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RESEARCH ARTICLE
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ANTHROPOMETRY OF MENISCI OF KNEE JOINT IN ADULT HUMAN CADAVER IN NORTH INDIAN POPULATION (A RATIONALE FOR CLINICAL IMPLICATIONS)

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Introduction:

The knee joint is the largest and most complex joint in human body.

The menisci of the knee lie within the knee joint between the femur and tibia and Each meniscus is a piece of fibrocartilage with a thickened outside edge and a thin inner edge so that it is wedge-shaped in cross section.[5]

The menisci (semilunar cartilages) are fibrocartilaginous laminae that are crescentic and intracapsular. They broaden and deepen the articular surfaces of the tibia that accept the femoral condyles for making knee joint.[3]

The knee joint menisci form a crucial functional unit that enhances joint congruence and helps in transmission of weight, reducing stress on the knee and preventing osteoarthritis.[2]

Meniscus has a dense extracellular matrix composed of water, collagen, Proteoglycans, noncollagenous proteins and glycoproteins. The cells of menisci are referred to as fibro chondrocytes because their appearance.[1]

The menisci are considered important components for articulation performing mechanical functions, such as supporting the weight, shock absorption, stabilization and rotational facilitation. There are marked differences in the contour and attachment between the lateral and the medial menisci which are important in relation to the injury mechanisms. Variations in morphometry particular of thickness and width of menisci can determine the possibility and the kind of injury.[4]

The anatomical abnormalities and variations of intra articular structures of the knee joint have recently become significant because of new techniques such as arthroscopy, computed tomography and magnetic resonance imaging. Removal of meniscus after trauma is the most commonly performed procedure in the knee and often leads to degenerative arthritis.[5]

Many studies show that meniscectomy leads to progressive degenerative osteoarthritis. Thus, utilizing meniscus allograft proves beneficial in reducing the likelihood of future arthritis.[10] Transplantation of a banked meniscus allograft is among the treatment options for young patients with knee pain after meniscectomy.[8]

Morphometric analysis of menisci is of great help for Orthopedic surgeons in determining the appropriate size and shape of meniscal transplant.[2]

Accurate matching of the size of meniscus allograft to the native meniscus affects the outcome to the same extent as the surgical technique.[8]

The proposed study envisages to carry out the morphometric assessment of human knee menisci and to compare the variation on medial and lateral menisci bilaterally.

Material and Methods:

The study was conducted in the Department of Anatomy, ESIC Medical College and Hospital, Faridabad, Haryana.

120 menisci of Adult Human Cadaver (60 Medial Meniscus (Bilateral -Right & Left), 60 Lateral Meniscus (Bilateral) were dissected.

1. Outer Circumference of Medial Meniscus and Lateral Meniscus in Right and Left knee was measured (OC).
2. Inner Circumference of bilaterally knee menisci was measured (IC).
3. Width of Medial and Lateral Menisci at Anterior 1/3rd(A/3), Middle 1/3rd(M/3) and Posterior 1/3rd(P/3) portion of Meniscus was measured in Right and Left knee
4. Thickness at the point of maximum thickness in both menisci in bilateral knees was observed

Fig:1

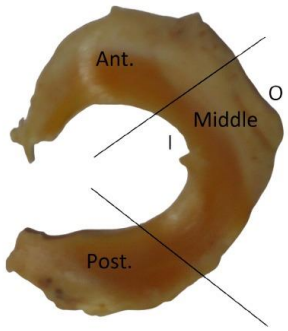


Fig: 2

The morphometric parameters were compared in medial and lateral menisci and bilateral parameters of right and left knee of one adult cadaver

Well Intact menisci were included for study whereas Broken menisci and degenerated menisci were not considered for study.

The circumference/length/distances were measured by using Non elastic cotton thread.

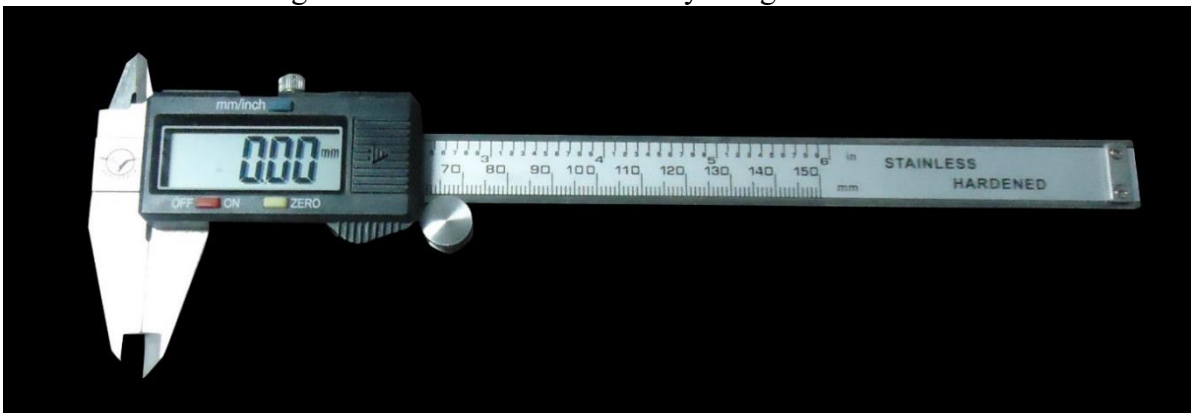


Fig:3

The width and thickness of menisci was measured by Digital Vernier Caliper (sensitive to 0.1mm).

Results:

From the results obtained, it was observed that there was statistically significant difference in the length of the outer circumference (P<0.0001) between medial meniscus (3.97 ± 0.58) and lateral meniscus (3.30 ± 0.29). The mean length of outer circumference of medial meniscus (3.97 ± 0.58) is more as compared to the lateral meniscus (3.30± 0.29) in right knee.

The mean length of inner circumference of medial menisci (2.48 ± 0.28) is also greater than the lateral menisci (2.39 ± 0.17) in right knee (Table 1)

Table:1 Comparison of Right Knee Measurements Between MM and LM Groups Using Independent Samples t-Test

	Group	Mean ± SD	t-value	p-value
OC	MM	3.97 ± 0.58	5.39	**< 0.0001***
	LM	3.30 ± 0.29		
IC	MM	2.48 ± 0.28	1.59	0.118
	LM	2.39 ± 0.17		

***P-value significant at 0.05 levels**

Graph:1- Comparison of Right Knee Measurements Between MM and LM Groups

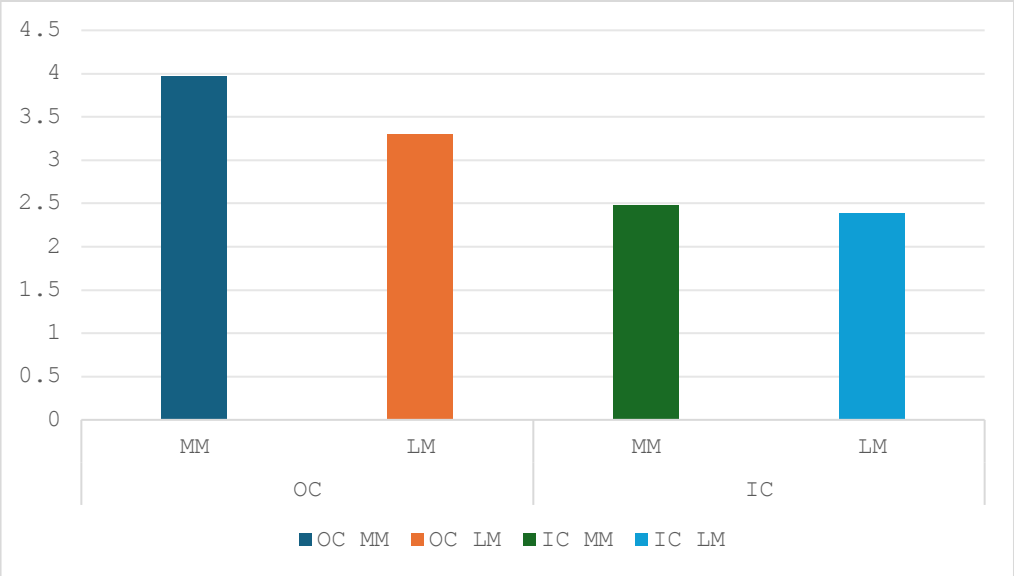
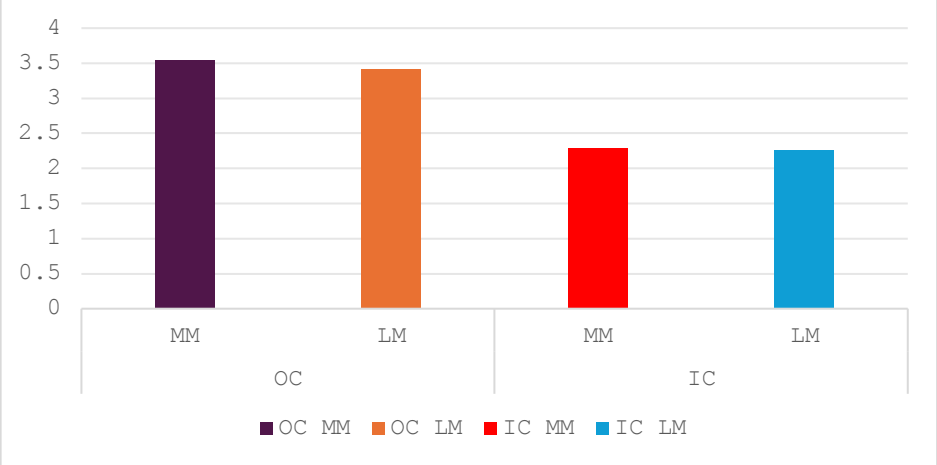


Table 2: Comparison of Left Knee Measurements Between MM and LM Groups Using Independent Samples t-Test

Parameter	Group	Mean ± SD	t-value	p-value
OC	MM	3.55 ± 0.13	5.64	**< 0.0001***
	LM	3.42 ± 0.10		
IC	MM	2.29 ± 0.13	2.86	**0.006***
	LM	2.26 ± 0.11		

***P-value significant at 0.05 levels**

Graph:2- Comparison of Left Knee Measurements Between MM and LM Groups



From the results obtained, it was observed that there was statistically significant difference in the length of the outer circumference (P<0.0001) between medial meniscus (3.55 ± 0.13) and lateral meniscus (3.42 ± 0.10) as well as length of inner circumference (P<0.006) between medial meniscus (2.29 ± 0.13) and lateral meniscus (2.26 ± 0.11).

Table 2 depicts the mean length of outer circumference of medial meniscus (3.55 ± 0.13) is more as compared to the lateral meniscus (3.42 ± 0.10) in left knee.

The mean length of inner circumference of medial menisci (2.29 ± 0.13) is also greater than the lateral menisci (2.26 ± 0.11) in left knee.

Table:3 Comparison of Left Knee Measurements Between MM and LM Groups

Factor	Group	Mean ± SD	t-value	p-value
A/3	MM	0.13 ± 0.05	-1.85	0.0690
	LM	0.16 ± 0.06		
M/3	MM	0.23 ± 0.06	-1.24	0.2204
	LM	0.25 ± 0.08		
P/3	MM	0.40 ± 0.09	5.60	**< 0.0001***
	LM	0.28 ± 0.08		
Thickness	MM	0.45 ± 0.08	9.40	**< 0.0001***
	LM	0.27 ± 0.06		

***p-value significant at 0.05 level**

Table 3 highlights the width and thickness of medial and lateral menisci in Left knee, the width means of Anterior 1/3rd and Middle 1/3rd was found more in lateral meniscus (0.16 ± 0.06 & 0.25 ± 0.08) as compared to medial menisci (0.13 ± 0.05 & 0.23 ± 0.06), whereas there was statistically significant (p<0.0001) difference in width of posterior 1/3rd between medial menisci (0.40 ± 0.09) as compared to lateral menisci (0.28 ± 0.08).

The thickness measured (0.45 ± 0.08) in medial menisci and (0.27 ± 0.06) in lateral menisci was found statistically significant (p<0.0001).

Graph:3- Comparison of Left Knee Measurements Between MM and LM Groups

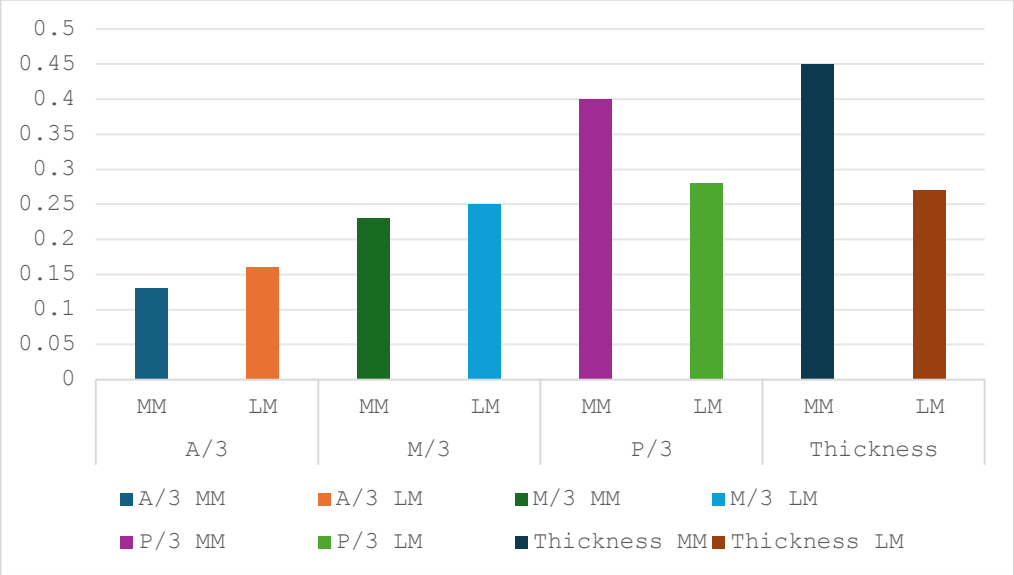


Table:4 Comparison of Right Knee Measurements Between MM and LM Groups

Factor	Group	Mean ± SD	t-value	p-value
A/3	MM	0.14 ± 0.07	-0.02	0.985
	LM	0.14 ± 0.07		
M/3	MM	0.24 ± 0.11	1.87	0.067
	LM	0.19 ± 0.09		
P/3	MM	0.49 ± 0.16	4.40	**0.01***
	LM	0.32 ± 0.12		
Thickness	MM	0.47 ± 0.20	2.66	**0.01***
	LM	0.34 ± 0.17		

***p-value significant at 0.05 level**

Table 4 showing width and thickness of medial and lateral menisci in Right knee, The width mean of Middle 1/3rd and posterior 1/3rd was found more in medial meniscus (0.24 ± 0.11& 0.49 ± 0.16) as compared to lateral menisci (0.19 ± 0.09 & 0.32 ± 0.12), whereas the width of anterior 1/3rd was found equal in medial menisci (0.14 ± 0.07) as compared to lateral menisci (0.14 ± 0.07).
The difference in posterior 1/3rd width in medial and lateral menisci was found statistically significant ($p<0.001$)
The thickness was measured (0.47 ± 0.20) in medial menisci and (0.34 ± 0.17) in lateral menisci which is more in medial menisci.

Graph:4 Comparison of Right Knee Measurements Between MM and LM Groups

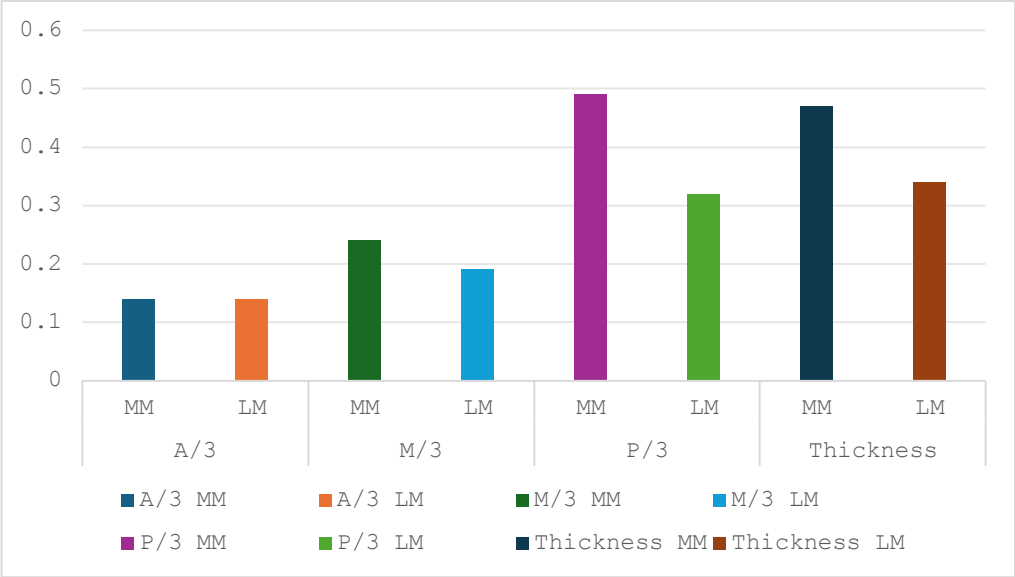


Table 5: Comparative Morphometric Evaluation of Medial Menisci Between Left and Right Knees

Measurement	Left Mean ± SD	Right Mean ± SD	p-value
Outer Circumference	3.56 ± 0.18	4.09 ± 0.30	**<0.001****
Inner Circumference	2.26 ± 0.14	2.61 ± 0.07	**0.003****
Width A/3	0.13 ± 0.07	0.17 ± 0.08	**0.04***
Width M/3	0.20 ± 0.07	0.25 ± 0.11	**0.02***
Width P/3	0.41 ± 0.09	0.62 ± 0.06	**<0.001****
Thickness T/End	0.48 ± 0.06	0.59 ± 0.13	**0.008****

***p-value significant at 0.05 levels, Test applied: Paired t-tests**

Table 5 depicts the comparison of morphometric evaluation of medial meniscus in right and left knee was found statistically significant and the mean values were found higher in right knee as compared to left knee.

The mean value of outer circumference of medial meniscus 4.09 ± 0.30 in right knee and 3.56 ± 0.18 in left knee was found statistically significant $p<0.001$.

The mean value of inner circumference of medial meniscus 2.61 ± 0.07 in right knee and 2.26 ± 0.14 in left knee was found statistically significant $p=0.003$.

The mean value of width at A1/3rd, M1/3rd and P1/3rd of medial meniscus was 0.17 ± 0.08, 0.25 ± 0.11 and 0.62 ± 0.06 in right knee and 0.13 ± 0.07, 0.20 ± 0.07 and 0.41 ± 0.09 in left knee respectively. The measurement was found statistically significant with p value 0.04, 0.02 and <0.001 respectively.

The morphometric comparison of mean of thickness in medial meniscus was 0.59 ± 0.13 in right knee and 0.48 ± 0.06 in left knee which was statistically significant with p value 0.008.

Table 6: Comparative Morphometric Evaluation of Lateral Menisci Between Left and Right Knees

Measurement	Left Mean ± SD	Right Mean ± SD	p-value
Outer Circumference	3.41 ± 0.09	3.06 ± 0.08	**0.013***
Inner Circumference	2.35 ± 0.11	2.55 ± 0.08	**0.03***
Width A/3	0.18 ± 0.05	0.15 ± 0.07	0.12
Width M/3	0.26 ± 0.05	0.20 ± 0.09	**0.04***

Width P/3	0.28 ± 0.08	0.33 ± 0.10	0.08
Thickness T/End	0.29 ± 0.05	0.39 ± 0.19	**0.03***

***p-value significant at 0.05 levels, Test applied: Paired t-tests**

The morphometric measurements of few parameters of lateral menisci were found statistically significant when compared in left and right sided knee

The mean value of outer circumference of lateral meniscus was 3.06 ± 0.08 in right knee and 3.41 ± 0.09 in left knee was found statistically significant p=0.013.

The mean value of inner circumference of lateral meniscus was 2.55 ± 0.08 in right knee and 2.35 ± 0.11 in left knee was found statistically significant p=0.03.

The mean value of width at A1/3rd, M1/3rd and P1/3rd of lateral meniscus was 0.15 ± 0.07, 0.20 ± 0.09 and 0.33 ± 0.10 in right knee and 0.18 ± 0.05, 0.26 ± 0.05 and 0.28 ± 0.08 in left knee respectively. The measurement was found statistically significant with p value 0.04 in width at M1/3rd in lateral meniscus when compared in right and left knee.

The morphometric comparison of mean of thickness in lateral meniscus was 0.39 ± 0.19 in right knee and 0.29 ± 0.05 in left knee which was statistically significant with p value 0.03.

DISCUSSION

Menisci of knee joint plays a vital role in stability of knee joint, movements, weight transmission and shock absorption. 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[16]

As menisci are more prone to injury, the morphometric details of menisci play an essential role in the meniscal graft fir treatment of meniscal injuries.

The present study was conducted to evaluate the morphometric measurements of
Medial and lateral menisci bilaterally to provide baseline data.

Researchers used various modalities for finding the different parameters.

Parameters discussed are:

Thickness of both menisci at maximum thickness.

Width of both menisci with regard to anterior third, middle third and posterior third.

Length of outer circumference and inner circumference of both menisci.

Researchers used following instruments and methods for morphometric analysis: Digital Vernier caliper, conventional methods using non- elastic cotton thread, silk thread.

The current study also attempted to explore any difference of data between the two sides (right and left). It is expected that the observations of present study will contribute as an anatomical reference for researchers and clinicians.

The present study shows that all parameters values (Outer circumference, Inner circumference, Width A1/3rd, M1/3rd, P1/3rd, thickness) are higher in medial meniscus bilaterally.

The mean value was found statistically significant in posterior 1/3rd width and thickness in medial meniscus bilaterally with P value of <0.0001 on left side and 0.01 on right side knee menisci.

The data pertaining to each parameter was compared to the findings of previous researchers. In many aspects, the observations of the present study correspond reasonably well with the data of earlier studies. However, the discrepancies could possibly be due to racial dissimilarities and regional variations.

Table 7: Length of outer circumference of menisci

Author	**Year**	**No. of Knee Joint**	**Method**	**Medial meniscus**	**Lateral meniscus**
Rao et al.[11]	2014	100	Non-elastic cotton thread /Vernier caliper	86.4 ± 0.27 mm	87.3 ± 0.65 mm

Rohila et al.[5]	2016	100	Non-elastic cotton thread /Digital Vernier caliper	10.50 ± 0.65 cm	10.15 ± 0.72 cm
Kaur et al.[12]	2013	100	Silk thread	91.85 ± 5.6 mm	92.80 ± 7.52 mm
Hathila et al.[7]	2018	30	Digital Vernier Caliper & analyzed with MS Excel	10.28 cm ± 0.77 Cm	9.64 ± 0.33 mm
Present Study	**2025**	**60 (30 Left)**	**Non Elastic Thread/ Digital Vernieallipe**r	**35.5 ± 0.13**	**34.2 ± 0.10**
		(30 Right)		**39.7 ± 0.58**	**33.0 ± 0.29**

Table 7 depicts the comparison of outer circumference of medial and lateral menisci in studies conducted by various authors. In present study, length of outer circumference of medial meniscus was found more bilaterally as compared to the lateral meniscus.

It is evident that the dimensions are found at appreciable variance in earlier studies by Rao et al[11] and Kaur et al[12] whereas the results were found similar in study conducted by Hathila et al[7] and Rohilla et al[5].

In a study conducted by Shiva Sakti M et al[1], they found almost equal outer circumference and inner circumference of medial and lateral meniscus

The present study is unique study in comparison of parameters of knee menisci in left and right sided knee.

In present study we established that the distance between the anterior and posterior cornua of lateral meniscus is less than the medial meniscus, giving an aspect in which the lateral meniscus shows the form of a ring almost complete.

This high proximity between the insertions of its cornua, would be one of the reasons for the lateral meniscus be less prone to lacerations[17,18].

Table 8: Width of medial meniscus

Author	**Year**	**No. of Knee Joint**	**Method**	**Medial meniscus**		
				Anterior (mm)	**Middle (mm)**	**Posterior (mm)**
Rao et al.[11]	2014	100	Non-elastic cotton thread / Vernier caliper	8.30 ± 1.06	10.50 ± 1.20	15.80 ± 2035
Rohila et al.[5]	2016	100	Non-elastic cotton thread / Digital Vernier caliper	7.37 ± 1.06	10.82 ± 1.69	14.34 ± 2.37
Kaur et al.[12]	2013	100	Silk thread	7.68 ± 1.36	9.32 ± 2.24	14.96 ± 2.66

Almeda et al.[13]	2004	22	Analogical Pachymeter/ Vernier caliper	9.02 ± 1.59	12.16 ± 2.58	17.37 ± 2.22
Dhananjaya et al.[14]	2013	40	Sagittal and coronal T1-weighted and T2 weighted MRI images	10.02 ± 1.59	7.8 ± 1	13.9 ± 0.8
Hathila et al.[7]	2018	30	Digital Vernier Caliper & analysed with MS Excel	9.05 ± 0.70	11.10 ± 0.45	15.39 ± 0.58
Bloecker et al.[15]	2011	Not mentio ned	MR Imaging / 3D morphometric analysis	9.9± 1.0mm		
Present study	**2025**	**60 (30 Left)**	**Non Elastic Thread/ Vernier Calliper**	**1.3 ± 0.05**	**2.3 ± 0.06**	**4.0 ± 0.09**
		(30 Right)		**1.4 ± 0.07**	**2.4 ± 0.11**	**3.2 ± 0.12**

Table 8 depicts the comparison of width of medial menisci in Anterior, Middle and Posterior part. It is evident that the width is more in posterior part of the medial meniscus.
The present study also showing results similar to earlier studies. The study was supported by Almeda et al[13] and Rao et al[11]
The width of medial meniscus was found more in posterior 1/3rd part bilaterally in left as well as right knee.

Table9: Width of lateral meniscus

Author	**Year**	**No. of Knee Joint**	**Method**	**Lateral meniscus**		
				Anterior (mm)	**Middle (mm)**	**Posterior (mm)**
Rao et al.[11]	2014	100	Non-elastic cotton thread / Vernier caliper	9.90 ± 1.16	9.70 ± 0.61	9.80 ± 1.16
Rohila et al.[5]	2016	100	Non-elastic cotton thread / Digital Vernier caliper	9.93 ± 1.71	11.21 ± 2.91	11.03 ± 1.40
Kaur et al.[12]	2013	100	Silk thread	11.32 ± 1.46	11.16 ± 1.64	11.67 ± 1.54
Almeda et al.[13]	2004	22	Analogical Pachymeter/ Vernier caliper	11.86 ± 1.81	11.97± 2.56	11.4 ± 1.07
Dhananjaya et al.[14]	2013	40	Sagittal and coronal T1-weighted and T2 weighted MRI images	11.8 ± 1.4	8.6 ± 1.2	12.0 ± 0.9
Hathila et al.[7]	2018	30	Digital Vernier Caliper & analysed with MS Excel	11.82 ± 0.81	12.53 ± 0.72	12.03 ± 0.8

Bloecker et al.[15]	2011	Not mentioned	MR Imaging / 3D morphometric analysis	10.1 ± 1.2 mm		
Present Study	**2025**	**60 (30 Left)**	**Non Elastic Thread/ Digital Vernier calliper**	**1.6 ± 0.06**	**2.5 ± 0.08**	**2.8 ± 0.08**
		(30 Right)		**1.4 ± 0.07**	**1.9 ± 0.09**	**3.2 ± 0.12**

Table 9 depicts the width of lateral meniscus bilaterally. The Width of lateral meniscus was found more in posterior 1/3rd part of lateral meniscus in left as well right knee in present study. The width was less in Anterior 1/3rd as compared to middle and posterior 1/3rd part.
The results were supported by study done by Dhananjaya et al[13] and Hathila et al[7] whereas a significant variance was observed in study conducted by Almeda et al[13].

Table 10: Thickness of medial meniscus

Author	**Year**	**No. of Knee Joint**	**Method**	**Medial meniscus**		
				Anterior (mm)	**Middle (mm)**	**Posterior (mm)**
Rao et al.[11]	2014	100	Non-elastic cotton thread / Vernier caliper	5.40 ± 0.5	5.60 ± 0.60	5.4 ± 0.50
Rohila et al.[5]	2016	100	Non-elastic cotton thread / Digital Vernier caliper	6.40 ± 1.3	6.43 ± 1.15	6.72 ± 1.12
Kaur et al.[12]	2013	100	Silk thread	6.17	6.31	5.18
Almeda et al.[13]	2004	22	Analogical Pachymeter/ Vernier caliper	5.92 ± 1.37	5.31 ± 1.06	5.91 ± 1.13
Dhananjaya et al.[14]	2013	40	Sagittal and coronal T1weighted and T2 weighted MRI images	6.3 ± 1.1	5.2 ± 1.3	6.9 ± 1.1
Hathila et al.[7]	2018	30	Digital Vernier Calliper & analysed with MS Excel	6.21 ± 0.6	6.18 ± 0.55	6.30 ± 0.42
Bloecker et al.[15]	2011	Not mentioned	MR Imaging / 3D morphometric analysis	7.7 ± 1.3mm		
Present Study	**2025**	**60 (30 Left)**	**Non Elastic Thread/ Digital Vernier Calliper**	**4.5 ± 0.08**		

		(30 Right)		**4.7 ± 0.20**

Table 10 highlights the comparison of thickness of medial meniscus in different studies conducted by various authors. It is evident that the thickness is almost equal at all portions of the menisci. In present study, thickness of the medial meniscus is more on right side as compared to the medial menisci of left side.

Table 11: Thickness of lateral meniscus

Author	**Year**	**No. of Knee Joint**	**Method**	**Lateral meniscus**		
				Anterior (mm)	**Middle (mm)**	**Posterior (mm)**
Rao et al.[11]	2014	100	Non-elastic cotton thread / Vernier caliper	5.90 ± 0.33	5.00 ± 0.56	5.70 ± 0.40
Rohila et al.[5]	2016	100	Non-elastic cotton thread / Digital Vernier caliper	4.73 ± 1.12	6.75 ± 1.13	6.18 ± 0.99
Kaur et al.[12]	2013	100	Silk thread	4.40	6.52	5.46
Almeda et al.[13]	2004	22	Analogical Pachymeter/ Vernier caliper	3.71 ± 1.15	6.10 ± 1.104	5.29 ± 0.78
Dhananjaya et al.[14]	2013	40	Sagittal and coronal T1-weighted and T2 weighted MRI images	4.8 ± 0.7	6.4 ± 1.1	7.0 ± 0.60
Hathila et al.[7]	2018	30	Digital Vernier Caliper & analysed with MS Excel	4.5 ± 0.5	5.90 ± 0.61	5.63 ± 0.60
Bloecker et al.[15]	2011	Not mentioned	MR Imaging / 3D morphometric analysis	7.2 ± 1.0mm		
Present Study	**2025**	**60 (30 Left)**	**Non Elastic Thread/ Digital Vernier Calliper**	**2.7 ± 0.06**		
		(30 Right)		**3.4 ± 0.17**		

Table 11 depicts the thickness of lateral meniscus on anteroposterior parts of menisci which are showing significant variations.

The present study is showing similar results as Almeda et al[13] whereas there was significant variance in different studies conducted by various authors.

As we have discussed the circumference, the morphometric dimensions of medial meniscus were found high on right side knee as compared to the left side knee. This depicts that the Length, width and thickness of medial meniscus is more on the right side knee as compared to the left side knee when compared bilaterally.

The knowledge of the data with reference to various parameters of lateral and medial menisci is useful to orthopedic surgeons while carrying out surgical repairs of menisci joint. This information may also be of relevance to the anthropologists in elucidating the evolution of posture and gait.

The current study revealed differences in the various morphometric parameters of medial and lateral meniscus when compared to previous studies. This could possibly be explained on the basis of racial variations.

An attempt has been made to provide a baseline data on anthropometric details of human knee menisci in Indian subjects. One of the salient highlights of the current investigation is the correlation between various morphometric parameters in left and right side. High statistical significance observed in correlation between some morphometric parameters supports their suitability for application in predicting the dimensions of grafts for meniscus repair**.**

Conclusion:

Familiarity with morphometric details and variations of human knee menisci is of great relevance for orthopedic surgeons. Precise knowledge of the morphometric values of meniscus and its components is crucial for achieving successful outcome of surgical procedures.

Dimensional anatomy of knee menisci is of paramount significance for performing surgical procedures involving meniscal tear, Arthroscopy of knee joint and knee joint replacement.

The results of the current study revealed a wide range of dimensions with regard to various meniscal components. Some of the parameters also displayed statistically significant difference between left and right sided values.

Additional discrepancies were noticed on comparison of the present data with the previous studies. These discrepancies could be due to racial dissimilarities and regional variations.

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