MORPHOMETRIC ANALYSIS OF THE ANTERIOR CRUCIATE LIGAMENT – A CADAVERIC STUDY

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ABSTRACT

The knee joint is the bicondylar variety of synovial joint of the human body formed by the articulation of lower end of femur with the tibia and patella. The anterior cruciate ligament (ACL) is an intra-articular, extra synovial ligament which is most frequently damaged ligament and also requires reconstructive surgery. As there are variation among the age, gender and different populations, the morphometric understanding of ACL is essential. This study aimed to assess the morphometric analysis of ACL in a cadaver. A descriptive observational study was carried out in the Department of Human Anatomy, Nepal Medical College Teaching Hospital from August 2024 to July 2025 in 26 cadavers including both right and left knees. The formalin preserved cadaveric knees were dissected, exposing the knee joint following the standard procedures. The length and breadth of the ACL were measured by Digital Vernier Caliper. The mean and standard deviation was calculated applying SPSS-16. All the 52 knees were measured and the mean length of ACL was 38.5 ± 0.49 mm and mean breadth of ACL was 10.00 ± 0.19 mm. The mean length of right and left side ACL was 38.60 ± 0.47 mm. and 38.40 ± 0.52 mm respectively. Similarly, the mean breadth of right and left side of ACL was 9.70 ± 0.16 mm and 10.31 ± 0.22 mm respectively. The present study concluded that the variation in both length and breadth of right and left ACL exists. A thorough understanding of ACL is mandatory during surgical intervention and reconstructive procedure of anterior cruciate ligament.

KEYWORDS

Morphometry, anterior cruciate ligament and knee joint

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INTRODUCTION

The knee joint is the bicondylar variety of synovial joint of human body formed by the articulation of lower end of femur with the tibia and patella.[1] One of the most important components of the knee joint is the anterior cruciate ligament (ACL) which plays important role in joint's stability during activities involving sudden flexion, extension and changes in direction.[2] The ACL is broad and intra-articular ligament that attaches to the anterior intercondylar space of tibia and the postero-medial side of the lateral femoral condyle.[3] The ACL is composed of two functional bundles; the anteromedial (AM) bundle and posterolateral (PL) bundle. Due to the action of AM bundle and PL bundle in flexion and extension, the ACL provides stability to the knee.[4-6]

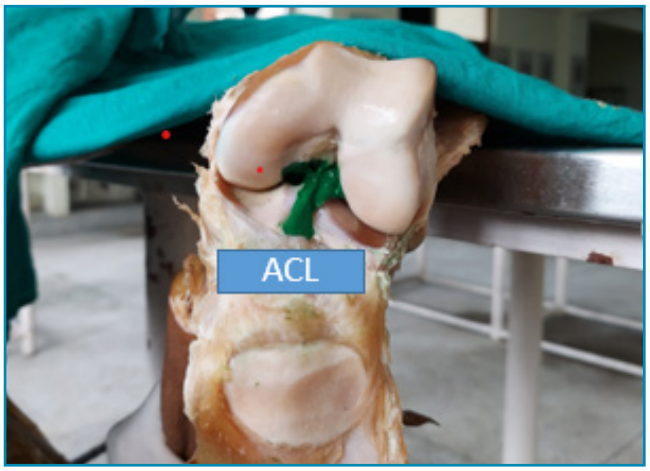

Fig. 1: Anterior cruciate ligament

ACL (Fig. 1) is the most commonly injured ligament which can manifest during sports and sudden changes in direction during playing. Gender variation of ACL tear also exists, with higher prevalence in females. ACL tears may at times lead to instability of knee, disrupts daily activities, increases the risk of early-onset osteoarthritis and the need for a total joint replacement.[7,8] Since the amount of physical activity in childhood and youth affects people in adulthood. The long-term effects of an ACL injury are more problematic for women who engage in physical activity.[9]

Studies have shown considerable variability in dimensions of ACL in diverse populations.[7,10] In addition, the sports injury affecting the knee joint involving the ACL are common and unavoidable. Morphometric study is very important in the reconstruction of ACL. A correct understanding of the measurement is helpful for avoiding iatrogenic injury during surgical procedures performed in close proximity to the ACL of the knee and to establish the different ranges of the motion of knee joint.[6,10] As a result, future planning of the management of repairing ACL will be more successful and less likely to failure. Hence, there is a need of region-specific databases related to ACL for the optimal surgical planning. The aim of the present study was to determine the length and width of ACL of the knee joint in the Nepalese population.

MATERIALS AND METHODS

A descriptive observational study conducted in the Department of Human Anatomy, Nepal Medical College Teaching Hospital, Attarkhel, Gokarneshwor-8, Kathmandu to determine the morphometric measurement of anterior cruciate ligament in a cadaver. The study samples were 52, all the embalmed cadavers present in the department including both right and left side of the lower limbs with knee joint and leg intact. In this study, the cadavers with acquired or congenital deformities of lower limb, damage in the area or amputation of the lower limb, cadavers which had reconstructive operations of the knee joint and leg, cadavers with knee replacement and skeletally immature cadavers were excluded. The study period was from August 2024 to July 2025. Ethical clearance was obtained from the Instituional Review Committe of NMC (Ref. No. 09-081/082).

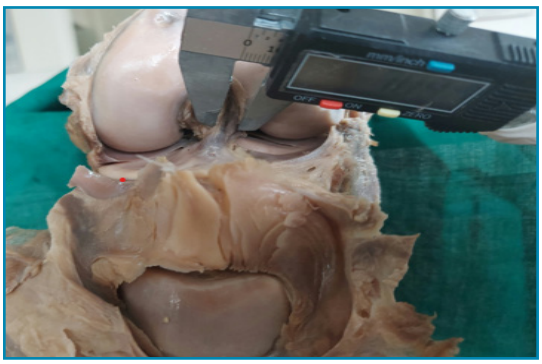

Fig. 2: Measurement of breadth of ACL

Fig. 3: Measurement of length of ACL

In this study, all the dissections were carried out on the cadaver placed in supine position on a dissection table and the neck was placed in neutral position. The skin and fascia were removed from the anterior compartment of thigh, knee and leg. The formalin preserved cadaveric knees were dissected leaving the knee joint intact with its capsular and ligamentous attachment. The ligaments of the knee joint were exposed, then the ACL was identified and observed following Cunningham's manual of dissection volume I.[1] Then attachment sites were outlined with the marker and the measurements (length and breadth) were taken by using digital Vernier Caliper (Fig. 2 and 3) and all the parameters were recorded for analysis. The data obtained was analyzed using SPSS-16. Descriptive statistical analysis was carried out and the results were presented in the form of table.

RESULTS

Among the 52 samples, mean length and mean breadth of ACL were 38.50 ± 0.49 mm and 10. 00 ± 0.19 mm respectively (Table 1).

Table 1: Mean length and breadth of the ACL:

Measurements obtained	Mean ± S.D.
Length (mm)	38.50 ± 0.49
Breadth (mm)	10.00 ± 0.19

The mean length and breadth of right-side ACL was 38.60 ± 0.47 mm and 9.70 ± 0.16 mm respectively. Similarly, the mean length and breadth of left side ACL was 38.40 ± 0.52 and 10.31 ± 0.22 mm respectively (Table 2).

Table 2: Mean length and breadth of the right and left ACL:

Measurements obtained	Right ACL (Mean ± S.D.)	Left ACL (Mean ± S.D.)
Length (mm)	38.60 ± 0.47	38.40 ± 0.52
Breadth (mm)	9.70 ± 0.16	10.31 ± 0.22

DISCUSSION

Knowledge of anatomy of different parts of human body is very essential. There are a lot of variations in them in relation to different age groups and gender. Injuries related to ACL are more common among youth and people active in sports. Apart from this, ACL injuries are also most commonly observed during road traffic accidents. The morphometry of ACL is crucial during reconstructive surgeries used to repair ACL during injuries. The ACL intra-articular length and breadth are essential for improved knee joint stability and laxity after reconstruction surgeries.[11]

Zantop *et al*[12] also suggested the importance of ACL during selecting the graft, during screw fixation, consideration has to be given to the length and thickness of ACL. The present study was conducted to provide morphometric information on the ACL in Nepalese.

In the present study the mean length of ACL was 38.50 ± 0.49 mm while the mean breadth was 10.00 ± 0.19 mm (Table 1) showing excellent alignment with many other studies revealing population specific morphometric variations. A study performed in Bangalore among 32 embalmed cadavers by Rani *et al*[13] revealed that the mean length and width of the ACL was 37.14 ± 3.91mm and 5.2 ± 1.09 mm. The mean length was in alignment with present study, however, the mean breadth was slight increase in this study. Sengodan *et al*[14] in their study observed 50 knee joints from 29 cadavers. They reported the mean length to be 29.73 mm ± 2.32 which was less than the findings of the present study. In the same study the mean breadth was more (11.15 ± 1.07 mm) than the present study.

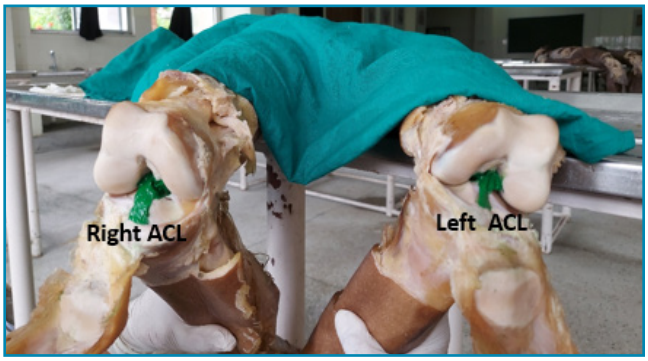

Fig. 4: Right and left ACL

Studies conducted so far on the length and breadth of ACL have shown similarity and discrepancies in the measurement between gender and right and left knee too. Present study also compared the length and breadth of ACL on right and left knee (Table 2), found the measurement of length was longer in right ACL (38.60 ± 0.47 mm) than on the left ACL (38.40 ± 0.52 mm). While the breadth was more on left ACL (10.31 ± 0.22 mm) than on the right ACL (9.70 ± 0.16 mm). This finding suggested that the length and breadth may vary between the right and left ACL (Fig. 4) even between individuals. The present study, however, did

not show the variation if exists in gender wise distribution or not as, it was not the objective of present research because of less number of female cadavers available in the department. However, meticulous literature review has shown variations existing in relation to gender also.

In another study conducted to identify the morphology of ACL among 22 isolated knee joints, Lalwani *et al*[15] reported the mean length of right ACL was 30.79 ± 5.35 mm and left ACL was 29.51 ± 7.61 mm. This finding was not in agreement with the present study. In line with the present study, Girgis *et al*[16] reported the length and breadth of ACL to be 31–38 mm and 10 mm respectively. Saxena *et al*[17] in their study conducted on 14 right and 12 left knees from 26 cadavers showed that the ACL length and width were 32.5 mm ± 4.33 and 9.38 mm ± 1.58 respectively. The length was 6 mm less than the present study while the breadth correlated with present study. Similar type of discrepancies was also reported by Odensten *et al*[18] among 33 cadaveric knee, reported the mean length of ACL as 31 mm ± 3, which was lesser than the current study. Iriuchishima *et al*[19] also reported the length of ACL to be 32.28 mm which was conducted among 15 cadavers. This findings was also lesser than the current study.

Van *et al*[20] on their study using radiographic method conducted among 40 patients, reported the length of ACL to be 40.6 ± 3.6 mm. Although Van ZR conducted their study on patients while others used cadaveric method, the reported length and breadth of both method can vary.[21] Studies have also focused on determining the risk factors related to ACL injury, with the main aim to implement preventive programs.[22-24] Anatomy of the joints, hormones, genetics, and characteristics of the neuromuscular system are few of the intrinsic factors, while, the playing field, the weather, the material conditions of playground are examples of extrinsic elements.[25,26] Partial injuries of ACL are still challenging to diagnose and repair in sports medicine. ACL partial tears account for 10.0% to 28.0% of all ACL rips and are quite prevalent. More advantages have been added with the development of magnetic resonance imaging (MRI) and the identification of damage patterns.[27]

Over the past 20 years, there has been a rising trends of ACL injuries among athletes who are skeletally immature. The rising number of kids and teenagers engaging in competitive sports and demanding sports training at a younger age as well as the increased rate of diagnosis due to raised awareness and expanded usage of cutting-edge medical imaging are the main causes of this elevated rate.[28] The measurement of knee laxity resulting from ACL injury has garnered more attention in the modern day. In clinical practice, the diagnosis is typically made through an arthroscopic confirmation procedure following a clinical examination and analysis of magnetic resonance imaging.[29]

The present study used morphometric analysis of anterior cruciate ligament and provided valuable insights into its structure and variability. It can be concluded that variation between the right and left side of the knee, both in relation to the length and breadth of ACL. This study also emphasizes on the careful surgical approach of surgeons during reconstructive surgery of ACL and to reduce the iatrogenic effect and also for excellent prognosis of the patient.

Limitations: The authors do acknowledge that due to the cadaveric nature of the study, in-vivo biomechanical properties could not be assessed. The sample size in this study was less which also limited the use of statistical power for subgroup analysis and for generalization of the results.

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