6.48	1.21	8.57	1.61	<0.001	Highly significant
Body width	8.37	1.54	9.79	1.71	<0.001	Highly significant
Posterior width	14.34	2.59	9.20	1.28	<0.001	Highly significant
Anterior thickness	4.81	1.34	3.03	0.93	<0.001	Highly significant
Body thickness	5.80	1.25	6.52	1.05	0.002	Significant
Posterior thickness	5.28	1.22	4.75	1.00	0.02	Significant

Table 5
Comparison among the three parts of width of medial meniscus and thickness of medial meniscus using One Way ANOVA test.

Width of medial meniscus	Mean (mm)	SD (mm)	Significance *p* value	Thickness of medial meniscus	Mean (mm)	SD (mm)	Significance *p* value
Anterior	6.48	1.21	0.001	Anterior	4.81	1.34	0.001
Body	8.37	1.54		Body	5.80	1.25	
Posterior	14.34	2.59		Posterior	5.28	1.22	

Table 6
Comparison among the three parts of width of the lateral meniscus and thickness of lateral meniscus using One Way ANOVA test.

Width of lateral meniscus	Mean (mm)	SD (mm)	Significance	Thickness of lateral meniscus	Mean (mm)	SD (mm)	Significance
Anterior	8.57	1.61	0.001	Anterior	3.03	0.93	<0.001
Body	9.79	1.71		Body	6.52	1.05	
Posterior	9.20	1.28		Posterior	4.75	1.00	

maximum thickness was present in the body part of the lateral meniscus, followed by posterior part and anterior part (Table 6).

4. Discussion

A basic knowledge of meniscal anatomy and physiology is essential for better understanding of meniscal pathology and treatment. The current study provides an anatomical comprehension of meniscal dimensions. In present study, we measured meniscal length, circumference, width and thickness of various parts of both the menisci and performed comparisons. These parameters have also been studied in previous studies using various modes in different ethnic groups.

McDermott et al.[8] (cadaveric study) studied dimensions of 44 cadaveric menisci attached intact on tibial plateaus and found average length (MML), width (MMW), and circumference (MMC) of medial meniscus as 45.7 ± 5 mm, 27.4 ± 2.5 mm and 99.0 ± 9.3 mm respectively. Average length (LML), width (LMW) and circumference (LMC) of lateral meniscus were 35.7 ± 3.7 mm, 29.3 ± 3.0 mm and 91.7 ± 9.6 mm respectively.

Murlimanju et al.[9] measured circumferences of menisci in 23 cadaveric knee joints. Mean Medial meniscal circumference was found to be 99.06 ± 11.21 mm and lateral meniscal circumference was 90.25 ± 9.36 mm.

This difference in the findings between the studies mentioned above and current study can be explained by demographic variations.

Erbagci et al.[10] studied dimensions of the normal menisci of 348 knee joints for width and thickness in 174 healthy subjects by using MRI and found that Posterior part (11.71 mm) of the medial meniscus was wider as compared to anterior (7.78 mm) and body part (7.37 mm). MAT, MBT and MPT were found to be 5.32 mm, 5.03 mm and 5.53 mm respectively. Posterior part was thicker compared to anterior and body part.

Erbagci et al.[10] found LAW, LBW and LPW to be 8.88 mm, 8.37 mm and 9.70 mm respectively. Posterior part was wider than anterior and middle parts of lateral meniscus. Thickness of posterior part of lateral meniscus (5.36 mm) was more than anterior (4.33 mm) and middle part (4.94 mm).

This difference in the finding between present study and study done by Erbagci et al.[10] can be attributed to different mode of study.

In the study done by Almeida et al.[11] on 22 knees of adult cadavers, comparison between the widths of three part of medial meniscus namely the anterior, body and the posterior parts, showed significant difference with *p* value of <0.05. It was found that the width of the posterior part (17.37 ± 2.22 mm) of the medial meniscus was the largest followed by middle part (12.16 ± 2.58 mm) and then the anterior part (9.02 ± 1.59 mm) of the medial meniscus. Comparison of thickness of medial meniscus between anterior (5.92 ± 1.37 mm), body (5.31 ± 1.06 mm) and posterior part (5.91 ± 1.13 mm) showed no significant difference with *p* value of <0.05. On the comparison of thickness of three parts of lateral meniscus, middle part (6.10 ± 1.04) showed larger thickness than anterior (3.71 ± 1.15) and posterior part (5.29 ± 0.78 mm) and it was found significant with *p* value of <0.05. There was no meaningful difference between widths of the three parts of lateral meniscus with *p* value of <0.05.

It was also observed that the mean values of width of medial meniscus in present study are in accordance with the studies performed by Erbagci et al.[10] and Almeida et al.[11] These findings of the width of medial meniscus are also in accordance with Moore and Dalley as stated in study of Braz and Silva[12] who described that the medial meniscus has a narrow anterior horn and wider posterior horn. This narrow anterior part has less chance to get ruptured than the other parts of medial meniscus because the narrow meniscus is subjected to a lesser degree of frictional forces of femoral condyle and other destructive forces acting on the menisci. This can be a reason for the observation that injuries of the anterior third of medial menisci are relatively rare.

It was observed in the present study that thicknesses of medial meniscus were more in the anterior and posterior parts than the thicknesses of lateral meniscus in those respective parts. Middle part of medial meniscus was thinner than middle part of lateral meniscus.

A significant observation made in the study was that middle third (body) part of both medial and lateral meniscus was the thickest part compared to the other two parts, namely the anterior and the posterior parts of both the menisci. The menisci have two fixed ends, the horns, while the middle part is mobile, thus making it more prone to stress and strain due to its mobility. This can be the reason why the middle thirds of both the menisci presented the highest incidence of injury. Similarly, as described by Braz and Silva[12] in their morphometric study on human menisci, it is the most frequently injured region in both the menisci.

It is observed in the present study that thickness of the middle third of the lateral meniscus was significantly greater than that of middle third part of the medial meniscus. It complies with the study of Almeida et al.[11]This gives us a reason to explain the higher incidence of injuries in the medial meniscus as compared to that of lateral meniscus.

Study done by Murlimanju et al.[9] on 23 samples of knees showed mean circumference of lateral and medial meniscus to be 90.25 ± 9.36 mm and 99.06 ± 11.21 mm respectively which was significant at 5% level of significance with p value of <0.05. Hence, present study is in accordance with the study conducted by Murlimanju et al.[9] in case of circumference and distance between anterior and posterior horns.

Study done by Murlimanju et al.[9] on 23 samples of knees showed significant difference in mean values of distance between anterior and posterior horn of medial meniscus and that of the lateral meniscus to be 24.13 ± 4.19 mm and 11.31 ± 3.86 mm respectively at 5% level of significance with p value of <0.05.

Study done by Almeida et al.[11] found significant difference, on comparing the distance between anterior horn and the posterior horn of medial meniscus (29.70 ± 4.12 mm) with that of lateral meniscus (12.71 ± 1.84 mm). It was greater in medial meniscus at 5% level of significance with p value of <0.05.

5. Conclusion

Thus, the morphological differences of dimensions of the menisci that are considered in the present study, in particular, the width and the thickness could be one of the major factors for the location and the kind of injury that occur in menisci.[11] The antero-posterior distance between horns of lateral meniscus is smaller than that of the medial meniscus. The insertions of both the horns of lateral meniscus are very close to each other. Close proximity of attachment of both the horns of lateral meniscus gives the appearance of a ring.[11] According to Kapandji, as stated in the study of Murlimanju et al.,[13] this might be the explanation for the observation that the lateral meniscus is less prone to damages caused by injuries.

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Conflicts of interest

The authors have none to declare.

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