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Original Research Article

Assessment of Anterior Cruciate Ligament Thickness in Patients Attending a Tertiary Care Hospital in North Kerala, India by MRI: A Cross-Sectional Study

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ABSTRACT

Background
The anterior cruciate ligament (ACL) helps in the stabilization of the knee joint. Anterior cruciate ligament injury is a very common condition and its improper management may lead on to long-term knee dysfunction. Thickness of ACL can be correlated with the ligament's strength, stability, integrity and susceptibility to injury. There is a lack of data in literature regarding the normal variation in anterior cruciate ligament thickness. This study aims to assess the thickness of ACL in individuals who attended a tertiary care hospital in North Kerala, India.

Methods
This is a retrospective cross-sectional analysis conducted at department of Radiodiagnosis, MES Academy of medical sciences using 1.5 Tesla MRI. The study included a total of 80 patients, consisting of 40 males and 40 females. The thickness of the ACL was measured at the mid-substance level. The measurements were made on axial and sagittal images.

Results
In patients studied between the age group of 20-60, the mean thickness of ACL at sagittal plane (AP diameter) was 7.9 ± 1.1 mm in males and 7.3 ± 1.0 mm in females, and the mean thickness of Anterior cruciate ligament in axial plane (transverse diameter) was 5.0±0.7 mm in males and 4.7± 0.6 mm in females. The Anterior cruciate ligament was found to be more thicker in males than in females irrespective of the age. ACL thickness varies significantly between sexes and also with age, with the greatest variance in the antero-posterior measurements.

Conclusion
ACL was found to be more thicker in males than in females in our study population. The mean AP and transverse diameter of anterior cruciate ligament is seen to decrease with age in females.

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Keywords: MRI, anterior cruciate ligament(ACL), anterior cruciate ligament thickeness, sagittal, coronal.

INTRODUCTION

The anterior cruciate ligament (ACL) plays an important role in the stabilization of the knee joint. It helps in controlling the anterior movement of the tibia with respect to the femur, prevents excessive rotation, and provides stability to knee during dynamic activities. Anterior cruciate ligament injury is a very common condition, especially among sport persons. It may lead on to long-term knee dysfunction and morbidity if not properly managed.(1)

Thorough understanding of the structural integrity of the ligament is one of the major factors in the diagnosis and management of ACL injuries. It can be influenced by various factors, including age, gender, activity level, and ethnicity.(2)

Magnetic Resonance Imaging (MRI) is considered as the investigation of choice in non-invasive imaging for assessing soft tissue structures around the knee, including the ACL.

MRI helps in detailed visualization of the ligament morphology, including its shape, size and integrity, making it an important and indispensable tool in the diagnosis of ACL injuries and pathologies.

Thickness of ACL ,which can be assessed by MRI can be correlated with the ligament's strength, stability, integrity and susceptibility to injury.(3)

However, there is a lack of data in literature regarding the normal variation in anterior cruciate ligament thickness across different populations, especially in regions where ethnic and genetic factors may influence ligament size and structure.

As the prevalence of ACL injuries are keeping on increasing and as the MRI being used widely for diagnostic purposes, it is of utmost importance to have a baseline data for ACL thickness in these populations, which may aid in the early detection, diagnosis, and treatment of ACL injuries.

This study aims to assess the ACL thickness in individuals who attended a tertiary care hospital in North Kerala and analyse the variation in the same among sexes and in various age groups. The study is conducted in the department of Radiodiagnosis using 1.5 Tesla MRI.

MATERIALS AND METHODS

This study is a retrospective cross-sectional analysis conducted at MES Academy of medical sciences, a tertiary care hospital in North Kerala. The study aimed to assess the thickness of the anterior cruciate ligament (ACL) in a population of patients using 1.5 Tesla MRI.

Study Population

The study included a total of 80 patients, consisting of 40 male and 40 female participants, who underwent knee MRI between January 2022 and December 2023. All participants were selected based on the following inclusion and exclusion criteria:

Inclusion Criteria

1. Patients aged 20 to 60 years.
2. Both male and female patients who underwent knee MRI as part of routine diagnostic work-up.
3. Patients who had no prior history of ACL injury, knee surgery, or any known knee pathology that might alter ACL morphology (e.g., osteoarthritis or ACL surgery).
4. Patients with no contraindications to MRI scanning.

Exclusion Criteria

1. Patients with previous ACL surgery

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2. Patients with any prior significant knee ligament or meniscal injury.
3. Patients with other knee joint pathologies such as osteoarthritis or neoplasms.
4. Patients with metallic implants, pacemakers, or other contraindications for MRI.

Data Collection

The relevant patient data were retrieved from the hospital's PACS (picture archiving and communication system). The demographic information, including age, gender, and clinical history were noted for each patient.

The studies were executed on a superconducting 1.5-T Siemens Magnetom Avanto MR unit using dedicated knee array coils. Our protocol included: axial proton density fat-suppressed, sagittal proton density fat-suppressed, coronal proton density fat-suppressed, axial T2 weighted, sagittal T2 weighted and coronal T1 weighted sequences. The researchers reviewed each patient's MRI and evaluated the anterior cruciate ligament in detail.

Images were reviewed by two experienced radiologists. The radiologists performed the following measurements:

Measurement of ACL Thickness

The thickness of the ACL was measured at the mid-substance level. The measurements were made on axial and sagittal images using the following technique:

1. **Sagittal Plane**: The ACL thickness was measured from the anterior to the posterior margins of the ligament at its mid-substance on a well-aligned sagittal image.
2. **Axial Plane**: The axial plane was also assessed, with thickness measured at the mid-substance of the ligament.

Figure 1- sagittal T2W image showing anterior cruciate ligament as a linear hypointense structure

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Figure 2- axial T2W image showing anterior cruciate ligament as a an ovoid hypointense structure

Figure 3- sagittal PDFS image showing anterior cruciate ligament as a linear hypointense structure

RESULTS

In patients studied between the age group of 20-60, the mean thickness of ACL at sagittal plane (AP diameter) was 7.9 ± 1.1 mm in males and 7.3 ± 1.0 mm in females (Table I and Table II), and the mean thickness of Anterior cruciate ligament in axial plane (transverse diameter) was 5.0±0.7 mm in males and 4.7± 0.6 mm in females (Table I and Table II). The Anterior cruciate ligament was found to be more thicker in males than in females irrespective of the age.

Table I: Descriptive Statistics (Males)					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
AP (mm)	40	5.6	10.0	7.913	1.1503
TR (mm)	40	3.6	7.1	5.023	.7820

Table 2 : Descriptive Statistics (Females)					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
AP (mm)	40	5.2	9.8	7.380	1.0629
TR (mm)	40	3.2	6.5	4.750	.6349

In general, the mean AP diameter of anterior cruciate ligament in the age group 20-30 years was 7.8 ±1.0 mm, 31-40 years was 7.3 ± 1.3 mm, 41-50 years was 7.4 ± 0 .9 mm and 51-60 years was 7.9 ± 1.0 mm and the mean transverse diameter of anterior cruciate ligament in the age group 20-30 was

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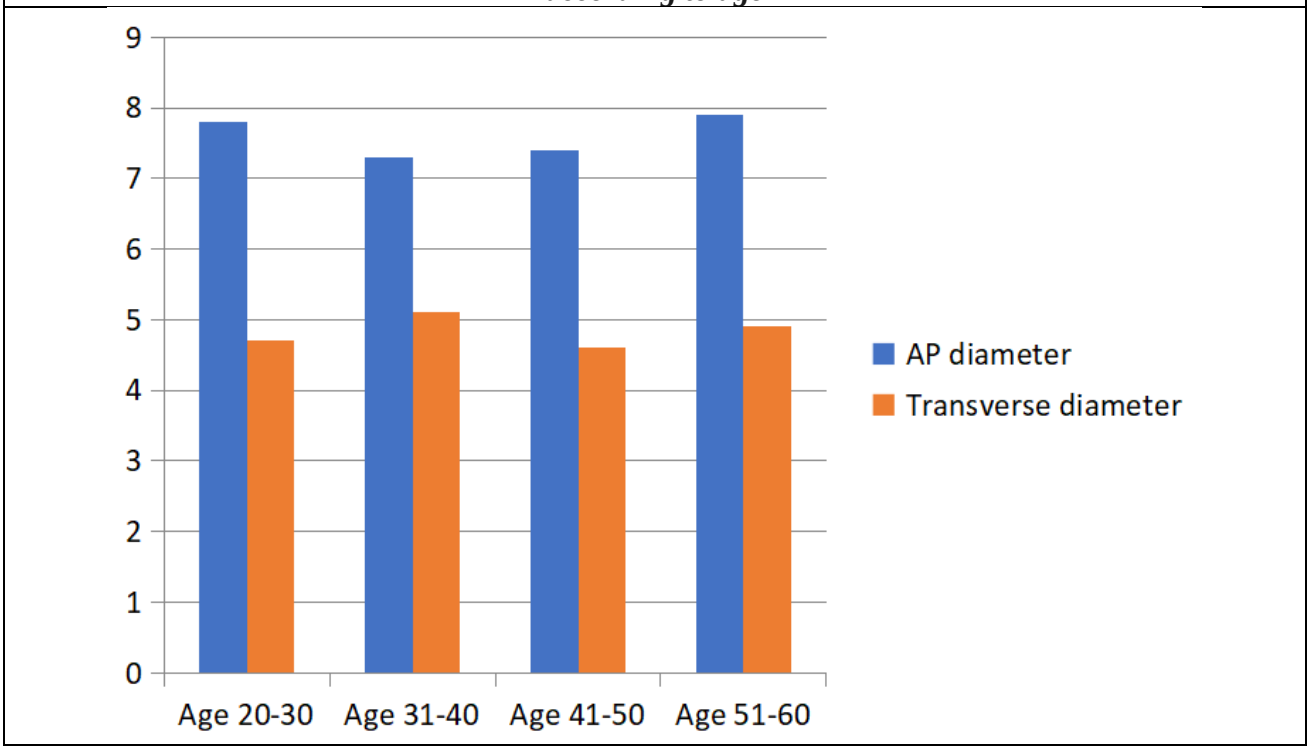
4.7 ±0.7 mm, 31-40 years was 5.1 ± 0.8 mm, 41-50 years was 4.6 ± 0 .5 mm and 51-60 years was 4.9 ± 0.7mm. Maximum thickness of anterior cruciate ligament in AP diameter was found in the age group of 51-60 years and in transverse diameter between 31-40 years.

From figure 4, it is evident that anterior cruciate ligament thickness in AP diameter tends to slightly decrease from age 20-30 to 31-40 and thereafter the thickness is seen to increase with age. The maximum thickness is seen in age group 51-60 years. There is no much difference in transverse diameter with age.

Figure 4: antero-posterior and transverse diameter of anterior cruciate ligament in general according to age



In males, the mean AP diameter of anterior cruciate ligament in the age group 20-30 was 7.9 ±1.1 mm, 31-40 years was 7.4 ± 1.1 mm, 41-50 years was 7.8 ± 1 .0 mm and 51-60 years was 8.5 ± 1.1 mm. The mean transverse diameter of anterior cruciate ligament in the age group 20-30 was 4.8 ±0.8 mm, 31-40 years was 5.2 ± 0.8 mm, 41-50 years was 4.8 ± 0 .5 mm and 51-60 years was 5.1 ± 0.8 mm respectively as depicted in Figure 4.

Figure 5: Antero-posterior and Transverse diameter of anterior cruciate ligament in males according to age

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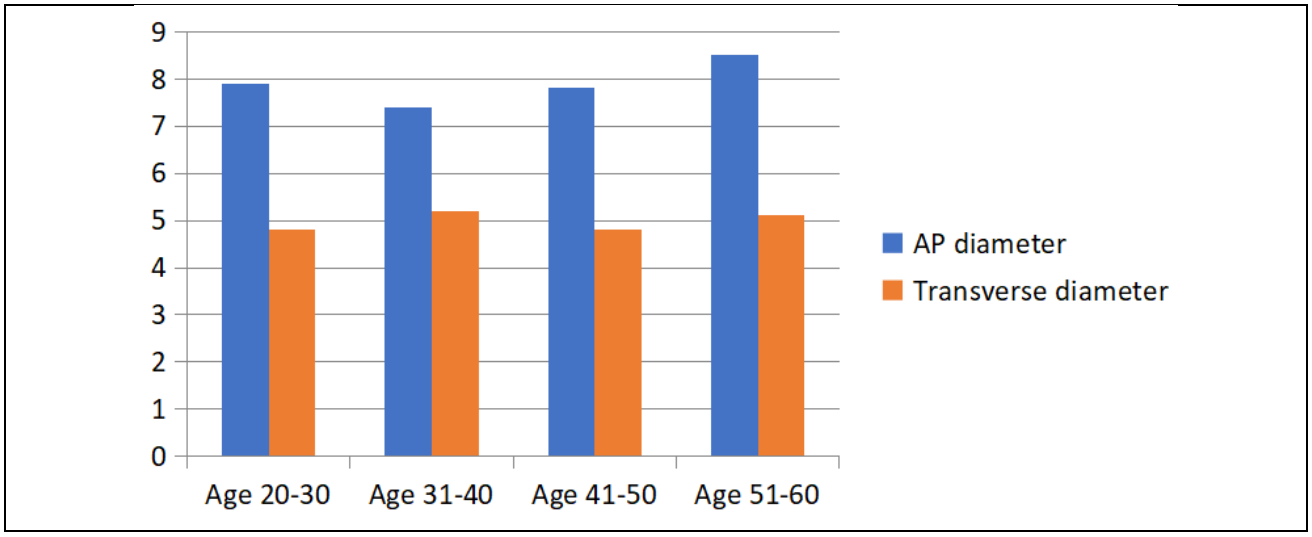
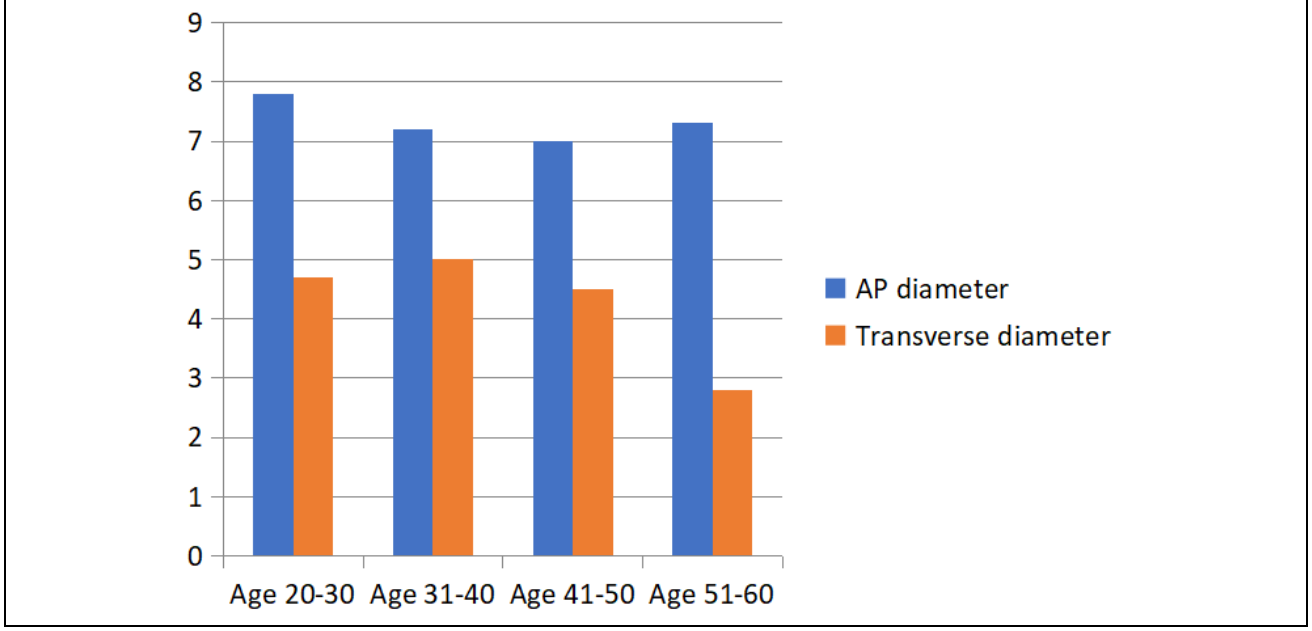


From Figure 5, it is evident that AP diameter of anterior cruciate ligament is seen to increase with age in males after 30 years. There is no much difference in transverse diameter with age.

In females, the mean AP diameter of anterior cruciate ligament in the age group 20-30 was 7.8 ±0.9 mm, 31-40 years was 7.2 ± 1.5 mm, 41-50 years was 7.0 ± 0.7 mm and 51-60 years was 7.3 ± 0.6 mm and the mean transverse diameter of anterior cruciate ligament in the age group 20-30 years was 4.7 ±0.5 mm, 31-40 years was 5.0 ± 0.7 mm, 41-50 years was 4.5 ± 0.6 mm and 51-60 years was 4.6 ± 0.5 mm respectively, as depicted in figure 5.

Figure 6: Antero-posterior and Transverse diameter of Anterior cruciate ligament in females according to age



From Figure 6, it is seen that mean AP diameter of anterior cruciate ligament is seen to decrease with age in females till 50 years and the transverse diameter decreases after 30 years.

DISCUSSION

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In this study, we found that ACL thickness varies significantly between sexes and also with age, with the greatest variance in the antero-posterior measurements. Specifically, ACL thickness in males was greater than that in females across ages and reached its greatest value for the 51-60 year age group.

Further, we identified sex-specific differences in the AP and Transverse diameter. There was significantly greater AP and transverse diameter in males compared to females.

The size of the ACL tends to be larger in males compared to females. Chandrasekhar et al, Hashemi J et al, Pujol N et al and Muneta Y et al in their studies found that the length[1,2], cross sectional area[3,4], and volume[1,2] have been found to be larger in males. Differences due to sex may be confounded by other variables such as height and weight, both of which have been shown to correlate positively with ACL size[1,5]. Anderson et al. found that ACL area normalized to total body mass remained about 15% larger in males than in females[6]

At the middle third of the ACL, Kupczik et al.[7] found a mean thickness of 4.8 mm using MRI examinations, while Anderson et al.[6] found a mean frontal thickness of 4.75 mm in women and 5.6 mm in men, and a mean sagittal thickness of 7.6 mm in women and 8.7 mm in men.

According to previous studies, the relative incidence of anterior cruciate ligament injuries has been reported to be significantly higher in females than in males.[8] From our study we found out that ACL is more thinner in females than in males which can be a reason for this.

We also found that the AP diameter of Anterior cruciate ligament is seen to increase with age in males and there is not much difference in transverse diameter. On the contrary, mean AP and transverse diameter of anterior cruciate ligament is seen to decrease with age in females. These findings build upon current knowledge in the field of human ACL thickness and also increased incidence of ACL injuries in females than in males. Yool cho et al in their study stated that receptors for estrogen and progesterone is present in human ACL fibroblasts. These cells produce collagen, which is critical for the load-bearing capacity of ACLs. Estrogen inhibits the formation of collagen by ACL fibroblasts, reducing the load-bearing capacity of ACLs. This therefore increases the probability of ACL injury due to reduced thickness of ACL in females than in males.[9]

Findings in this study mirror previously reported changes in ACL thickness between ages and sexes. Our data on ACL thickness for ages from 20-60 fit within reported ranges from prior studies[10] with improved understanding of sex- and age-specific changes in ACL thickness, improvements in injury prevention programs, diagnostics, and treatment plans may be possible.

CONCLUSION

In summary, age- and sex-specific changes occur in the thickness of ACL during human growth. ACL was found to be more thicker in males than in females in the population we studied. We also found that the mean AP and transverse diameter of anterior cruciate ligament is seen to decrease with age in females . Taken together, these changes suggest that female populations may require highly individualized consideration in order to understand ACL injury risk, diagnostics, and treatments.

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REFERENCES

1. Chandrashekar N, Slauterbeck J, Hashemi J. Sex-based differences in the anthropometric characteristics of the anterior cruciate ligament and its relation to intercondylar notch geometry: a cadaveric study. Am J Sports Med. 2005 Oct;33(10):1492–8. Epub 2005 Jul 11. [PubMed: 16009992]
2. Hashemi J, Mansouri H, Chandrashekar N, Slauterbeck JR, Hardy DM, Beynnon BD. Age, sex, body anthropometry, and ACL size predict structural properties of the human anterior cruciate ligament. J Orthop Res. 2011 Jul;29(7):993–1001. Epub 2011 Jan 18. [PubMed: 21246609]

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3. Pujol N, Queinnec S, Boisrenoult P, Maqdes A, Beaufils P. Anatomy of the anterior cruciate ligament related to hamstring tendon grafts. A cadaveric study. Knee. 2013 Dec;20(6):511–4. Epub 2012 Nov 15. [PubMed: 23157968]
4. Muneta T, Takakuda K, Yamamoto H. Intercondylar notch width and its relation to the configuration and cross-sectional area of the anterior cruciate ligament. A cadaveric knee study. Am J Sports Med. 1997 Jan-Feb;25(1):69–72. [PubMed: 9006695]
5. Fayad LM, Rosenthal EH, Morrison WB, Carrino JA. Anterior cruciate ligament volume: analysis of gender differences. J Magn Reson Imaging. 2008 Jan;27(1):218–23. [PubMed: 18050351]
6. Anderson AF, Dome DC, Gautam S, Awh MH, Rennirt GW. Correlation of anthropometric measurements, strength, anterior cruciate ligament size, and intercondylar notch characteristics to sex differences in anterior cruciate ligament tear rates. Am J Sports Med. 2001 Jan-Feb;29(1):58– 66. [PubMed: 11206258]
7. Fabiano Kupczik[a], Marlus Eduardo Gunia Schiavon[b], Bruno Sbrissia[b], Rodrigo Caldonazzo Fávaro[b], Rafael Valério[c], ACL ideal graft: MRI correlation between ACL and humstrings, PT and QT. PubMd.2013 Oct 18;48(5):441–447. doi: 10.1016/j.rboe.2012.11.002
8. Rizzo M, Holler SB, Bassett FH 3rd. Comparison of males' and females' ratios of anterior-cruciate-ligament width to femoral-intercondylar-notch width: a cadaveric study. Am J Orthop (Belle Mead NJ). 2001 Aug;30(8):660-4
9. Gender disparity in anterior cruciate ligament injuires, Yool Cho, Sahnghoon Lee1, Yong Seuk Lee2, Myung Chul Lee. Arthrosc Orthop sports med 2014;1:65-74, July1, 2014.
10. Size and Shape of the Human Anterior Cruciate Ligament and the Impact of Sex and Skeletal Growth, Stephanie G. Cone, BS1,2,*, Danielle Howe, BS1,2,*, Matthew B. Fisher, PhD1, JBJS Rev. 2019 June ; 7(6): e8.