Tibial Footprint for Single Anatomical Anterior Cruciate Ligament Reconstruction by the Meniscal Reference Point: The Cadaveric Study

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Objective: *ACL reconstruction is the gold standard for the torn ACL. To perform the anatomic reconstruction, knowledge of the footprint location is important. The femoral footprint was described in many studies, but the tibial footprint has less information. The authors study the relationship of ACL tibial footprint by using the meniscuses as landmark.*
Material and Method: *20 knee specimens from the anatomy department were obtained and dissected. The footprint area was determined by locating the tibial stump of ACL first, isolated it from another structures, the footprint size was measured and then the mid portion of the footprint was identified. The relationship between the meniscuses to the mid portion of the ACL tibial footprint was determined.*
Results: *The authors have found that the mid portion of the ACL tibial footprint in all of specimens was located anterior to the posterior border of anterior horn of lateral meniscus, with the average of 3.2 $\pm$ 0.25 millimeters.*
Conclusion: *The meniscuses can be used as landmark to locate the footprint of the tibial part of the ACL. The mid portion of the ACL tibial footprint is anterior to the posterior border of anterior horn of lateral meniscus. This information will help the surgeons to locate the footprint with more accuracy while performing the anatomic ACL reconstruction.*

Keywords: *ACL, Tibial footprint, Single bundle, Anatomy*

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Anterior cruciate ligament (ACL) is one of the most frequently studied structures of the musculoskeletal system. ACL's anatomic description can be found on an Egyptian papyrus scroll, back to 3,000 BC[1].

The ACL is a band of dense connective tissue that connects the femur and the tibia. It was divided into 2 functional bundles, which vary the tension among the fibers in the ligament with different ranges of motion, namely the anteromedial (AM) bundle and the posterolateral (PL) bundle. However, histological examination of the ACL reveals the same tissue pattern[2]. The functions of the ACL are the primary restraint to anterior tibial translation and secondary restraint to internal rotation of the weight bearing and non-weight bearing knee[3].

The ACL femoral footprint has been well described in many studies[4,5]. But there is less information about the ACL tibial footprint. In the present study, the authors study the course of the ACL tibial footprint and its relationship to the lateral meniscus. The authors' research question is whether the lateral meniscus could be served as a landmark for placing ACL graft. This will help the surgeons to locate the position of the tibial guide to place the ACL graft correctly.

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Material and Method

The present study was obtained from cadaveric knee specimens, collected at the Department of Anatomy, Phramongkutklao College of Medicine between August 2010 and March 2011.

The 26 cadaveric knees specimens, collected at the Department of Anatomy, Phramongkutklao College of medicine were examined. The knee was dissected deep down to the intraarticular structure. In each of the specimens, the ACL was identified. Then the ACL was isolated from other structures (Fig. 1). After that, the attention was paid on the tibial part of the specimens. The lateral meniscus was identified. The inclusion criteria are all the specimens with normal

intraarticular structure and anatomical landmark. And the exclusion criteria are the specimens with distorted anatomy, so that the intraarticular structure and anatomical landmark could not be determined, the knee with previous surgery and the specimen that the demographic data cannot be found also be excluded.

From the 26 cadaveric knees specimens, 6 specimens were excluded. The rest of the specimens were examined by the authors (KC, AA and NK). The specimens that met the criteria were included. The selected specimens had 20 knee joints, did not matched. The demographic data were obtained.

From the specimens' examination, the tibial stump of the ACL was identified and the stump size was measured. Then, the mid portion of the ACL tibial stump was located. After that, the lateral meniscus was identified. The authors had measured the distance between the posterior border of anterior horn of the lateral meniscus and the mid portion of the ACL tibial stump using the calipers (Fig. 2).

Results

The total of 20 tibias was examined. The demographic data were shown in the Table 1. There are 7 males and 3 females. The age of the specimens is range from 60 to 95 years old, with the average age of 74.78 years old.

After the thorough dissection, the authors found that the areas of the ACL tibial footprint had distinct characteristics from the surrounding structures. For the tibial footprint, the anterior border was the line in the same plane with the posterior border of anterior horn of the medial meniscus. The medial border was lateral surface of medial tibial spine and continues laterally to the point near the lateral tibial spine. In the present study, the ACL has never extended more lateral than the lateral tibial spine. And the authors found that in all of the specimens, the mid portion of the ACL was lie anterior to the posterior border of anterior horn of lateral meniscus. The stumps size and the distance between the mid portions of ACL and lateral meniscus were shown in the Table 2.

Discussion

The gold standard for treatment of the ruptured ACL is the ACL reconstruction. The reconstruction technique can divide into single-bundle and double-bundle reconstruction, base on the concept of "anatomic reconstruction". The concept of anatomical reconstruction is to consider and adjust the location of the reconstruction sites according to the patients' anatomy. In recent meta-analysis study, both technique show no clinically difference in

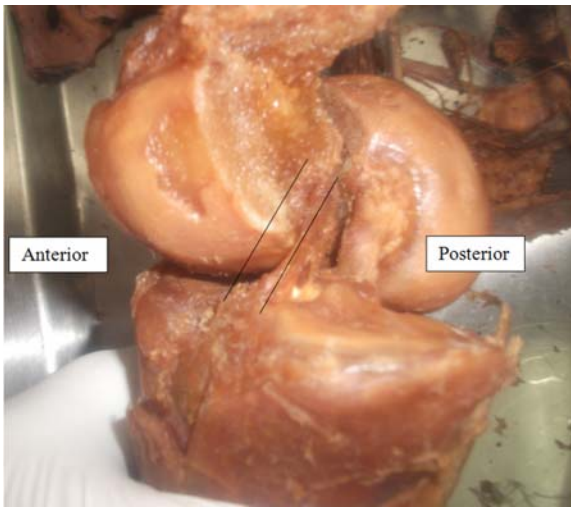

Fig. 1 Right knee specimen. ACL was identified and isolated. The lines represent the course of ACL

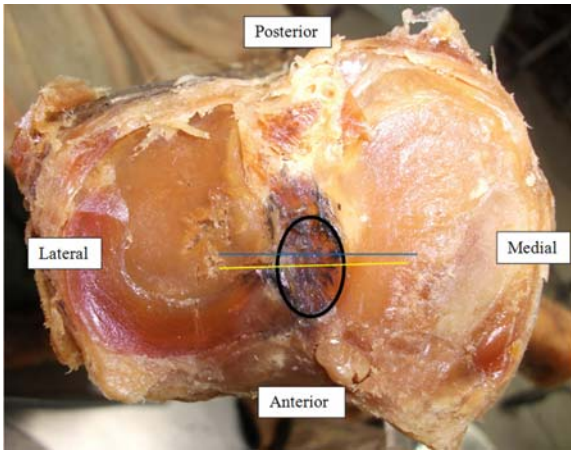

Fig. 2 Right knee specimen. Distance between mid portion of ACL stump and posterior border of anterior horn of lateral meniscus was measured**.** Blue line = posterior edge of anterior horn of lateral meniscus, yellow line = mid portion point of ACL

Table 1. The demographic data of the specimens

Demographic Data	Sex	Age	Tibia	
			Right	Left
Male	14	71.85 (60-84)	7	7
Female	6	82.66 (61-95)	3	3
Total	20	74.78 (60-95)	10	10

Table 2. The tibial footprint data

Tibial Footprint	Size	SD
Length (mm)	16.12	0.56
Width (mm)	10.18	0.7
Footprint size (mm^2)	16.12 x 10.18	-
Distance from lateral meniscus tomid portion of ACL (mm)	3.2	0.25

arthrometer (KT-2000) and pivot-shift test data[6]. In Thai people, there are the limitation of tunnel size and the grafts availability[7]. So the single anatomical reconstruction should be considered.

Edwards[8] have studied the tibial footprint size in Europeans; they found that the footprint size was 18 ± 2 x 9 ± 2 mm. In the present study, the authors found that the average footprint size in the specimens was 16.12 ± 0.56 x 10.18 ± 0.7 mm. Van Eck[7] had recommended the minimum footprint size to perform the double bundle anatomical ACL reconstruction of more than 16 mm in diameter. In the present study, the authors found that the tibial footprint in some specimens were smaller than 16 mm and may not appropriate to double bundle ACL reconstruction technique. Though superior in biomechanical testing, the double bundle anatomical reconstruction did not show the difference in clinical and subjective test data[6,9]. With the limitation of allograft available in Thailand, the double bundle reconstruction will need autografts and this may increase the donor's site morbidity to the patient. The authors encourage the surgeons to perform the single bundle anatomical ACL reconstruction, which the authors think suit well to the most of Thai population.

When the single bundle anatomical reconstruction technique is applied, it's important to place the graft in to the center of the ACL footprint, to cover most of the native ACL insertion site. There are many techniques discussed about the reference point to mark the location of the ACL tibial foot print. The conventional technique is about 7 mm anterior to the PCL. When apply to the present study, the authors found that it was too posterior compare to the ACL footprint. Ziegler[10] had described the center of the ACL footprint that it was located at the same level with posterior edge of anterior horn of lateral meniscus. The authors found that this point was more anterior. The authors propose the menisci and medial tibial spine as landmark to place the ACL tibial guide while performing the surgery. At first, the authors use the posterior border of anterior horn of medial meniscus as a reference line for anteroposterior (AP) axis and then the authors determine the point draw 3.2 mm anterior to the poster edge of anterior horn of lateral meniscus as the point where the center of the ACL stump was located. The authors use the lateral edge of medial tibial spine as a reference line for mediolateral (ML) axis, by determined the point adjacent to the lateral edge of medial tibial spine and not extended further than the medial edge of lateral tibial spine. With this technique, the authors can find the proper place for the tibial guide to make sure that the graft will occupies most of the footprint area. Then the single bundle anatomical reconstruction can be achieved.

Conclusion

In Thai people, the role of double bundle anatomical ACL reconstruction maybe limited due to the footprint size and the graft availability. The single bundle anatomical ACL reconstruction can be the answer. The information from the present study can help the surgeons while performing the single bundle anatomical ACL reconstruction. The average size of ACL tibial foot print is 16.12 x 10.18 mm and the distance from posterior edge of anterior horn of lateral meniscus to the mid portion of the ACL is 3.17 mm. With this knowledge, the authors can correctly determine the center of the ACL footprint and can reduce the mistake while performing the surgery. However, further clinical studies maybe needed to acquire more information.

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Potential conflicts of interest

None.

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การผ่าตัดเอ็นไขว้หน้าแบบ single anatomical bundle โดยใช้หมอนรองกระดูกเป็นจุดกำหนด tibial footprint: การศึกษาในผู้บริจาคร่างกาย

นิธิศ รีบุญลาภ, ณัฏฐา กุลกำม์ธร, กรกฎ ซรากร, อรรถพล อรรฆสีหยุทธ

จุดประสงค์*: การผ่าตัด ACL reconstruction ถือเป็นมาตรฐานในการรักษาเอ็นไขว้หน้าที่ขาด เพื่อให้เอ็นไขว้หน้าใหม่อยู่ในตำแหน่งที่ใกล้เคียงกายวิภาคเดิมที่สุด การรู้ตำแหน่ง footprint ของเอ็นเดิมเป็นเรื่องสำคัญ การศึกษา footprint ที่กระดูก femur มีการพูดถึงอย่างกว้างขวาง แต่ที่กระดูก tibia ยังมีการศึกษาน้อย ผู้นิพนธ์ศึกษาความสัมพันธ์ของ ACL tibial footprint โดยใช้หมอนรองกระดูกเป็นจุดอ้างอิง*

วัสดุและวิธีการ*: ผู้นิพนธ์ศึกษาเข่าจากผู้บริจาคร่าง 20 ท่าน โดยการผ่าเปิดเข้าไปถึงบริเวณภายในข้อเข่า ทำการหาเอ็นไขว้หน้าและแยกออกมาจากโครงสร้างอื่น ผู้นิพนธ์ได้ทำการวัดขนาดของ footprint และหาตำแหน่งที่เป็นจุดกึ่งกลางของ footprint จากนั้นจึงศึกษาความสัมพันธ์ของ footprint เมื่อเทียบกับหมอนรองกระดูก*

ผลการศึกษา*: ผู้นิพนธ์พบว่าจุดกึ่งกลางของ ACL tibial footprint อยู่หน้าต่อขอบหลังของหมอนรองกระดูกด้านนอก โดยมีค่าเฉลี่ย 3.2 $\pm$ 0.25 มิลลิเมตร*

สรุป*: หมอนรองกระดูกสามารถใช้เป็นจุดอ้างอิงในการหาตำแหน่ง footprint ของเอ็นไขว้หน้าที่กระดูก tibia ได้ สามารถเพิ่มความแม่นยำในการหาตำแหน่ง tibial footprint เมื่อนำไปใช้กับการผ่าตัดจริงได้*