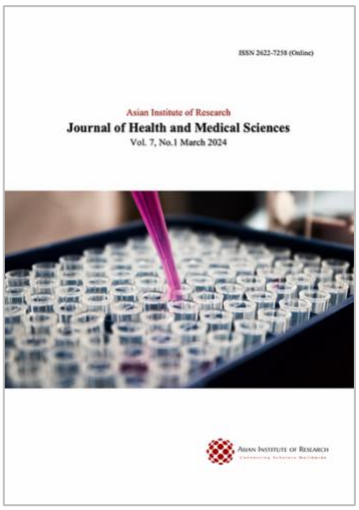

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MRI Topometric of ACL Footprint on Femoral and Tibial Site in Indonesian Population

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Abstract
Anterior cruciate ligament (ACL) injuries are one of the most commonly injured ligaments of the knee. In the US, the incidence rate has reached 100,000 – 200,000 people per year based on the annual population. At Dr. Hasan Sadikin Bandung Hospital, the incidence has reached 32 cases from January 2020 – January 2021. This is a comparative analytical study with a cross-sectional approach that aims to determine whether there is a difference between the ACL footprint size that Monica has examined on the previous cadaveric knee and the ACL footprint size using the MRI knee. Measurement of ACL footprint on cadavers by Adisuhanto on the cadaveric ACL footprint length femoral site (12.05±1.18 mm), the width (8.65±1.02 mm). This size is compared with the results of the MRI measurement of the knee ACL footprint length femoral site (11.36±1.5 mm), a mean width (8.5±1.06 mm). Cadaveric ACL footprint length on the tibial site (12.11 ± 1.29 mm), the width (9.22±0.79 mm). These were compared to the MRI size of the ACL footprint length on the tibial site (13.18±1.32 mm), and the width (8.6±1.31 mm). This study was analogous to the study of measuring ACL footprint on cadavers so that this MRI ACL footprint study can represent cadaveric ACL footprint research with sufficient previous samples with p-value <0.05. The conclusion is that Indonesian ACL footprints were smaller than Thai, Chinese, and Americans.

Keywords: ACL Footprint, Indonesia, MRI, Topometry

1. Introduction

The Anterior Cruciate Ligament (ACL) contributes as the primary stabilizer of the knee joint. Insertion of ACL is located on the medial aspect of the anterior horn of the tibial plateau (LaBella, 2014). ACL tear has serious effect especially young population, acute ACL injury has an undesirable/unfavorable effect on knee joint function, and affect significantly quality of life (QoL), where the majority of the patient has osteoarthritis of the knee joint as one of late complication (Domnick, 2016).

ACL role as restraint of anterior tibial translation, and malrotation of the knee joint. ACL reconstruction is currently a challenge for orthopedic surgeons, it has difficulty restoring normal genu kinematics in patients with unstable ligaments. Abnormal genu kinematics are the primary cause of OA after anterior cruciate ligament reconstruction (Willinger, 2023).

The disturbance of knee function/disorders post ACL reconstruction has various consequences. This condition could be a consequence of the malposition of the anatomical placement of the graft. Inadequate positioning of the ACL footprint at the femur and tibial tunnel can increase graft pressure, altering graft length and tension. Based on previous research on cadaveric topography that has been carried out by Monica, the footprints of the cruciate ligament in Indonesian people are small. The selected single bundle technique can be applied as ACL footprint 13 mm as treatment of ACL reconstruction (Chien, 2020).

Therefore, it is necessary to carry out MRI measurements of ACL footprints in the femur and tibia to determine the placement and size of the graft by the number of samples that are representative of the Indonesian population. Therefore, it is necessary to conduct research with similar data on the Indonesian population for anatomical ACL reconstruction surgery.

2. Methods

The subjects of this study were all patients who underwent an MRI of the knee joint and went to the Orthopedic and Traumatology clinic of Dr. Hasan Sadikin General Hospital Bandung, Indonesia (RSHS). The design study was a comparative analytical study design, a cross-sectional to determine whether there is a difference between the size of the ACL footprint that has been studied by Monica previously and the size of the ACL footprint using knee MRI. This study is useful to determine the characteristics of the ACL footprint at its origin and insertion and the position of the ACL concerning the PCL and the anterior edge of the tibial condyle. The research sample was obtained using the Consecutive Sampling technique on treatment at the Orthopedic and Traumatology Clinic which will perform a knee MRI examination from January 14, 2021 – to March 04, 2021 period. There are 34 knee MRIs used in this study. The inclusion criteria consist of Indonesian citizens, aged 14-50, The patients with complaints of knee pain with ACL intact condition. The exclusion criteria consisted of patients with foreign national identity, knee pain with ACL rupture condition, and inflammatory arthritis with deformity. Ethical clearance was obtained, and the ethical clearance number is B.02.01/X.6.5/259/2020 from the Health Research Ethics Committee of Dr. Hasan Sadikin General Hospital Bandung, Indonesia.

To choose hypothesis analysis, the researcher performs a normality data test. This normality data test for topometry MRI/ACL imprint and topography of the cadaveric ACL imprint on the femur and tibia in both length and width were normally distributed, respectively. The normality test was carried out to find out the distribution of the data with the Shapiro-Wilk test. In both samples, the cadaveric ACL topography and the ACL topography using MRI were each normally distributed so that parametric tests could be used. Thus, we used the Independent Sample T Test to see the Characteristics of the ACL Footprint based on the Length and Width of the ACL Footprint.

3. Results

There were 34 knee MRI examinations conducted, 23 men and 11 women, it was found that the intact ACL included 26 people and the remaining 8 people could not be included in this study because they did not meet the inclusion criteria. Sample who was not included in this study, 4 had an intact ACL, 1 patient was 4 years old, 2 patients had a history of fracture in the knee region, and 1 patient was diagnosed with a bone tumor in the distal femur. Table 4.1 lists the characteristics of the study subjects by sex, and ACL footprints on the femoral and tibial sites. The research subjects were male as many as 18 patients (69.2%) and female sex as many as 8 patients (30.8%). The cadaveric ACL topography and the ACL topography using MRI were each normally distributed so that parametric tests could be used. To test the difference can use the Independent Sample T Test.

Table 1 characterizes the long axis of the ACL footprints of the anteromedial bundle and posterolateral bundle on the femoral site. The mean length of the anteromedial bundle ACL footprint length axis on the femoral site was

4.42 mm while the mean posterolateral bundle ACL footprint length axis on the femoral site was 7.4 mm. Table 2 presents the characteristics of the variable length and width of the ACL imprint on the tibial site. The ACL imprint on the site of the tibia has an average length of 12.92 mm and an average width of 8.78 mm.

Table 1: Characteristics of the Length and Width of the ACL Footprint on the Femoral Site

Variable	**(n=26)**
ACL footprint length on femoral site (mm)	
Mean±STD	11.36 ± 1.5
median	11.69
Range (min-max)	6 (8.14-14.14)
Width of ACL imprint on femoral site (mm)	
Mean±STD	8.5 ± 1.06
median	8.26
Range (min-max)	3.38 (6.95 – 10.33)

Table 2: Characteristics of ACL Footprint Length and Width on the Tibial Site

Variable	**(n=26)**
ACL Footprint Length on Tibial Site (mm)	
Mean±STD	13.18 ± 1.32
median	12.92
Range (min-max)	5.33 (10.17 – 15.5)
ACL Footprint Width on Tibial Site (mm)	
Mean±STD	8.6 ± 1.31
median	8.78
Range (min-max)	3.97 (6.92 – 10.89)

The comparison results between Monica's 2017 study on the topography of the ACL imprint on the cadaveric knee and the ACL topometry on the MRI of the knee, it was found that there was no difference between the study of the ACL footprint size that Monica had studied on the cadaveric knee in 2017 and the ACL footprint size using the MRI of the knee. This knee MRI study can represent the previous research conducted by Monica on the cadaveric knee because of the sufficient number of measurement samples with p-value >0.05 (Monica, 2017).

4. Discussion

The arrangement of the ACL fibers is in the form of individual fiber bundles which are named according to their insertion site on the tibia (Morales, 2023). The ACL insertion is on the tibial plateau medial to the anterior horn of the lateral meniscus, in the sulcus in the anterolateral tibial spine anterior. The origin of the ACL is located in the femur, namely the medial wall of the condyle of the femur (Yonetani, 2019). This study aimed to measure the ACL footprints and boundaries of the tibial and femur, the length of the ACL, and the long axis of the anteromedial and posteriorlateral bundles of the ACL.

In this study, the ACL footprint data on the femoral site had an average length of 12.05±1.18 mm and an average width of 8.65±1.02 mm. This measure is similar to the data obtained in the Thai population (mean length 12.01±1.66 mm and mean width 9.52±1.37 mm) as well as in the Singaporean Chinese population (mean length 13.1±4.4 mm and mean width 9.7± 3.4 mm) (Pontoh, 2021).

The limitation of this study was MRI examination was unable to describe the bony structure, especially the 2 important structures used as landmarks of the ACL footprint on the femoral site, namely the lateral intercondylar ridge (resistant ridge) and lateral bifurcate ridge (cruciate ridge) so that researchers could not identify the existence of these 2 important structures as landmarks. To identify these important structures by obtaining a sample coverage that is as large as this study, a CT scan can be carried out (Tank, 2021).

There was a limitation to this study, researchers suggest further research to be conducted, it is a CT scan of the knee study, and it can identify important structures that are used as landmarks of the ACL footprint on the femoral

site, namely the lateral intercondylar ridge (resistant ridge) and lateral bifurcate ridge (cruciate ridge) to identify the existence of these 2 important structures as landmarks.

In conclusion, the comprehension of topography is expected to be a source of data that is used as a guide during ACL reconstruction to achieve more anatomical reconstruction results. Guidance in the placement of the tibial tunnel can use the characteristics of the distance between the anterior edge of the ACL imprint on the tibial site and the average anterior edge of the tibia 5.35±0.63 mm and the distance between the posterior edge of the ACL imprint on the tibial site and the anterior edge of the PCL imprint. on the tibial site an average of 13.37±1.16 mm. This data is useful if there is damage to the ACL insertion area, making it difficult to identify to determine the graft position. Insertion ACL of the Indonesian population is small (<13 mm).

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Conflict of Interest: The authors declare no conflict of interest.

Informed Consent Statement/Ethics Approval: All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Dr. Hasan Sadikin General Hospital Bandung, Indonesia LB.02.01/X.6.5/259/2020

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