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Original Research Article

THE MORPHOMETRIC STUDY AND SITES OF ATTACHMENTS OF ANTERIOR CRUCIATE LIGAMENT: A CADAVERIC STUDY

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ABSTRACT

Background: Most frequently injured structure is the anterior cruciate ligament (ACL) during sporting activities. This injury of anterior Cruciate ligaments has long term effects on movement of knee joint because of osteoarthritis and instability of joint which affects the normal gait. The Cruciate ligament reconstruction has become a widely accepted procedure over the past few years. Reconstruction of joint by surgery aims to restore the normal walking and stabilization of the injured knee. Hence, surgeons should have detailed anatomical knowledge for the reconstruction of cruciate ligaments. So for this surgery, various morphometric parameters of anterior cruciate ligament are necessary. This detailed anatomy of ACL will guide the surgeon to select proper size of the graft for the reconstruction. The aim and objective is to measure morphometric dimensions of the ACL, to estimate morphometry and variations of right and left anterior cruciate ligament footprints (attachments) and to compare the Morphometric parameters of anterior cruciate ligaments of both sides.

Materials and Methods: Cross-sectional study was done on sixty-two adult cadaveric knee specimens by dissection, out of sixty-two specimens, thirty-two of right and thirty of left side were studied. The dimensions of anterior cruciate ligaments measured were length, anteroposterior and transverse width close to the attachments on femur and tibia. Same measurements were also noted at middle of both attachments. Length and width of tibial and femoral foot print (attachment) were noted. 'Digital Vernier Caliper' of 0.1mm precision was used for all parameters. The statistical analysis of all the parameters was done by using SSPS, version 16.

Results: The mean length of ACL was 36.62±1.56 mm. Average anteroposterior diameters of ACL were 6.79±1.32 mm on femoral aspect, 10.92±1.33 mm in the middle and 12.74±1.57 mm on tibial aspect. Average transverse diameters of ACL were 9.05±0.99 mm on femoral aspect, 10.66±1.39 mm on middle and 12.30±1.66 mm on tibial aspect. The mean transverse and anteroposterior diameters of tibial footprint of ACL were noted as 14.27±1.64 mm and 12.82±1.43 mm. The average anteroposterior and transverse measurements of femoral footprint of ACL were 18.19±2.98 mm and 7.29±1.22 mm respectively.

Conclusion: The mean length of ACL on right and left side was similar. The anteroposterior diameter and transverse diameter of ACL was progressively increasing from femoral to tibial aspect on both sides. Difference between respective parameters of both sides of the ACL were not significant. Position of tibial footprint site of anterior cruciate ligaments showed variation on both side. Position of femoral footprints of ACL on right and left side were statistically similar.

Keywords: Morphometry; Cruciate ligament; Footprint & Reconstructive surgery.

INTRODUCTION

Knee joint is formed tibia, femur and patella. Tibia and femur are connected by pair of ligaments which cross each other. They are in the form of anterior and posterior Cruciate ligaments. Both are situated inside the capsule of knee joint. They are covered by synovial membrane of joint anteromedially and anterolaterally but not posteriorly, it appears that ligaments as if they invaginated the membrane from this side. Anterior and posterior cruciate ligaments are rounded strong bands of the knee joint and extends from the upper surface of the tibia to the intercondylar area of the femur. Both ligaments are intracapsular of which anterior cruciate ligament (ACL) is lateral and posterior cruciate ligament (PCL) is medial the joint capsule. These ligaments cross each other inside the joint between femoral and tibial attachments and hence called cruciate. The point of crossing is located somewhat posterior to the Centre of articular surfaces. ACL and PCL are attached to nonarticular areas of upper surface of tibia anteriorly and posteriorly and so named as anterior and posterior cruciate ligaments.[1]

The ACL attachment is to a facet on intercondylar area between anterior horns of medial and lateral menisci. The ligament extends postero-superiorlly and laterally, twisted on itself and is attached to lateral femoral condyle on its posteromedial aspect in the intercondylar area of lower end of the femur. The average length of ACL is 38 mm and the width is of 11 mm in adults on both the sides.[1] Functional bundles of ACL that may be demonstrated by microdissection but are not apparent to the naked eye.[1] These bundles can be named depending on their attachment to tibia as anteromedial, intermediate and posterolateral.[2] ACL is key structure for the stability of the knee joint as it prevents anterior tibial displacement and rotation in weight bearing position.[3-5]

The most frequently injured ligament is ACL during sports of high impact.[6] Reconstruction by surgery aims to stabilize the injured knee for normal gait. During the last few years, ACL reconstruction has become a widely performed and accepted. ACL anatomy is required during surgical reconstructions to know the functional role of it. Absence of ACL congenitally is usually associated with lower limb dysplasia may be the cause of instability of the knee joint, though it is very rare.[1]

During surgical reconstruction, to place the graft correctly requires knowledge of anatomy of ACL.[7] Hence for the surgical repair of anterior cruciate ligaments, detailed anatomical knowledge of it is necessary for the procedure. should have detailed anatomical knowledge about various morphometric parameters of ACL. This may guide them to choose appropriate size of the graft to be use during the reconstruction.[8]

MATERIALS AND METHODS

Cross-sectional study was done on total sixty-two adult cadaveric knee specimens. Out of these specimens, thirty-two of right and thirty of left side were identified. The study was conducted in Anatomy Department in private Medical Colleges in Maharashtra at Pune and Sangli. The gender of specimens were unknown. Knee specimens with ACL tear, macroscopic degenerative changes and trauma were excluded from the study.

All specimens were dissected according to the method described by Cunningham's practical manual Volume-II (16th edition) to explore the ACL. For the measurements of ACL, the knee was positioned in 90 degrees flexion with the help of goniometer. The ACL length was measured between its attachment to femur and tibia. Anteroposterior and transverse diameters of ACL were noted close to femoral, tibial aspect and in the middle of its attachments. For obtaining various measurements of footprint the cruciate ligament was cut from its bony attachment and coloured ink skin marker was used to outline the attachment sites (footprint). The length and diameter of femoral and tibial footprint were measured. The parameters of the tibial footprints of cruciate ligament were measured from their anterior, posterior, medial and lateral margin to articular margin of tibia. All the dimensions were measured by the Digital Vernier caliper with precision 0.01 mm. All measurements were analyzed in 'SPSS Version 16' software.

The following parameters of anterior cruciate ligaments were studied. For ACL we measured length (ACL-L) between femoral and tibial attachments, Anteroposterior diameter close to femur (ACL-AP-F), in middle (ACL-AP- M) & close to tibia (ACL-AP-T).

Transverse width (ACL-W) of ACL was measured close to femur (ACL-W-F), in middle (ACL-W-M) & close to tibia (ACL-W-T)

The Transverse diameter (ACL-TFP-T) & Anteroposterior diameter (ACL-TFP-A) of ACL tibial footprint was measured [Figure 1]. And the length (ACL-FFP-L) and width (ACL-FFP-W) of ACL femoral footprint were also measured.

RESULTS

During present study, it is observed that the mean length of ACL of right and left were 36.49±1.17 mm and 36.76±1.91 mm respectively and average was 36.62±1.56 mm.

The mean anteroposterior diameter of the ACL was found to be 6.79±1.32 mm on femoral aspect, 10.92±1.33 mm in the middle and 12.74±1.57 mm on tibial aspect. The anteroposterior diameter of ACL was progressively increasing from femoral to tibial aspect on right and left side. The comparison of anteroposterior diameter of ACL at femoral aspect, middle and tibial aspect showed significant difference (P=0.00). Above statistical analysis

showed progressive increase in anteroposterior diameter from femoral to tibial aspect. The bilateral comparison of anteroposterior diameter of ACL at femoral aspect, middle and tibial aspect were statistically not significant.

The mean transverse width of ACL was 9.05±0.99 mm at femoral aspect, 10.66±1.39 mm in the middle and 12.30±1.66 mm at tibial aspect. The comparison of transverse width of ACL at femoral aspect, middle and tibial aspect showed significant difference (P=0.00). Above statistical analysis showed progressively increased in transverse width from femoral to tibial aspect. The bilateral comparison of respective transverse width of ACL at femoral aspect, middle and tibial aspect were statistically non-significant.

The mean transverse diameter and anteroposterior diameter of tibial footprint of anterior cruciate ligament were 14.27±1.64 mm and 12.82±1.43 mm respectively. Position of tibial footprint site of anterior cruciate ligament showed variation on right and left side. Out of 32 right sided tibial footprints of anterior cruciate ligament, 14 (43.75%) were present towards the medial aspect and 18 (56.25%) were present towards the lateral aspect. While, on the left side (n=30), 16 (53.33%) were present towards the medial aspect, 1 (3.33%) was present at the center and 13 (43.33%) were present towards the lateral aspect. [Table 1 and 2]

The femoral footprint anteroposterior length of ACL on right and left side did not show statistically significant difference. The average mean anteroposterior length of ACL footprint was 18.19±2.98 mm. The femoral footprint width ACL on right and left side was almost same. The average mean width of ACL was 7.29±1.22 mm. [Table 1].

Table 1: Tibial and Femoral footprint of ACL (mm).

	Parameters	Mean	Std. Deviation	Range
Tibial footprint	Transverse width	14.27	1.64	11.03- 16.56
	Antero-posterior length	12.82	1.43	08.62-15.39
Femoral footprint	Length	18.19	2.98	13.70-28.43
	Width	7.29	1.22	5.10-9.98

Table 2: Variations of position of tibial footprint of ACL in mm.

Footprint Position	Right(n=32)			left(n=30)		
	Medial	Central	Lateral	Medial	Central	Lateral
Numbers	14	0	18	16	1	13
Percentage	43.75 %	0 %	56.25 %	53.33 %	3.33 %	43.33 %

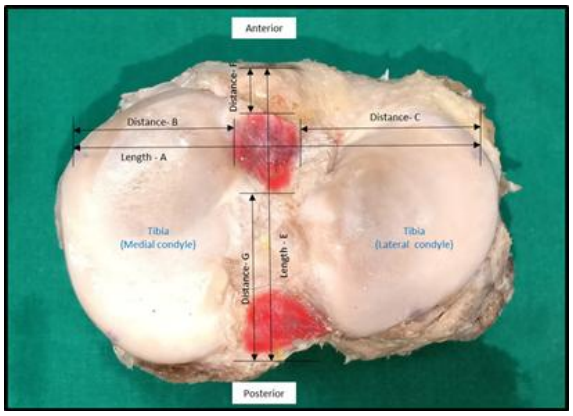

Figure 1: Tibial footprint Parameters of anterior cruciate ligament

DISCUSSION

Knee injuries are common in high impact sport activity.[6] The cruciate ligaments tear is mainly responsible for instability of joint and affects normal gait. Cruciate ligament tears are managed surgically by cruciate ligament reconstruction technique, which is helpful to restore joint stability and normal gait. So, our quantitative data of the ACL can be helpful for the ACL reconstructive surgeries.

In the present study, we noted the parameters as length, anteroposterior and transverse diameters, tibial and femoral footprint measurements of ACL. The anteroposterior diameter and transverse diameter observed at three places at femoral aspect, tibial aspect and between them. We also observed position of tibial footprint of ACL. In addition, we compared all the respective parameters bilaterally.

In the present study, we observed ACL-L was 36.49±1.17 mm on right side, 36.76±1.91 mm on left side and average was 36.62±1.56 mm. Which was higher than values noted by Hosseini et al,[9] Saxena A et al,[10] Wang et al,[11] Tylor et al,[12] Utturkar et al,[13] Zyl et al,[14] Guenoun et al,[15] Kumar et al,[8] Sangeeta et al.[16] However, length of anterior cruciate ligament in Stijak et al,[17] and Yelicharla et al,[18] 37.14±3.91 mm, 42.6±3.0 mm respectively and Geetharani et al,[19] in male and female were 43.5+4 mm and 41.9+3.9 mm, which were higher than values of present study. Our observations of ACL-L were similar to the study of Wang et al,[11] and Sangeeta et al. [16]

ACL tear was very common in sporting activities, car or vehicle accidents. Sometime ACL can be injured due to hyperextension. Length of ACL was important for selection of tendon graft for ACL reconstruction. [6,10,20]

Many researchers, [6,8,10,16,18,19] observed maximum width of ACL but they did not measure it at femoral aspect, middle and tibial aspect.

We compared anterior cruciate ligament width at middle (ACL-W-M) with previous study. In our study ACL-W-M was 10.83±1.39 mm on right, 10.49±1.39 mm on left side and 10.66±1.39 mm average of both sides. Which is similar to width

obtained by Kumar et al,[12] Jayagandhi et al,[6] Saxena A. et al. [10] Geetharani et al,[19] observed ACL width which was smaller as compare to present study. However, width of anterior cruciate ligament in Gray's,[1] Yelicharla et al,[18] and Sangeeta et al,[16] were higher than present study.

Present study, revealed that the tibial footprint length of ACL as 12.82±1.43 mm. these measurements are coinciding with value noted by Yelicharla et al.[18] Tibial footprint length of anterior cruciate ligament noted by Jayagandhi et al,[6] Saxena A. et al,[10] Kulkamthorn et al,[21] and Iyaji et al,[20] was15.36±2.33 mm, 18.34±3.49 mm, 15.36±2.33 mm and 14.2 mm respectively, which were higher than present study.

For ACL reconstruction, using either the single bundle technique or the double bundle approach, tunnels are drilled straight through the original attachment site (footprints) after the graft has been placed anatomically.[22] Tibial footprints size has a role in deciding the technique to be selected.[23] If tibial attachment size of ACL if smaller than 14mm, this may not be suitable for double bundle reconstruction surgery.[24]

Tibial footprint width of anterior cruciate ligament noted 12.82±1.43 mm in our study, which is higher than values quoted by Jayagandhi et al,[6] Yelicharla et al,[18] Kulkamthorn et al,[21] and Iyaji et al. [20] While Saxena et al,[10] noted, width of anterior cruciate ligament tibial footprint which was higher than present study. The knowledge of tibial footprint was important for accurate tunnel placement of ACL reconstruction for restoration of normal Anatomy.[10] [Table 1]

We observed the femoral footprint length and width of anterior cruciate ligament, where the length was higher and width was smaller than values mentioned by Jayagandhi et al,[6] Yelicharla et al,[18] and Kulkamthorn et al.[21] We also observed that the femoral footprint length and width of the anterior cruciate ligament were statistically similar on both sides. [Table 1]

Present study revealed details of ACL. However, the sample size needs to be extended with gender specific morphometric parameters of anterior cruciate ligament are required to generalised the results of the study.

CONCLUSION

The study revealed that the length of anterior cruciate ligament is similar on both side. Significant differences in multiple dimensions of anterior cruciate ligament were observed. Anteroposterior diameter and transverse width of ACL were significantly increased from femoral aspect to tibial aspect. This increase in dimensions of ACL were observed on right and also on left side. Position of tibial footprint site of anterior cruciate ligaments showed variation on both side. [Table 1]

Position of femoral footprint of the anterior cruciate ligament on right and left side were statistically similar.

The morphometric data collected in this study may be helpful for Anatomists, Anthropologists, Medico legal specialists, Forensic experts, and for Surgeons to plan and perform ligament reconstruction surgery.

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