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นิพนธ์ต้นฉบับ (Original article)

การประเมินภาพถ่ายทางรังสีดูตำแหน่งเจาะรูเอ็นไขว้หน้าที่กระดูกแข้งภายหลังการผ่าตัดสร้างเอ็นไขว้หน้าโดยใช้หมอนรองเข่าด้านนอกเป็นจุดอ้างอิง

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บทคัดย่อ

บริบท การผ่าตัดสร้างเอ็นไขว้หน้าโดยวิธีเจาะรูตามตำแหน่งกายวิภาคเดิมนั้นช่วยแก้ไขปัญหาข้อเข่าไม่มั่นคงจากเอ็นไขว้หน้าฉีกขาดเป็นอย่างดีทั้งโดยเทคนิคแยกเอ็นสองเส้นและแบบรวมเส้น

วัตถุประสงค์ เพื่อประเมินความแม่นยำของรูเจาะของเอ็นไขว้หน้าที่สร้างขึ้นด้วยการใช้หมอนรองเข่าด้านนอกเป็นจุดอ้างอิงที่กระดูกแข้งโดยใช้ภาพเอ็กซเรย์คอมพิวเตอร์สามมิติ โดยเปรียบเทียบกับรายงานที่เคยศึกษา

วิธีดำเนินงานวิจัย การศึกษาย้อนหลังเชิงพรรณนา โดยเก็บข้อมูลในผู้ป่วยเอ็นไขว้หน้าขาด 20 คน ในโรงพยาบาลพระมงกุฎเกล้า ระหว่างเดือนมกราคม พ.ศ. 2555 - ธันวาคม พ.ศ. 2557 ซึ่งได้รับการผ่าตัดสร้างเอ็นไขว้หน้าตามกายวิภาคเดิมโดยเทคนิครวมเส้นเดียว และใช้หมอนรองเข่าด้านนอกเป็นจุดอ้างอิง ในการเจาะรูทางฝั่งกระดูกแข้ง ทำการวัดตำแหน่งของรูเจาะที่กระดูกแข้งจากภาพเอ็กซเรย์และภาพเอ็กซเรย์คอมพิวเตอร์สามมิติภายหลังการผ่าตัด โดยเปรียบเทียบกับรายงานที่เคยศึกษา

ผลการวิจัย ภาพเอ็กซเรย์หลังผ่าตัดพบว่า ตำแหน่งกึ่งกลางของรูเจาะเอ็นไขว้หน้าทางฝั่งกระดูกแข้งห่างจากทางด้านหน้า ร้อยละ 32.8±4.7 และอยู่ห่างจากขอบด้านใน ร้อยละ 41.1±2.4 ในเอ็กซเรย์คอมพิวเตอร์สามมิติ พบว่าตำแหน่งกึ่งกลางของรูเจาะสร้างเอ็นไขว้หน้าทางฝั่งกระดูกแข้งนั้น อยู่ห่างขอบหน้าของกระดูกแข้งเทียบเป็นร้อยละ 36.5±5.6 และอยู่ห่างจากขอบด้านในของกระดูกแข้งเทียบเป็น ร้อยละ 44.9±3.0 ซึ่งเมื่อเทียบกับรายงานที่เคยศึกษาไว้อยู่ในจุดที่ยอมรับ

สรุปผล ขอบหลังของหมอนรองเข่าด้านนอกส่วนหน้าสามารถใช้เป็นจุดอ้างอิงในการเจาะรูฝั่งกระดูกแข้งผ่านการส่องกล้องผ่าตัดสร้างเอ็นไขว้หน้าตามกายวิภาคด้วยวิธีการรวมเส้นเอ็นได้

คำสำคัญ จุดเกาะเอ็นไขว้หน้า ตำแหน่งเอ็นไขว้หน้าที่กระดูกแข้ง

ผู้นิพนธ์ที่รับผิดชอบ ณัฐฐพล สุรัชต์หนาแน่น
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Postoperative radiographic evaluation of Tibial ACL footprint after single bundle Anatomic ACL reconstruction: By the lateral meniscus as reference point

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Abstract

Context: The anatomic ACL reconstruction technique helps to resolve problematic knee instability from an ACL injury, providing an excellent result for both single-bundle and double-bundle techniques.

Purpose: To confirm that the tibial ACL tunnel creates, by the posterior edge of the lateral meniscus a reliable arthroscopic reference point, i.e., as compared with postoperative evidence-based radiography.

Materials and Methods: This descriptive retrospective study collected data from 20 ACL deficient patients at Phramongkutklao hospital between January 2012 and December 2014. These 20 patients underwent anatomic single-bundle ACL reconstruction by one surgeon, whereby the tibial tunnel was created with the lateral meniscus and medial tibial spine as reference points. Both a postoperative radiograph and CT-3D reconstruction were used to further evaluate the tibial tunnel position and the results were compared with supporting literature.

Results: The postoperative plain x-ray lateral view showed the centrum of the tibial ACL tunnel was 32.8±4.7%; the AP view showed the centrum of the tibial ACL tunnel at 41.1±2.4%. The postoperative CT-3D reconstruction showed the centrum of the tibial ACL tunnel from the anterior was 36.5±5.6% -- and from the medial the centrum was 44.9±3.0%. These were all within the acceptable range according to literature.

Conclusions: The medial tibial eminence and posterior border of the LM were reliable arthroscopic landmarks for determining the tibial tunnel, in single anatomical ACL reconstruction technique.

Keywords: Anterior cruciate ligament footprint, ACL tibial landmark

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การอ้างอิง

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Introduction

Nowadays the anatomic Anterior Cruciate Ligament (ACL) reconstruction technique helps to resolve knee instability following an ACL injury, providing an excellent result using both single-bundle and double-bundle techniques.[1-4] In a recent meta-analysis study, both techniques show no clinical difference in arthrometer (KT-1000) and pivot-shift test data.[3] However, as Asians and Thais have a smaller ACL footprint than American and European (less than 14 mm on average)[5] therefore, a single-bundle anatomic ACL reconstruction is more suitable.[6]

There are many studies about arthroscopic anatomical landmarks and radiographic images of tibial ACL footprints.[7-9] But, most of these studies describe a double-bundle anatomic ACL technique, rather than a single-bundle technique. However, Reeboonlap et al. have reported on the tibial footprint for single-bundle anatomic ACL reconstruction by using the lateral meniscus as a reference point for created tibial ACL tunnel (Figure 1).[10]

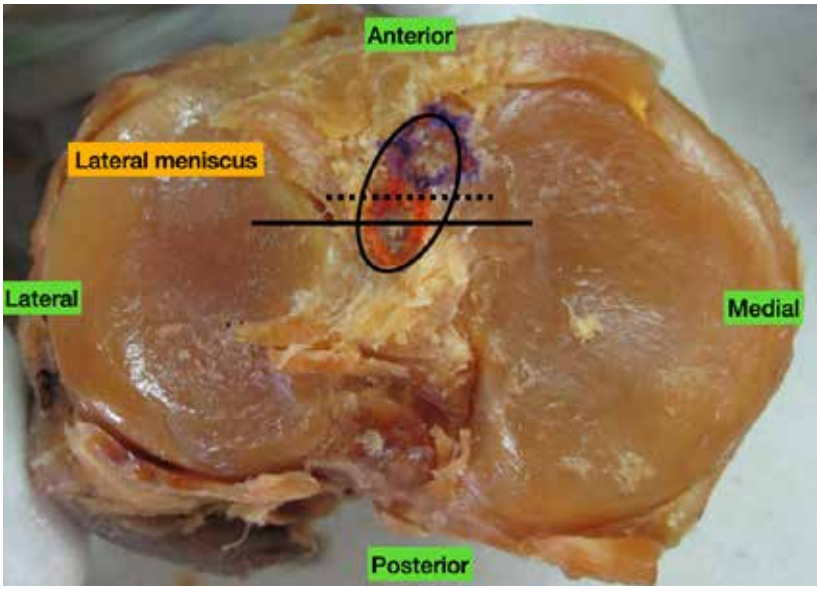

Figure 1 Left knee: The distance between the mid portion of the Anterior Cruciate Ligament (ACL) stump and posterior border of the anterior horn of the lateral meniscus was measured**.** Solid line = the posterior edge of the anterior horn of the lateral meniscus; Dot line = the mid portion point of the ACL.[10]

After using the reference points, as mentioned above, for single-bundle anatomic ACL reconstructions, the authors further studied the radiographic findings, to compare against literature[8,11-18], the position of the footprint and tunnel orientation, for preoperative planning in cases needing revision.

The purpose of this study was to evaluate the position of the tibial ACL footprint and tunnel via film x-ray and 3D CT

reconstruction. As well, the purpose of this study was to confirm that the lateral meniscus is a reliable arthroscopic reference point to create the tibial ACL tunnel.

Materials and Methods

This retrospective descriptive research studied knee patients with an ACL deficiency or dysfunction from injury, receiving surgery at Phramongkutklao Hospital in Bangkok, Thailand, from January 2012 to December 2014. This study was approved by Institutional Review Board Royal Thai Army Medical Department, No 505/2558

Inclusion criteria:

1. Patients who have previously undergone primary, single-bundle anatomical ACL reconstruction.

2. Patients were over 18 years old, or mature skeleton.

Exclusion criteria:

1. Patients who have had multiple, same side ligament reconstructions

2. Patients with any fracture around the knee (same side).

3. Patients who have had changes in their knee due to arthritis

The arthroscopic single-bundle ACL reconstruction technique

The technique of arthroscopic single-bundle ACL reconstruction is based on the use of 3 portal techniques: anterolateral (AL), anteromedial (AM) and the accessory anteromedial (AAM) portal. The femoral tunnel was drilled first in the native ACL stump: 8 mm anterior from the posterior border of the lateral femoral condyle, posterior to the lateral intercondylar ridge, through the AM portal, bending the knee in maximal flexion. The tibial tunnel was drilled via Aimer Guide, oriented at 55 degrees to the joint line, with the tip of the guide located at 3.2 mm (measured by the arthroscopic cauterization Opes) (Figure 2) anterior to the posterior edge of the anterior horn of the lateral meniscus, in the anteroposterior plane, as Reeboonlap described.[10] The graft was passed into the tunnel, with the femoral side fixed by either endobutton or bioscrew. Graft pretensioning was performed and the tibial side was fixed by bioscrew and suture.

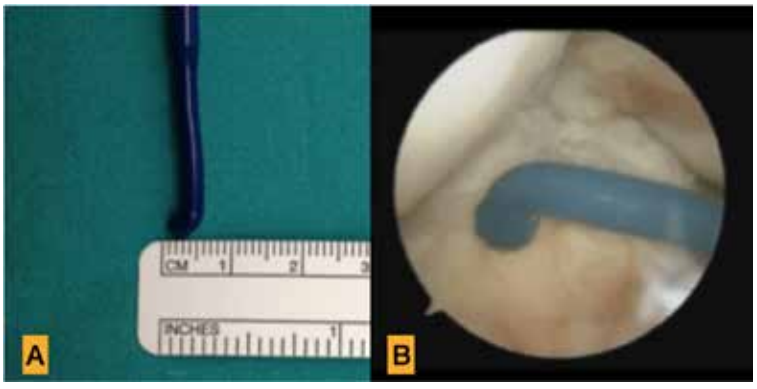

Figure 2 Measuring instrument (A) 3 mm diameter Opes (B) View through the AL portal.

Following their surgeries, the 20 ACL deficient patients were evaluated with plain film x-rays and 3D CT reconstruction scans. The images were loaded into a picture archiving and communication system (PACS) for further measurement.

Postoperative radiographic evaluation of Tibial ACL footprint

On the true lateral plain x-ray (Figure 3 A), the Amis and Jacob's line (P) was drawn, and the center of the tibial tunnel (dot) was measured to locate the position (as a percentage of the line's length). In true AP view (Figure 3 B), the mediolateral width of the tibia was measured, and the centrum of the tibial ACL tunnel was measured (also as a percentage of this line).

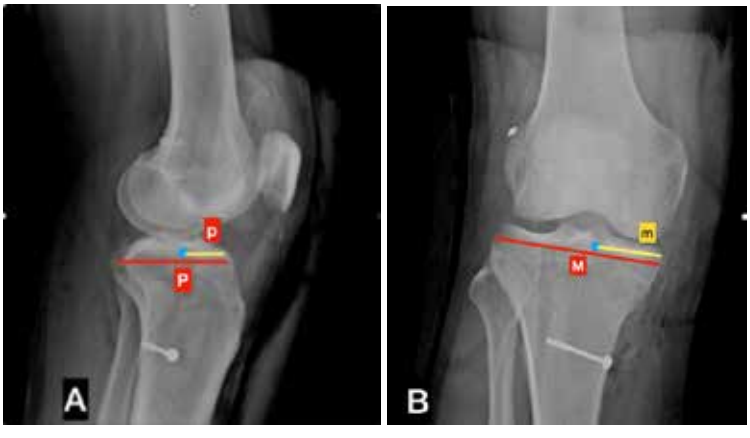

Figure 3 Postoperative ACL reconstruction x-ray: (A) Describes the method of measuring the tibial tunnel location as a percentage of the tibial plateau, anterior to the posterior by means of the lateral view (p/P) (dot = center of ACL tibial tunnel, P line = Amis and Jacob's line, p line = distance from anterior border of tibia to center of ACL tibial tunnel); (B) Describes the method of measuring the tibial tunnel location as a percentage of the tibial plateau, medial to the lateral via the AP view (m/M). (dot = center of ACL tibial tunnel, M line = width of tibial plateau, m line = distance from medial border of tibia to center of ACL tibial tunnel).

The axial view of the 3D CT reconstruction shows the width drawn and measured mediolaterally and anteroposteriorly. The centrum of the tibial tunnel was measured as a percentage of both line (Figure 4).

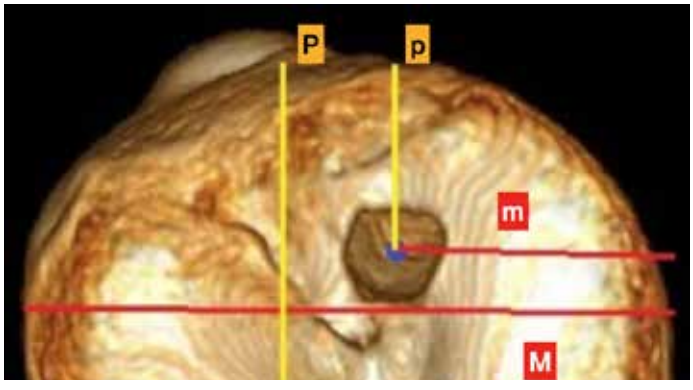

Figure 4 This 3D CT reconstruction describes the method of measuring the tibial tunnel location as a percentage of the tibial plateau, anterior to the posterior depth (p/P) and medial to the lateral width (m/M).

Statistical analysis

All data were recorded in Microsoft Excel version 16 and SPSS version 27, and analyzed using descriptive statistics including the mean value, standard deviation as well as minimum and maximum values.

Results

Twenty ACL reconstruction patients were grouped according to their knee of operation: 12 right side and 8 left side knees. All patients were male with an average age of 32 years. The demographic data is shown in Table 1.

Table 1 The demographic data of 20 patients

	Mean	SD	Minimum	Maximum
Age (years)	32	5.8	18	45
Height (cm)	72.15	3.3	65	80
Weight (kg)	174.4	4.0	169	180
BMI (kg/m^2)	23.68	0.9	22.2	25.4

The postoperative lateral view of the plain x-ray shows the centrum of the tibial ACL tunnel at 32.8±4.7 % from the anterior, and in the AP view the centrum of the tibial ACL tunnel was about 41.1±2.4% from the medial. In the postoperative CT-3D reconstruction, the centrum of the tibial ACL tunnel from the anterior was 36.5±5.6 %, and from the medial was 44.9±3.0% (Table 2).

Table 2 The average locations of the ACL tibial tunnel by plane knee x-ray and 3D-CT reconstruction.

Tibial ACL Tunnel	X-ray		CT 3D reconstruction	
	Mean (min-max)	SD	Mean (min-max)	SD
ACL from Anterior (%)	32.8 (24.5-40.3)	4.7	36.5 (28.0-46.7)	5.6
ACL from Medial (%)	41.1 (37.5-45.1)	2.4	44.9 (36.8-49.8)	3.0

Discussion

Many authors have reported no significant difference in clinical outcomes after the ACL reconstruction by either double-bundle (DB) and single-bundle (SB) technique.[1-4] Tiamklang et al has published a 2012 review in the Cochrane database comparing the double-bundle technique to single-bundle ACL reconstruction. They found that there is no statistically or clinically significant difference between DB and SB reconstruction according to subjective functional knee scores (subjective IKDC, Tegner activity or the Lysholm score), in both the intermediate interim (6 months to 2 years since surgery) or long-term periods (2 to 5 years) after operation. Furthermore, the authors concluded that there was insufficient evidence to determine the relative effectiveness of double-bundle and single-bundle reconstruction for an ACL rupture in adults.[2] There was limited evidence that the double-bundle ACL reconstruction yielded an objectively measurable superior result in knee stability, and protection against repeated ACL ruptures, or even a new meniscul injury. This same result was reported by Richard, who found that the double-bundle reconstruction did not result in a clinically significant difference using KT-1000 arthrometer or pivot-shift tests. The results did not support the theory that the double-bundle reconstruction gave patients better control of their knee rotation.[3]

Describing the anatomic centrum of the ACL AM and PL bundles, via the lateral knee radiograph method, may be based on either the proximal tibial plane of Amis and Jakob[11], or the plane of Stäubli and Rauschning.[12] Literature review shows that both planes yield similar results: the center of the AM bundle of the ACL is approximately one-third of the AP distance along either line, and the center of the PL bundle is approximately 40% to 50% of the AP distance along either line.[8,14,19-21]

There were many reports of the position of the tibial ACL footprint in both cadaver and 3D CT reconstruction. They were divided into AM and PL bundles in both the anteroposterior and medialateral planes.[13,15-17] A similar report by Brian R. Wolf et al. mentions that an acceptable range of the tibial ACL footprint in 3D CT reconstruction is between 0.3 - 0.55 in the plane of the anterior to the posterior, and 0.4 - 0.51 from medial to lateral.[18]

In this study, the ACL tibial tunnel was created using arthroscopic landmarks – as Reeboonlap et al. reported that the centrum

tibial ACL footprint is 3.2±0.5 mm anterior from the posterior border of the lateral meniscus in the anteroposterior plane. Postoperative x-rays and CT 3D reconstructions of the ACL tibial tunnel shows the measurements are within an acceptable range as reported by the literature.[8,11-18] (Table 3)

There were several limitations to this study. First, this study had a small sample size. Second, because this study had only male patients, it does not represent the general athlete or the normal population.

In conclusion, the posterior border of the anterior horn of the LM was a reliable arthroscopic landmark to create the tibial tunnel, using a single anatomical ACL reconstruction technique, and further confirmed by postoperative imaging.

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Table 3 Comparison of tibial ACL centers by plain X-ray, CT-3D reconstruction and Cadaveric

Authors, Year	X-ray		CT-3D reconstruction		Cadaveric	
	Sagittal view	Coronal view	Anterior-posterior: from anterior	Medial-lateral: from medial	Anterior-posterior: from anterior	Medial-lateral: from medial
Amis and Jakob (1998)[11]	AM 33% PL52% ACL43%					
Stäubli and Rauschning (1994)[12]	ACL 43.3%					
Amit Sahasrabudhe et al (2010)[13]	AM 35.7±6.7% PL 53.7±6.8%					
Brian R. Wolf et al (2013)[18]			ACL 30-55%	ACL 40-51%		
Forsythe et al (2010)[15]			AM 25±2.8% PL 46.4±3.7%	AM 50.5±4.3% PL 52.4±2.5%		
Lorenz el al (2009)[16]	AM 41±3% PL 52±3%		AM 37±3% PL 48±3%	AM 48±2 % PL 50±2%		
Colombet et al (2006)[14]	AM 36±3.8% PL 52±3.4%					
Zantop et al (2008)[8]	AM 30% PL 44%					
Tsukada et al (2008)[17]					AM 37.6 ± 3.6% PL 50.1 ± 5.0%	AM 46.5 ± 3.2% PL 51.2 ± 2.4 %
Surachtnanan et al (2022)	ACL 32.8±4.7%	ACL 41.1±2.4%	ACL 36.5±5.6%	ACL 44.9±3.0%		

Note: Data are mean±SD; AM = anteromedial bundle of the ACL; PL = posterolateral bundle of the ACL; ACL= the whole ACL

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