

Morphometric Study of Intracapsular Ligaments of Knee Joint

Dr A. N. V. V. Veerajju¹, Dr.D.A.V.S.Sesi², Dr.B. Narayana Rao³, Mrs.V.Vinila⁴

¹Associate professor, Department of Anatomy, Konaseema Institute of Medical sciences and Research foundation, Amalapuram.

²Professor and Head, Department of Anatomy, Rangaraya Medical College, Kakinada

³Professor and Head, Department of Anatomy, Konaseema Institute of Medical sciences and Research foundation, Amalapuram.

⁴Assistant professor, Department of Anatomy, Konaseema Institute of Medical sciences and Research foundation, Amalapuram

Abstract

BACKGROUND

This study was conducted to evaluate the various intracapsular ligaments of the knee joint, their arrangement, and their attachments. We also wanted to do a morphometric analysis of anterior cruciate ligament, posterior cruciate ligament, anterior and posterior meniscomfemoral ligaments and transverse ligament of the knee joint.

METHODS

The present study was conducted among 50 adult human cadavers (29 male and 21 female) presented to department of Anatomy, Rangaraya Medical College, Kakinada and department of Anatomy, Andhra Medical College, Vishakhapatnam which were allotted to undergraduate students for their routine dissection. Permission was obtained from ethics committee to conduct the present study.

RESULTS

The infra patellar synovial fold was present in only 57% of the knee joints. The mean length and width of the anterior cruciate ligament in males and females was 3.56cm-0.90cm and 3.45cm-0.85cm respectively. The mean length and width of the posterior cruciate ligament in males and females were 3.57cm-1.03cm and 3.48cm-1.00cm respectively. The mean length and width of the anterior meniscomfemoral ligament in males and females were 1.30cm-0.31cm and 1.21cm-0.29cm respectively. The mean length and width of the posterior meniscomfemoral ligament in males and females were 2.87cm-0.31cm and 2.85cm-0.32cm respectively. The mean length and width of the transverse ligament in males and females were 3.41cm-0.27cm and 3.31cm-0.26cm respectively.

CONCLUSION

The posterior cruciate ligament is broader than the anterior cruciate ligament. The variations observed in the length and width of the anterior and posterior cruciate ligaments in comparison to other studies may be due to racial differences.

Key words: Morphometric study, Intracapsular ligaments, Knee joint.

Introduction

The knee joint being the largest compound joint in the body. It is most unstable because the articular surfaces taking part in the formation of the joint are non-congruous and not co-extensive.

But the truth is against this view. Even though the articular surfaces are non congruous and not co-extensive complete dislocation of the tibiofemoral part of the knee joint is very rare. Only subluxation of the tibiofemoral joint is seen with fracture injuries of one or both cruciate ligaments.

In fact, the tibiofemoral part of the knee joint has become so stable because of the extra-capsular and intra-capsular ligaments. The anterior part of the knee joint is not supported or covered by any muscles. The posterior part of the knee joint is strengthened by both heads of the gastrocnemius and popliteus muscles. In such an event the stability of the joint is only due to the extra-capsular and intra-capsular ligaments.

Among the extracapsular structures

- 1) The capsule of the knee joint is very lax anteriorly and is not strong enough to play a major role in the stability of the joint except for the medial and lateral patellar retinacula.
- 2) Ligamentum patellae is definitely very strong below the patella up to the tibia.
- 3) The tibial collateral ligament of the knee joint affords certain strength to the joint on the medial side.
- 4) The fibular collateral ligament even though it is short, offers strength to the joint to a certain extent on the lateral side.
- 5) Oblique popliteal ligament is also broad and strong and affords strength to the joint on the posterior aspect.
- 6) Arcuate popliteal ligament is not strong enough to offer stability to the joint.

The extracapsular ligaments, retinacula and capsule can only offer their strength when the femur and tibia are held together.

Such “holding together of both bones” is done by the various intra-articular structures. This importance of intracapsular structures in maintaining the stability of the joint has prompted us to select this topic for a dissertation.

The intra articular structures are the anterior and posterior cruciate ligaments, anterior and posterior meniscomfemoral ligaments, medial and lateral alar folds, medial and lateral menisci and transverse ligament of the knee.

The arrangement of all these structures is much complicated and can only be understood with good anatomical knowledge. Their interrelationships are to be fully understood while doing an arthroscopic examination of the knee joint. To achieve these goals an attempt is made to identify, analyze and understand the intracapsular structures.

Aims & Objectives

- 1) To observe and study the various intracapsular ligaments of the knee joint, their arrangement, and their attachments.
- 2) Morphometric analysis of anterior cruciate ligament, posterior cruciate ligament, anterior and posterior meniscomfemoral ligaments and transverse ligament of the knee joint
- 3) To identify and record the morphological variations and abnormalities of intra-capsular ligaments during the above study.

Methods

The present study was conducted among 50 adult human cadavers (29 male and 21 female) present in the department of Anatomy, Rangaraya Medical College, Kakinada and department of Anatomy, Andhra Medical College, Vishakhapatnam which were allotted to undergraduate students for their routine dissection. In total, 100 knee joints of lower limbs were dissected, and studied and the specimens were recorded by taking photographs. The museum specimens available in departments of anatomy, Rangaraya Medical College, Kakinada and Andhra Medical College, Visakhapatnam were also observed and studied. The photographs obtained from the departments of Orthopedics and Radiology, Government General Hospital, Kakinada were also used for the study. Permission was obtained from the ethics committee to conduct the present study.

Study Procedure

The following structures were exposed and cleaned: A vernier calipers and a steel tape were used to measure the various parameters of the structures. The data obtained was analyzed, tabulated and compared between males and females.

Anterior Cruciate Ligament

The upper attachment, lower attachment and the direction are recorded. The length and width of the anterior cruciate ligament are recorded. The length is measured from the anterior most point of attachment on the anterior intercondylar area of the tibia to posterior most point of attachment on the medial surface of the lateral condyle of femur. The width is recorded at the middle of the anterior cruciate ligament. The observed variations in the attachment of anterior cruciate ligament are recorded.

Posterior Cruciate Ligament

The upper attachment, lower attachment and the direction are recorded. The length and width of the posterior cruciate ligament are recorded. The length is measured from the posterior most point of its attachment on the posterior intercondylar area of tibia to anterior most point of attachment on the lateral surface of the medial condyle of femur. The width is recorded at the middle of the posterior cruciate ligament. The observed variations in the attachments of posterior cruciate ligament are recorded.

Anterior Menisofemoral Ligament

The upper attachment, lower attachment and direction are recorded. The length and width of the anterior menisofemoral ligament are recorded. The length is recorded from a point of its attachment on posterior horn of lateral meniscus to a point of its attachment on lateral surface of medial condyle of femur anterior to attachment of posterior cruciate ligament. The width is recorded in the middle of the anterior menisofemoral ligament. The observed variations in the attachment of anterior menisofemoral ligament are recorded.

Posterior Menisofemoral Ligament

The upper attachment, lower attachment and direction are recorded. The length and width of the posterior menisofemoral ligament are recorded. The length is recorded from a point of its attachment on posterior horn of the lateral meniscus to a point of its attachment on lateral surface of medial condyle of femur posterior to attachment of posterior cruciate ligament. The width is recorded in the middle of the posterior menisofemoral ligament. The observed variations in the attachments of posterior menisofemoral ligament are recorded.

Transverse Ligament

The medial attachment and lateral attachment are recorded. The length and width of the transverse ligament are recorded. The length is recorded from the most medial point of attachment on anterior horn of medial meniscus to most lateral point of attachment on anterior convex margin of lateral meniscus. The width is recorded at the middle of the transverse ligament.

Results

	Right		Left			
	Study Conducted	Infrapatellar Synovial Fold Present	Study Conducted	Infrapatellar Synovial Fold Present		
Male	29	16	29	17		
Female	21	11	21	13		
Study conducted: 100 Infra patellar synovial fold present: 57						
Study of the Infra Patellar Synovial Fold						
	Right		Left			
	Study Conducted	Medial Alar Fold	Lateral Alar Fold	Study Conducted	Medial Alar fold	Lateral Alar fold
Male	29	29	29	29	29	29
Female	21	21	21	21	21	21
Study conducted: 100 Medial Alar fold present: 100 Lateral Alar fold present: 100						
Study of the Medial and Lateral Alar Folds						

Table 1

Synovial Membrane

The synovial membrane is intact in all the knee joints studied. The extent of the synovial membrane is in conformity with the standard text-book description and they do not show any variations. The suprapatellar bursa is consistently present above the patella between the quadriceps femoris tendon and lower end of the femur.

Distal to the patella the synovial membrane is found lining the infrapatellar pad of fat which extends between the femoral and the tibial condyles as free and crescentic medial and lateral alar folds. The medial and lateral alar folds are consistently present in all the 100 knee joints studied.

The infrapatellar synovial fold is present in only 57 of the knee joints studied (33 out of 58 males and 24 out of 42 females).

Proximally and distally, the synovial membrane is attached to the margins of the articular surfaces of the femur and the tibia. In the posterior aspect of the intercondylar part, the synovial membrane is not attached to the capsule but reflects on to the cruciate ligaments covering the front and the sides. The synovium does not line the menisci.

	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	3.81	1.00	3.76	1.02
Minimum	3.37	0.81	3.37	0.84
Mean	3.58	0.89	3.55	0.90
Median	3.56	0.92	3.48	0.88
Mode	3.56	0.92	3.48	0.92
Standard Deviation	0.162	0.056	0.137	0.048
Study of Length and Width of the Anterior Cruciate Ligament in Male				
	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	3.78	0.96	3.70	0.92
Minimum	3.21	0.71	3.26	0.76
Mean	3.45	0.84	3.45	0.85
Median	3.44	0.86	3.46	0.86
Mode	3.44	0.86	3.46	0.86
Standard Deviation	0.177	0.064	0.157	0.050
Study of Length and Width of the Anterior Cruciate Ligament in Female				

Table 2

Anterior Cruciate Ligament

The anterior cruciate ligament was present in all the 100 knee joints studied. The femoral and tibial attachments and the direction of the anterior cruciate ligament are in conformity with the standard text-book description and they do not show any variations except in one male cadaver (limb no: 62) in which a bundle of fibers of the anterior cruciate ligament is attached proximally into intercondylar area of the femur. The distal attachment of the anterior cruciate ligament is found in the anterior intercondylar area of the tibia. It extends obliquely upwards and backwards on the lateral side of the posterior cruciate ligament to attach to the medial surface of the lateral femoral condyle.

The mean length of the anterior cruciate ligament in males was 3.58cm on the right side and 3.55cm on the left side. The mean width of the anterior cruciate ligament in males was 0.89cm on the right side and 0.90cm on the left side.

The mean length of the anterior cruciate ligament in females was 3.45cm on both right and left sides. The mean width of the anterior cruciate ligament in females was 0.84cm on the right side and 0.85cm on the left side.

	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	3.70	1.10	3.68	1.08
Minimum	3.45	0.98	3.48	0.96
Mean	3.56	1.02	3.58	1.03
Median	3.54	1.02	3.60	1.04
Mode	3.52	0.98	3.60	1.04
Standard Deviation	0.082	0.041	0.060	0.043
Study of Length and Width of the Posterior Cruciate Ligament in Male				
	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	3.62	1.10	3.60	1.06
Minimum	3.35	0.89	3.36	0.92
Mean	3.49	0.99	3.47	1.00

Median	3.48	1.01	3.48	1.00
Mode	3.48	1.02	3.60	1.04
Standard Deviation	0.072	0.064	0.081	0.046

Study of Length and Width of the Posterior Cruciate Ligament in Female

Table 3

Posterior Cruciate Ligament

The posterior cruciate ligament was present in all the 100 knee joints studied. The femoral and tibial attachments and the direction of the posterior cruciate ligament are in conformity with the standard text book description and they do not show any variations.

The distal attachment of the posterior cruciate ligament was found to be on the posterior intercondylar area of the tibia. It passes upwards and forwards on the medial side of the anterior cruciate ligament to attach to the lateral surface of the medial condyle of the femur.

The mean length of the posterior cruciate ligament in males was 3.56cm on the right side and 3.58cm on the left side. The mean width of the posterior cruciate ligament in males was 1.02cm on the right side and 1.03cm on the left side.

The mean length of the posterior cruciate ligament in females was 3.49cm on the right side and 3.47cm on the left side. The mean width of the posterior cruciate ligament in females was 0.99cm on the right side and 1.00cm on the left side.

	Right				Left			
	Study Conducted	Meniscomfemoral Ligaments Present			Study Conducted	Meniscomfemoral Ligaments Present		
		aMFL	pMFL	Both		aMFL	pMFL	Both
Male	29	6	12	6	29	8	12	5
Female	21	3	9	4	21	5	8	4

Study conducted: 100 aMFL present: 22 pMFL present: 41

Both aMFL and pMFL present: 19

Table 4: Study of the Meniscomfemoral Ligaments

Meniscomfemoral Ligaments

In the present study 82 of the knee joints out of 100 showed presence of any one or both of the anterior and posterior meniscomfemoral ligaments. Both meniscomfemoral ligaments were present in 19 knee joints, anterior meniscomfemoral ligament alone was present in 22 knee joints and the posterior meniscomfemoral ligament alone was present in 41 knee joints.

	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	1.35	0.35	1.36	0.34
Minimum	1.18	0.29	1.18	0.28
Mean	1.30	0.31	1.30	0.31
Median	1.32	0.30	1.30	0.31
Mode	1.30	0.32	1.30	0.30
Standard Deviation	0.059	0.018	0.061	0.020

Study of Length and Width of the Anterior Meniscomfemoral Ligament in Males

	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	1.34	0.31	1.34	0.32
Minimum	1.19	0.26	1.18	0.28
Mean	1.22	0.28	1.21	0.29
Median	1.20	0.29	1.20	0.30
Mode	1.20	0.28	1.18	0.28
Standard Deviation	0.054	0.016	0.050	0.014

Study of Length and Width of the Anterior Menisofemoral Ligament in Females

Table 5

Anterior Menisofemoral Ligament (Ligament of Humphry)

The anterior menisofemoral ligament was present in 41 out of 100 knee joints studied. The meniscal and femoral attachments and the direction of the anterior menisofemoral ligament were in conformity with the standard text book description and they did not show any variations.

It extends from posterior horn of the lateral meniscus and passes forwards and medially in front of the posterior cruciate ligament and attaches to lateral surface of the medial condyle of femur anterior to the attachment of posterior cruciate ligament.

The mean length of the anterior menisofemoral ligament in males was 1.30cm on both right and left side. The mean width of the anterior menisofemoral ligament in males was 0.31cm on both right and left sides.

The mean length of the anterior menisofemoral ligament in females was 1.22cm on the right side and 1.21cm on the left side. The mean width of the anterior menisofemoral ligament in females was 0.28cm on the right side and 0.29cm on the left side.

	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	3.20	0.34	3.00	0.34
Minimum	2.68	0.28	2.64	0.28
Mean	2.87	0.31	2.87	0.30
Median	2.85	0.32	2.86	0.31
Mode	2.90	0.32	2.90	0.32
Standard Deviation	0.145	0.018	0.122	0.016

Study of Length and Width of the Posterior Menisofemoral Ligament in Males

	Right		Left	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Maximum	3.00	0.38	3.00	0.34
Minimum	2.64	0.30	2.68	0.30
Mean	2.87	0.32	2.82	0.32
Median	2.88	0.32	2.81	0.32
Mode	2.88	0.32	2.80	0.32
Standard Deviation	0.091	0.022	0.092	0.015

Study of Length and Width of the Posterior Menisofemoral Ligament in Females

Table 6

Posterior Menisofemoral ligament (Ligament of Wrisberg)

The posterior menisofemoral ligament was present in 60 out of the 100 knee joints studied.

The meniscal and the femoral attachments, and the direction of the posterior menisofemoral ligament were in conformity with the standard text book description and they did not show any variations.

It extends from posterior horn of the lateral meniscus and passes medially behind the posterior cruciate ligament and attaches to lateral surface of the medial femoral condyle proximal to the margin of attachment of posterior cruciate ligament.

The mean length of the posterior menisofemoral ligament in males was 2.87cm on both right and left sides. The mean width of the posterior menisofemoral ligament in males was 0.31cm on the right side and 0.30cm on the left side.

The mean length of the posterior menisofemoral ligament in females was 2.87cm on the right side and 2.82cm on the left side. The mean width of the posterior menisofemoral ligament in females was 0.32cm on both right and left sides.

Comparative Study of the Right and Left Knee Joints

All the parameters that are studied like length and width of the cruciate ligaments, meniscofemoral ligaments, transverse ligament, the margins, width, and thickness of the menisci are compared in right and left side.

It was observed that there was no statistically significant difference in all parameters between the right and left knee joints in males and females.

S.No	Parameter	Male		Female		P value	Significance
		Mean	SD	Mean	SD		
1	ACL length	3.56	0.150	3.45	0.165	0.0008	YES
2	ACL width	0.90	0.052	0.85	0.057	0.0001	YES
3	PCL length	3.57	0.072	3.48	0.076	0.0001	YES
4	PCL width	1.03	0.042	1.00	0.055	0.0026	YES
5	aMFL length	1.30	0.059	1.21	0.050	0.0001	YES
6	aMFL width	0.31	0.019	0.29	0.015	0.0010	YES
7	pMFL length	2.87	0.133	2.85	0.092	0.5192	NO
8	pMFL width	0.31	0.018	0.32	0.019	0.0426	YES
27	TL length	3.41	0.149	3.31	0.146	0.0097	YES
28	TL width	0.27	0.029	0.26	0.030	0.1854	NO

Table 7: Comparative Study of the Knee Joint in Males and Females

Abbreviations used: ACL = Anterior Cruciate Ligament, PCL = Posterior Cruciate Ligament, aMFL = anterior Meniscofemoral Ligament, pMFL = posterior Meniscofemoral Ligament, TL = Transverse Ligament, SD = Standard Deviation

A 'P' value (probability) of less than 0.05 is considered significant and 'P' value of less than 0.01 is considered very significant.

Comparative Study of the Knee Joint in Male and Female

All the parameters that are studied like length and width of the cruciate ligaments, meniscofemoral ligaments, transverse ligament, the margins, width and thickness of the menisci are compared in the male and female knee joints.

It was observed that the differences in length and width of cruciate ligaments, anterior meniscofemoral ligaments, width of the posterior meniscofemoral ligament and length of the transverse ligament are statistically significant where as differences in length of the posterior meniscofemoral ligaments and width of the transverse ligament are statistically not significant.

The differences observed in width of the anterior 1/3 and middle 1/3 parts and thickness of the posterior 1/3 part of the medial meniscus are not statistically significant where as differences in the width of the posterior 1/3 part, and thickness of the anterior and middle 1/3 parts of the medial meniscus are statistically significant.

The differences observed in width of the anterior 1/3, middle 1/3 and posterior 1/3 parts and thickness of the anterior 1/3 and posterior 1/3 parts of the lateral meniscus are not statistically significant where as difference in the thickness of the middle 1/3 part of the lateral meniscus is statistically significant.

Discussion

Cruciate Ligaments

One of the important factors in the stability of the knee joint is its ligaments and in particular cruciate ligaments. A significantly higher rate of anterior cruciate ligament injuries occur in women involved in sports activities compared to corresponding male population. The reasons for this disparity are not well understood. However, sex based differences in the geometry of anterior cruciate ligament, its morphological characteristics and the intercondylar notch size have been cited as possible factors.

The length and width of the anterior and posterior cruciate ligaments have been studied by several workers. The posterior cruciate ligament is broader than the anterior cruciate ligament in all the studies conducted. The variations observed in the length and width of the anterior and posterior cruciate ligaments in various studies may be due to racial differences. The values reported in western literature are higher when compared to Asian population as reported by J.L.Tan (1998)^[1] who conducted a study in Chinese population in Singapore and Abbasi Mohadi et al. (2003)^[2] who conducted a study in Iranian population. The values obtained in present study are close to values of other studies conducted in Asian population.

Aplasia of cruciate ligaments is a very rare congenital anomaly which was first described in 1956 by Giorgi. It is typically associated with other congenital musculoskeletal disorders, congenital meniscus malformations, congenital short femur and aplasia of fibula or patella. Malformations of cruciate ligaments can either affect the anterior or both cruciate ligaments. The deficiency can occur unilaterally or bilaterally. Bilateral congenital absence of anterior cruciate ligament was reported by several authors like J.Noble M.B (1975), Barrett G.R (1988),^[3] A.P.Anderson (1992),^[4] Alessandro De Ponti (2001)^[5] and Hujun, Dushi-xin et al. (2010). Congenital anomalies of posterior cruciate ligaments are less frequent when compared to anterior cruciate ligament. Unilateral aplasia of both cruciate ligaments and an extremely narrow intercondylar notch has been reported by Mauria Balke et al. (2010).

One anomaly was found in the present study. In one limb a bundle of anterior cruciate ligament fibres was attached to intercondylar notch.

Meniscomfemoral Ligaments

Though meniscomfemoral ligaments have been described by many authors, their reports vary regarding incidence ranging from 70% to 100%, anterior from 35 to 50% and posterior from 35 to 70% with both present in 6 to 64% of the knee joints. The ligaments are variable in size with the posterior meniscomfemoral ligament larger than the anterior meniscomfemoral ligament in both sexes. The present study observations are comparable to the study of Radoievitch.

The present study showed that the two meniscomfemoral ligaments are separate structures coexisting in 19% of the knee joints with separate attachments to the posterior horn of the lateral meniscus and to the femur. The present study observations are comparable to the study of Erbagsi et al.

Transverse Ligament

Transverse ligament plays an important role in steadying of the menisci during movement and in the prevention of hyper rotation.

The present study observations are comparable to study conducted by Tubbs RS and Michelson. Transverse ligament is a source of misinterpretation of oblique tears of anterior horn of the medial meniscus as described by Sintzoff et al. 1992.^[6]

Conclusion

The cruciate ligaments are very strong ligaments and most of the knee stability is facilitated through these ligaments. The posterior cruciate ligament is broader than the anterior cruciate ligament. The variations observed in the length and width of the anterior and posterior cruciate ligaments in comparison to other studies may be due to racial differences.

The present study showed that the two meniscomfemoral ligaments are separate structures with separate attachments to the posterior horn of the lateral meniscus and to the femur.

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