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# CADAVERIC STUDY OF MORPHOLOGY AND MORPHOMETRY OF ANTERIOR CRUCIATE LIGAMENT OF HUMAN KNEE JOINT

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## Abstract:

**Background:** The incidence of anterior cruciate ligament (ACL) damage, the necessity of anatomy in surgical repair, and the propensity for the torn ACL to predispose to osteoarthritis all demand a thorough study of its architecture.

**Aim:** To study the morphology and morphometry of Anterior cruciate ligament

**Methods & Materials:** The present study was used 150 anterior cruciate ligaments from 75 human embalmed cadavers of lower limbs obtained from the anatomy departments of

Dr. D. Y Patil Medical College in Pune and DVVPF's Medical College and Hospital in Ahmednagar. After remove the skin, fascia and muscles were removed by making a longitudinal incision on each side of the knee joint capsule, identified the Anterior Cruciate ligament Measurements were taken using a digital Vernier Caliper and Statistical analysis was done by descriptive statistics as mean, SD, percentage.

**Results:** Morphological variations of ACL bundles were noted macroscopically. Mean length width and thickness of ACL on the right side was noted as 31.54±2.46, 12.59±2.95, 4.95±1.02 and on the left side it was observed as 30.12 ± 4.4, 12.33±1.18,4.72±0.82mm respectively.
**Conclusion:** The morphological and the morphometric data provided in the present study may be utilized by surgeons to use more anatomically aligned ACL transplants.

**Key words:** Knee joint, Cruciate ligaments, Morphology, Morphometry, Transplants

## Introduction:

The cruciate ligaments are so named because they cross one other in intra capsular structures. The anterior and posterior cruciate ligament attachments on the tibia are quite robust. The knee joint is a synovial joint in the body that is made up of the patello-femoral joint and the tibio-femoral joint. In the joint cavity, there are two cruciate ligaments[1]. The anterior cruciate ligament (ACL) is linked interiorly to the intercondylar portion of the tibia, and then ascends posterolaterally, twisting and fanning out to attach to the medial side of the lateral femoral condyle[2]. ACL length and breadth in adults are 38mm and 11mm, respectively. It is composed of two functional bundles, anteromedial (AM), intermediate, and posterolateral (PL), which attach to the tibia [3]. The ACL matrix is made up of highly structured collagen fibres, 90% of which are type I and 10% are type III [4]. ACL is an uncommon congenital abscence associated with dysplasia and knee joint instability[5]. In electrical investigations, ACL bundles are made up of collagen fibres that run parallel and in a periodic wave pattern. It is usually harmed in 60% of all knee injuries[6]. ACL tears, knee joint degradation, and functional instabilities are typically accompanied with osteoarthritis, medial colletaral ligaments, and medial menisci ripping[7]. ACL tears are surgically managed using a double or single bundle reconstruction procedure. Anatomical double bundle ACL repair is superior than single bundle reconstruction in surgery[8,9]. With tendon transplant procedures, we often use patellar or hamstring tendons to get an understanding of ACL architecture and morphometric measures[10]. Henceforth It is vital to have the thorough anatomical knowledge of ACL is essential for surgical repairs to orthopedic surgeons, which will lead them in the right size of the allowgraft of ACL reconstruction operation[11]**.** The goal of our research was to look at the morphology and morphometric measures of the human knee's anterior cruciate ligament (ACL).

**Material and Methods:**

The current study used 150 anterior cruciate ligaments from 75 (Males: 61; Females: 14) human embalmed cadavers of lower limbs obtained from the anatomy departments of
Dr. D. Y Patil Medical College in Pune and DVVPF's Medical College and Hospital in Ahmednagar. The anterior cruciate ligaments were approached by dissection after the skin, fascia, and muscles were removed by making a longitudinal incision on each side of the knee joint capsule. The following parameters were used: 1. the number of bundles 2. Width
3. length 4.Thicknes 5. The length and breadth of the anterior cruciate ligaments' tibial and femoral attachments .Measurements were taken using a digital Vernier Caliper and analyzed using Microsoft Excel. Descriptive statistics such as mean, SD, percentage, and so on were used for statistical analysis. For data analysis, a licensed copy of the statistical analysis programme

SYSTAT version 12 (manufactured by Crane's software, Bangalore) was utilized.

## Results

Anterior cruciate ligaments were present in all the knee joints and their attachments were normal as per the description of standard textbooks. Morphological variations of ACL bundles were macroscopically noted, as depicted in Table no.1.

Present study we observed that the minimum length of ACL was 22.23 mm and maximum was 37.42 mm.While widths minimum was 6.64 mm and maximum was 14.65mm. Minimum thickness was 1.42 mm; maximum thickness of ACL was 6.03mm. Mean ± SD of length, width and thickness of was shown in Table No 2.

In the present study we observed the ACL attachments on femoral and tibia. The mean±SD length and width of right and left anterior cruciate ligaments were given in Table no.3. There was no statistically significant difference in the measurements of right and left ACL.

The Femoral and Tibial attachments of mean± SD of length and width of right and left Anterior Cruciate ligament were as shown in Table no 4.

**Discussion:**

Understanding the architecture of the ACL is necessary due to the prevalence of ACL injuries, the significance of anatomy in surgical repair, and the possibility that a torn ACL predisposes to osteoarthritis

ACL restoration with an autograft made from hamstring tendons is required when injuries to the intraarticular components of the knee joint occur during activities like food ball and basket ball[12].The length of the ACL is critical in acquiring graft for surgical reconstruction, and data on ligament thickness at the femoral and tibial attachments provides a precise description for collecting the amount of graft from the donor location[13].

Regarding the quantity and nomenclature of the ACL fiber bundles, there is a lot of confusion. The majority of authors concur that the anterolateral and posteromedial bundles, which are anatomically and functionally separate, can be used to partition the ACL. According to certain authors, a third intermediate bundle [1, 14] Tan et al.[15] found no anatomically different bundles in the ACL and concluded that these bundles are more functional than anatomical. A flat ACL concept without any bundles has been presented by Siebold et al. [16] and Smigielski et al. [17]

The morphology and morphometry of the ACL in the human knee joint were examined in the current study. The ACL was divided into single, double, three, and four bundles for classification.as shown in (table1). The most frequent ACL ligaments that was observed were double (86.6%) and very rarely four bundles. The current study, however, has clearly discovered and verified the presence of three unique ACL bundles, each of which has a different location, length, and fibre orientation. Ferretti et al.[18], who have also confirmed the existence of three anatomical bundles by gross anatomy and histology, made similar observations to those observed in the current study[5,6], and our results are consistent with theirs. In contrast to what was seen in the present investigation, the nomenclature of these bundles as stated by the majority of writers and conventional anatomy textbooks differs. The two bundles have been referred to as anteromedial

and posterolateral by authors who have characterized them. The current nomenclature will undoubtedly change with the documentation of the fourth bundle. The posterolateral bundle, a small but consistent bundle that is clearly distinct from the other three in these investigations, appears to have been neglected.

We measured the ACL's length, breadth, and thickness in both the right side and left side of the body for the current study (Table 2). In the current investigation, there was no discernible right-left difference in any of the study measures.

In the current study, we measured the ACL's length, breadth, and thickness in males and females. After statistical analysis, there is no significant difference found in length width and the thickness among the genders (Table 3)

AMB length on the right side was reported by SakkaraiJayagandhi[19]to be 36.09 mm, while PLB length in the right side was reported to be 29.23 mm and left side to be 28.18 mm. The anterior cruciate ligament's AMB and PLB were not measured in the current investigation.

Yellicherla[20] noticed the average length& width in both male and female as 43.5mm, 12.1mm & 41.9mm, 11mm respectively. While Girgis FG et al (1975)[2] observed the length of 31.38mm and the width of 10mm in their study for ACL. Geetha rani et al[21]. Claimed that the average ACL length was 37.14 ± 3.916, however the current investigation found lower values 31.54±2.46, 30.12 ± 4.4 of right and left side respectively. The length of the ACL in the present study is in correlation with study conducted by Grigis et al [2] (1975) &Odenstein et al[22] (1985)

The width of the ACL in the present study is 12.59±2.95mm &12.59±2.95mm on respective right and left sides & is co-inciding with the observations made by Grigis et al [2] (1975) ,Yellicherla et al [20](2014) ,Sampath kumar et al[23] (2019)while the width observed by Iriuchishima T et al [24] (2010), Awadelcsied et al[25] (2015) , Rajarshi Dutta et al[26] (2017)fall under a lower values as compared with the present study.

The thickness in the present study was found to be 4.95±1.02mm & 4.72±0.82 respectively on right and left sides. There was no earlier literature available on the thickness of the anterior cruciate ligament. This research can contribute to the body of knowledge concerning the morphometry of the cruciate ligaments of the knee joint.

**Conclusion:**

In conclusion, it was found that the ACL consists of a complex of spirally structured bundles of varying lengths, width and thickness. It is theorized that this unusual configuration facilitates simultaneous rotation in extension and resistance to translation at various degrees of knee flexion. Further investigations utilizing finite element analysis are required to confirm the data. This information may potentially be used by surgeons to use more anatomically aligned ACL transplants. This information will be useful for understanding the biomechanics and selecting the appropriate graft size for cruciate ligament restoration. The study will be more appropriate if MRI and other 3D imaging systems are used to assess the ligaments' morphology in more detail.

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**Table No.1: Showing number of bundles of Anterior Cruciate ligament**

| No. of Bundles | One Bundle | Two Bundles | Three Bundles | Four Bundles |
|---|---|---|---|---|
| 'n' | 1 | 129 | 17 | 3 |
| Percentage | 0.66% | 86% | 11.34% | 2% |

**Table No 2: Showing the average length, width and thickness of right and left Anterior Cruciate ligament**

| Parameters | Length of ACL (mm) | Width of ACL (mm) | Thickness of ACL (mm) |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD |
| **Right** | 31.54±2.46 | 12.59±2.95 | 4.95±1.02 |
| **Left** | 30.12 ± 4.4 | 12.33±1.18 | 4.72±0.82 |

**Table No.3 Showing Average length, Width, and thickness of Male and Female Anterior cruciate ligament**

| Parameters | Gender | ACL | |
|---|---|---|---|
| | | Mean ± SD | 'p' value |
| Length of ACL (mm) | Male | 30.86±3.57 | p=0.1124, not significant |
| | Female | 30.88±2.11 | |
| Width of ACL (mm) | Male | 12.52±2.05 | p=0.3242, not significant |
| | Female | 12.26±1.00 | |
| Thickness of ACL (mm) | Male | 4.83±0.98 | p=0.2258, not significant |
| | Female | 4.92±0.83 | |

**Table No 4: Showing the Femoral and Tibial attachments of mean± SD of length and width of right and left Anterior Cruciate ligament**

| Parameters | ACL | | |
|---|---|---|---|
| | Side | Femoral attachment | Tibial attachment |
| | | Mean ± SD | Mean ± SD |
| Length | Left | 17.97±2.32 | 16.14±2.85 |
| | Right | 16.97±2.65 | 15.98±3.41 |
| Width | Left | 11.06±2.05 | 11.08±1.63 |
| | Right | 10.87±1.94 | 10.71±1.55 |

**TableNo.5: Comparision of length width & thickness of Anterior cruciate ligament present study with the previous studies.**

| Author | Length (mm) | | Width (mm) | Thickness (mm) |
|---|---|---|---|---|
| | | | | |
| Yellicharla AK et al ( 2014) | Male | 43.5 | 12.1 | - |
| | Female | 41.9 | 11 | - |
| Geetha rani et al (2019) | 37.14 ± 3.916 | | 5.2±1.094 | - |
| Girgis FG et al (1975) | 31.38 | | 10 | - |
| Grays (2008) | 38 | | 11 | - |

| | | | | |
|---|---|---|---|---|
| **Odenstein et al (1985)** | 32±3 | | - | - |
| **Awadelcsied et al (2015)** | 37 | | 5 | - |
| **Iriuchishima T et al (2010)** | 32.28 | | 3 | |
| **Sampath kumar et al (2019)** | **Right** | 28.53±1.691 | 10.23 ±0.651 | - |
| | **Left** | 28.06±1.571 | 10.33±0.872 | - |
| **Gillquist et al (1996)** | 32 | | | |
| **Rajarshi Dutta et al (2017)** | **Right** | 20.06 | 6.23 | |
| | **Left** | 20.02 | 6.54 | |
| **Present study** | **Right** | 31.54±2.46 | 12.59±2.95 | 4.95±1.02 |
| | **Left** | 30.12 ± 4.4 | 12.33±1.18 | 4.72±0.82 |

**Figure 1.Showing anterior view of knee in flexion presenting Anterior cruciate ligament**

**Figure 2.Showing length of anterior cruciate ligament with Digital vernier calliper**


**Figure3.Showing width of anterior cruceiate ligament with Digital vernior calliper**


- **Figure 4.Right side .ACL showing -1 Bundle**

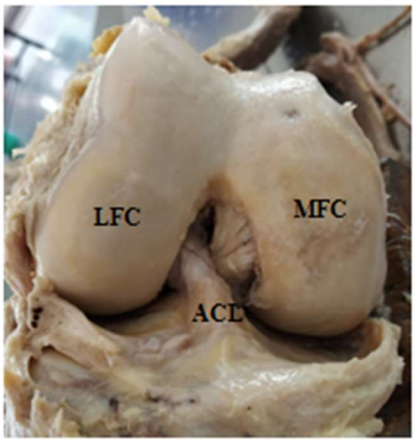


**Figure 5. Left side .ACL showing - 2 Bundles**

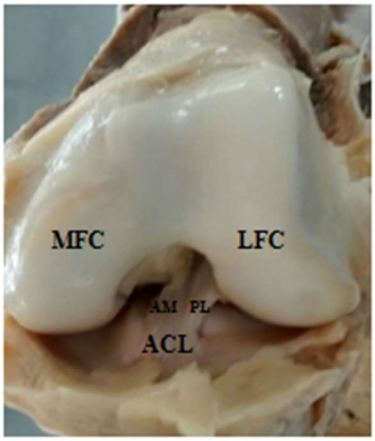

**Figure 6. Left side ACL showing – 3 Bundles**

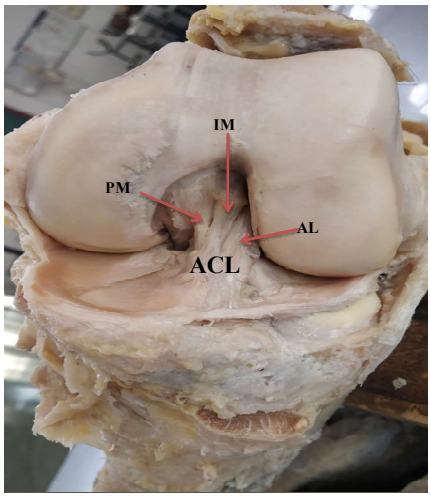


**Figure 7. Left side. ACL showing – 4Bundles**