Original article

Morphometric study of Menisci of Knee joints: A cadaveric study in an Eastern Indian Medical College

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Abstract:

Introduction: The study of morphometry of menisci of the knee joint will provide data to meniscal anatomy in the native population,which is necessary for various surgical procedures and also for arthroscopy of the knee joint. To study the morphometric parameters of menisci of knee joint including their shape ,breadth and thickness of, distance between their anterior and posterior horns and outer and inner circumferential length of each meniscus.

Methods & Materials : The study was carried out in the Department of Anatomy of Institute of Post Graduate Medical Education &Research(IPGME&R),Kolkata ,in cadavers donated to the department during a period of one year. Subjects having no mcroscopic deformities of their knee joints and ages ranging between 30 years to 60 years were only chosen . 50 knee joints belonging to 25 cadavers matching the above criteria were dissected for the study.Data analysis was done at IPGME&R, Kolkata and NRS Medical College, Kolkata.

Observations &Results : Lateral Meniscus(LM) studied were found to be “circular” and all of the Medial meniscus(MM) studied were found to be “oval” in shape. , The mean inter horn distance in case of LM was measured as 12.72mm and the same for MM was recorded as 29.02mm..The mean inner circumferential length of the LM of Left side was measured to be 43.49mm and the same for Right side was 43.68mm.

Conclusion :This study will enrich the literature regarding the morphometry of the menisci and will also help to understand the mechanisms behind their injury.

Keywords: :Morphometry, menisci, knee joint

Introduction:

The menisci are two crescent-shaped fibrocartilaginous structures those are found within the knee joint between the femoral condyles and the tibial plateau. They 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[1]. Injuries to the meniscus are common in work, sports and day to day activities, and are disabling. Transplantation of a banked meniscus allograft is among the treatment

options for young patients with knee pain after meniscectomy[2].Accurate matching of the size of meniscus allograft to the native meniscus affects the outcome to the same extent as the surgical technique .Garret & Steensen and Johnson et al. noted that differences of only a few millimeters were associated with poorer biomechanical outcomes[3,4]. According to Dienst et al., allograft size must be matched to within 10% of the size of the native meniscus[5]. The study of morphology of menisci of the knee joint will provide data to meniscal anatomy in the native population,which is necessary for various surgical procedures and also for arthroscopy of the knee joint.

Aims &Objectives

To study the following parameters of menisci of knee joint –

a) Morphological variations in their shape.

b) Breadth and thickness of menisci at their anterior 3rd,middle 3rd

and posterior 3rd.

c) Distance between their anterior and posterior horns .

d) Outer and inner circumferential length of each meniscus.

Materials &Methods

The study was carried out in the Department of Anatomy of Institute of Post Graduate Medical Education &Research, Kolkata,in cadavers donated to the department during a period of one year. Subjects having no mcroscopic deformities of their knee joints and ages ranging between 30 years to 60 years were only chosen . 50 knee joints belonging to 25 cadavers matching the above criteria were dissected for the study. Data analysis was done at IPGME&R, Kolkata and NRS Medical College, Kolkata This is a cross-sectional observational study. For dissection of the cadavers the standard dissecting instruments such as Surgical Scalpel(no.22) with a BP Handle , Allis Tissue Forceps , Scissors(blunt & sharp),Dissecting Forceps(plain & toothed) were used . For taking various measurements , a Digital Vernier Calliper and a non-elastic coloured copper wire were used. In the formalin embalmed cadavers after dissecting the skin, soft tissues 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 ligaments transversely. In order to expose the menisci clearly, the joint capsule were cut, and the condyles were circumferentially detached from their soft tissue attachments, exposing the tibial plateau. The menisci were then studied for their shape. The distance between their anterior and posterior horns were then measured ,without disturbing the attachments to the tibial plateau .After this the menisci were dissected out of their tibial attachments for further measurements. The outer circumferential length and the inner circumferential length were then recorded by a non-elastic coloured malleable copper wire and a digital Vernier Calliper. After this, each menisci were divided into 3 equal parts(ant. ,middle & post. 3rds.).The thickness and maximum breadth of the above three parts were measured by digital Vernier Calliper. Data were summarised by routine descriptive Statistics, viz – Mean & SD, for numerical variables and counts. Numerical variables were compared between sub groups by Student's Unpaired T-Test and for the sides by Student's Paired T-Test as they were normally distributed.

Observation & Results

Amongst the 50 cadaveric knee joints dissected (in 25 cadavers) for the purpose of this present study, 13 were males and 12 were females.The mean age of the cadavers were found to be 56.32 with a Standard

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Deviation (SD) of 3.755.The maximum age was recorded to be 60 yrs. and minimum to be 49yrs. , All of the Lateral Meniscus(LM) studied were found to be “circular” in shape ,irrespective of the gender of the cadavers .On the other hand, all of the Medial meniscus(MM) studied were found to be “oval” in shape , bilaterally .For the MM also, no gender differences for the shape were noted.

Table.1: Measurements of Left sided Lateral and Medial meniscus

	N	Mean	95%CI	95%CI	Median	Min	Max	Lower	Upper	Std.
		(mm)								Dev.
			LL	UL				Quartile	Quartile	
Age	50	56.32	55.25	57.39	58.00	49.00	60.00	52.00	59.00	3.755
Left side										
LM_IntHornDist	50	12.72	12.51	12.94	12.92	11.75	13.85	11.98	13.48	0.748
LM_OuterCirc	50	67.79	67.51	68.08	68.40	66.51	69.30	66.78	68.72	0.997
LM_InnerCirc	50	43.49	43.08	43.90	44.01	35.54	44.85	42.75	44.53	1.438
LM_ThickAnt	50	2.59	2.43	2.74	2.69	1.92	3.47	2.03	3.12	0.545
LM_ThickMid	50	4.54	4.33	4.74	4.73	2.98	5.77	3.85	5.17	0.724
LM_ThickPost	50	4.53	4.33	4.72	4.78	3.13	5.71	3.87	5.19	0.684
LM_WidthAnt	50	5.91	5.70	6.13	6.16	5.01	6.99	5.12	6.71	0.755
LM_WidthMid	50	7.02	6.82	7.22	7.07	6.12	8.70	6.35	7.78	0.717
LM_WidthPost	50	7.57	7.38	7.76	7.87	6.47	9.52	6.95	8.03	0.664
MM_IntHornDist	50	29.02	28.76	29.28	29.37	27.47	30.37	28.13	29.78	0.900

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MM_OuterCirc	50	85.45	85.25	85.66	85.81	84.12	86.95	84.80	86.03	0.725
MM_InnerCirc	50	47.42	47.10	47.74	47.95	45.61	49.91	46.26	48.29	1.143
MM_ThickAnt	50	4.08	3.88	4.28	4.11	3.01	5.73	3.42	4.71	0.703
MM_ThickMid	50	4.61	4.39	4.83	4.61	3.21	6.64	3.91	5.19	0.783
MM_ThickPost	50	4.88	4.68	5.07	4.91	3.45	6.65	4.19	5.51	0.679
MM_WidthAnt	50	5.70	5.43	5.97	5.61	4.21	8.78	4.99	6.61	0.960
MM_WidthMid	50	5.80	5.54	6.05	5.73	4.40	8.10	5.11	6.13	0.885
MM_WidthPost	50	10.55	10.37	10.72	10.91	9.12	11.30	9.92	11.12	0.616

Table 2. Measurements of Right sided Lateral and Medial meniscus.

	N	Mean (mm)	95%CI LL	95%CI UL	Median	Min	Max	Lower Quartile	Upper Quartile	Std.Dev
LM_IntHornDist	50	12.71	12.50	12.92	12.88	11.78	13.82	11.95	13.46	0.738
LM_OuterCirc	50	67.80	67.52	68.09	68.41	66.56	69.07	66.80	68.75	0.994
LM_InnerCirc	50	43.68	43.42	43.93	44.04	42.39	44.97	42.78	44.58	0.891
LM_ThickAnt	50	2.57	2.42	2.72	2.72	1.92	3.35	2.01	3.10	0.526
LM_ThickMid	50	4.55	4.35	4.74	4.78	3.61	5.58	3.81	5.14	0.680
LM_ThickPost	50	4.53	4.35	4.71	4.79	3.65	5.42	3.85	5.12	0.635
LM_WidthAnt	50	5.87	5.66	6.08	6.12	5.01	6.91	5.12	6.65	0.742
LM_WidthMid	50	7.01	6.81	7.22	7.13	6.13	8.69	6.31	7.71	0.721
LM_WidthPost	50	7.52	7.34	7.70	7.75	6.68	9.11	6.91	8.01	0.643
MM_IntHornDist	50	29.18	28.95	29.41	29.09	28.11	31.02	28.41	29.81	0.799
MM_OuterCirc	50	81.29	81.08	81.49	81.18	79.96	82.36	80.66	82.02	0.723
MM_InnerCirc	50	46.39	46.18	46.59	46.42	45.11	47.31	45.86	47.11	0.715
MM_ThickAnt	50	2.31	2.26	2.36	2.36	1.98	2.61	2.13	2.44	0.180
MM_ThickMid	50	4.38	4.31	4.45	4.39	3.96	5.13	4.19	4.51	0.249
MM_ThickPost	50	4.31	4.25	4.36	4.29	3.98	4.91	4.13	4.41	0.198
MM_WidthAnt	50	5.32	5.20	5.45	5.21	4.12	5.96	5.06	5.81	0.441
MM_WidthMid	50	5.21	5.08	5.33	5.24	4.12	5.83	4.96	5.58	0.444
MM_WidthPost	50	10.39	10.26	10.53	10.61	9.61	11.22	9.92	10.81	0.488

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Table 3: **Comparison of numerical variables between Male and Female –** (Left side)

Student's unpaired t test

	Mean M (mm)	Mean F	t-value	df	p	Valid N M	Valid N F	Std.Dev. M	Std.Dev. F
Age	56.30	56.35	-0.0479	48	0.962	27	23	3.709	3.892
Left side									
LM_IntHornDist	13.36	11.97	18.6251	48	0.000	27	23	0.344	0.108
LM_OuterCirc	68.69	66.74	35.6652	48	0.000	27	23	0.240	0.111
LM_InnerCirc	44.12	42.75	3.7543	48	0.000	27	23	1.733	0.120
LM_ThickAnt	3.06	2.04	19.7759	48	0.000	27	23	0.239	0.068
LM_ThickMid	5.13	3.83	14.5584	48	0.000	27	23	0.303	0.327
LM_ThickPost	5.09	3.87	13.9060	48	0.000	27	23	0.286	0.333
LM_WidthAnt	6.58	5.14	24.0014	48	0.000	27	23	0.279	0.077
LM_WidthMid	7.62	6.31	16.0418	48	0.000	27	23	0.380	0.097
LM_WidthPost	8.12	6.92	14.8463	48	0.000	27	23	0.369	0.121
MM_IntHornDist	29.80	28.10	21.0507	48	0.000	27	23	0.317	0.240
MM_OuterCirc	86.08	84.72	19.2656	48	0.000	27	23	0.253	0.242
MM_InnerCirc	48.40	46.27	19.4853	48	0.000	27	23	0.437	0.317
MM_ThickAnt	4.65	3.41	12.9879	48	0.000	27	23	0.334	0.335

MM_ThickMid	5.18	3.94	9.2858	48	0.000	27	23	0.515	0.419
MM_ThickPost	5.40	4.26	10.8264	48	0.000	27	23	0.386	0.349
MM_WidthAnt	6.39	4.90	8.6968	48	0.000	27	23	0.752	0.357
MM_WidthMid	6.43	5.05	8.6730	48	0.000	27	23	0.687	0.348
MM_WidthPost	11.09	9.91	23.6309	48	0.000	27	23	0.127	0.218

Table 4: **Comparison of numerical variables between Male and Female –** (Right side)

Student's unpaired t test

	Mean	**Mean**	**t-value**	**df**	**p**	**Valid N**	**Valid N**	**Std. Dev**	**Std. Dev**
	(mm)								
	M	F				M	F	M	F
LM_IntHornDist	13.34	11.96	20.0706	48	0.000	27	23	0.318	0.099
LM_OuterCirc	68.70	66.75	41.9572	48	0.000	27	23	0.202	0.100
LM_InnerCirc	44.46	42.76	22.8321	48	0.000	27	23	0.337	0.121
LM_ThickAnt	3.03	2.03	21.8825	48	0.000	27	23	0.210	0.062
LM_ThickMid	5.11	3.88	15.6628	48	0.000	27	23	0.253	0.305
LM_ThickPost	5.06	3.91	15.6166	48	0.000	27	23	0.231	0.291
LM_WidthAnt	6.53	5.11	24.9789	48	0.000	27	23	0.262	0.079
LM_WidthMid	7.63	6.30	17.3050	48	0.000	27	23	0.360	0.083

LM_WidthPost	8.07	6.88	17.1370	48	0.000	27	23	0.320	0.092
MM_IntHornDist	29.80	28.45	11.2027	48	0.000	27	23	0.506	0.302
MM_OuterCirc	81.86	80.61	12.2676	48	0.000	27	23	0.427	0.257
MM_InnerCirc	46.93	45.75	10.5489	48	0.000	27	23	0.428	0.356
MM_ThickAnt	2.44	2.15	9.4721	48	0.000	27	23	0.099	0.117
MM_ThickMid	4.53	4.21	5.8615	48	0.000	27	23	0.204	0.176
MM_ThickPost	4.44	4.15	7.6607	48	0.000	27	23	0.162	0.091
MM_WidthAnt	5.64	4.96	8.6546	48	0.000	27	23	0.303	0.246
MM_WidthMid	5.48	4.89	6.1070	48	0.000	27	23	0.338	0.334
MM_WidthPost	10.81	9.90	18.5142	48	0.000	27	23	0.208	0.119

Regarding the gender variations for these inter horn distances,in case of Males ,that for the LM of Left side was found to be 13.36mm with SD of 0.344. For the Female cadavers ,the same was found to be 11.97mm with SD of 0.108. Unpaired t test performed, showed a "p" value of **<** 0.001.For the Right side also, "p" value was calculated to be **<**0.001, which signified a considerable difference between the values found between male and female cadavers.

Discussion

Data related to the morphometric study of the menisci of the knee joints are scarce; therefore, the main objective of the present study was to record and analyze the morphometric measurements of the human cadaveric meniscus, thereby, enriching the literature on this subject and correlating these variations with the possibility, location and type of lesions. Regarding the shape of the menisci, C.M.Charles[6] reported that LM has a crescentic shape whereas Smillie[7] observed a few discoid LM in his study. A similar discoid shape of the LM had been reported also by Kelly & Green[8].These variations of the shape of menisci were explained by the embryological development of the meniscus by Kale et al[9].However,in the present study ,none of them were found to be discoid in shape .In fact, all of the LM studied were found to be "circular" in shape ,irrespective of the gender of the cadavers .On the other hand, all of the MM studied were found to be "oval" in shape , bilaterally .For the MM also, no gender differences for the shape were noted. The

present study did not correlate with the study done by Murlimanju et al [10] ,where 54 cadaveric knee joints were studied for the shape of the meniscus .Out of those,50% of the MM were noted to be oval or crescent shaped,38.9% were found to be sided V-shaped and 11.1% were found to be sided U-shaped .The types of LM found in the same study were,61.1% to be C-shaped and 38.9% to be Crescent shaped .The study did not mention about findings of any discoid LM, which was consistent with the findings regarding the shape of the LM in the present study. In the present study, the mean inter horn distance in case of LM was measured as 12.72mm with SD of 0.748 and the same for MM was recorded as 29.02mm with a SD of 0.9.These values were observed as almost similar to the study undertaken by Kapandji et al [11],who reported the inter horn distance of LM as 12.55mm and the same of MM as 25.88mm,which was slightly lower than that found in the present study. In another study done by Almeida et al [12] , the mean inter horn distance in case of LM was recorded as 12.71mm and that for the MM as 29.70mm.So, the values observed in the study by Almeida et al ,were qiuet similar to the values found in this present study .Similar type of observations were also reported by Braz & Silva[13]. None of the previous studies mentioned the variations of the inter horn distance of LM and MM between right and left sides specifically. But, in the present study,while the previously mentioned mean values were for the left side ,the mean inter horn distance for the right side were recorded to be 12.71mm with SD of 0.738 for the LM and 29.18mm with SD of 0.799 for the MM.Regarding the gender variations for these inter horn distances ,in case of Males ,that for the LM of Left side was found to be 13.36mm with SD of 0.344. For the Female cadavers ,the same was found to be 11.97mm with SD of 0.108. Unpaired t test performed, showed a "p" value of < 0.001.For the Right side also, "p" value was calculated to be <0.001, which signified a considerable difference between the values found between male and female cadavers.The study done by Braz and Silva ,recorded no significant difference in the length of the outer circumference (p>0.05) between the MM and LM , the individual values for which were recorded to be 91.85mm and 92.8mm for the MM and LM respectively. But, in this present study, a significant variation was noted for the above parameters .In case of the LM the mean outer circumference was found to be 67.79mm with SD of 0.997 and that for the MM was found to be 85.45mm with SD of 0.725 for the left side .For the right side ,the same for LM was recorded to be 67.80mm with SD of 0.994 and for MM to be 81.29mm with SD of 0.723. In another study done by Kaur & Sodhi [14], the mean OC in case of MM of the Right knee was recorded to be 92mm ,whereas the same in the Left knee was 97mm.These were considerably greater than those measured in the present study.

	Present study	Braz & Silva	Kaur & Sodhi
Mean OC of LM	67.79mm(Lt. side) 67.80mm(Rt. Side)	92.80mm	No data recorded
Mean OC of MM	85.45mm(Lt. side) 81.29mm(Rt. Side)	91.85mm	92.0mm(Rt. Side) 97.0mm(Lt. side)

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The mean inner circumference of the MM of left knee was found to be 64mm in the study done by Kaur & Sodhi .The same for the right knee was found to be 62mm.In the present study, though ,the mean IC of the MM on Left side was recorded to be 47.42mm with SD of 1.143 and that of the Right side was found to be 46.39mm with SD of 0.715.Those were found to be much less when compared to the data recorded by Kaur & Sodhi .No data had been given regarding the IC for the LM in any previous studies .But, in the present study, though ,the mean length of IC of the LM of Left side was measured to be 43.49mm with SD of 1.438 and the same for Right side was 43.68mm with SD of 0.891. In the study, done by Braz & Silva,the posterior third of the MM (5.18mm mean), appeared thinner when compared to the anterior third (6.17mm mean) or the middle third (6.13mm mean).

	Present study	Almeida et al	Braz & Silva
Thickness ant. 3rd of LM	2.59mm (Lt) 2.57mm (Rt)	3.71mm	4.40mm
Thickness middle 3rd of LM	4.54 mm (Lt) 4.55mm (Rt)	6.10 mm	6.52mm
Thickness post. 3rd of LM	4.53mm (Lt) 4.53mm (Rt)	5.29 mm	5.46 mm

In none of the previous studies mentioned here, there was any information regarding the side or gender variations of these morphometric measurements. But in the current study side as well as gender variations were recorded in details and analyzed.In the study conducted by Chintan et al[15], it was observed that in the anterior and posterior thirds, the MM was significantly thicker ($p<0.05$),when compared with the same areas of the LM. This view did not corroborate with this present study.

Conclusion

The objective of this study was to measure the various morphometric data of the menisci obtained from the eastern Indian population, which happens to be one of its kind so far. For transplantation of the menisci, exact size of those is the most important requirement. It is interesting to correlate the allograft size with the dimensions of the menisci. The cadaveric dissection of knee joint can help in choosing the correct allograft size .So, keeping these facts in mind, the present study was intended to record the various morphometric data of the menisci and also compare those data between two sides and both sexes. This will enrich the literature regarding the morphometry of the menisci and will also help to understand the mechanisms behind their injury.

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