A Comparison of Lateral Radiograph of the Knee in Extended Weight Bearing and 30° Flexion to Predict a Patellar Tendon Length

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Background: *Anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) reconstruction with bone patellar tendon bone graft (BPTB) are commonly performed. Lack of precision in patellar tendon length measurement may result in a graft-tunnel mismatch. Presently, preoperative planning needs to evaluate the limb alignment from knee extended weight bearing radiograph and the length of the patellar tendon from knee 30 degrees flexion radiograph.*
Objective: *To compare knee extended weight bearing radiograph and knee 30 degrees flexion radiograph to find which one can predict the patellar tendon length with more precision.*
Study Design: *Cross-sectional diagnostic study.*
Material and Method: *Thirty-six patients who received a cruciate ligament reconstruction with BPTB graft at Phramongkutklao Hospital were enrolled. Patellar tendon lengths were measured from knee extended weight bearing radiograph and knee 30 deegrees flexion radiograph and then compared to a real intraoperative patellar tendon length. Analysis using intra-class correlation coefficient and paired t-test was done.*
Results: *The mean patellar tendon length from radiographic taken at 30 degrees of knee flexion and extended weight bearing were 43.90 mm and 42.95 mm respectively. The difference was less than 1 mm which might not be clinically significant. The prediction of patellar tendon length from 30° flexed film is statistically closer (ICC 0.760: 0.717, p-value < 0.001). By the way, they were both in intermediate reliability level (0.6 < ICC < 0.8). It also seems not clinically different.*
Conclusion: *Preoperative film knee extended weight bearing alone is enough for evaluation both limb alignment and length of the patella tendon leading to decreasing cost, time and radiation exposure of patients.*

Keywords: *Anterior cruciate ligament, Posterior cruciate ligament, Bone patellar tendon bone graft, Preoperative planning, Patellar tendon length prediction*

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Anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) injuries, with or without associated lesions of other structures of the knee, are common with a yearly incidence of 0.8 per 1,000 inhabitants aged 10 to 64 years[8]. The injury leads to knee instability, functional limitations and decline in quality of life. The risk of osteoarthritis (OA) is higher in the long term result, about 50% of patients with ACL and meniscal injuries have OA with associated pain and functional limitations[10]. Reconstruction of the ligaments are the gold standard for the treatment. ACL and PCL reconstruction with bone-patellar tendon-bone graft (BPTB) are commonly performed. Lack of precision in patellar tendon length measurement may result in a graft-tunnel mismatch. This graft-tunnel mismatch can be problematic because a standard interference screw cannot be used for graft fixation. If the length of the patellar tendon portion of the graft could be predicted, preoperative planning would show the graft to be too long or too short. In cases where the graft is too long, graft fixation other than an interference screw may be necessary. In cases where the graft is too short, a different graft may be required[5].

Presently, there are two positions of the knee required for preoperative films. The first one is weight bearing extended knee radiograph to evaluate the limb alignment. The other one is 30 degrees flexed knee radiograph to estimate the length of the patellar tendon[1]. The purpose of the present study was to compare the efficacy of lateral radiographs taken at 30 degrees of knee flexion and extended weight bearing in

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predicting patellar tendon length. Accurate preoperative prediction of patellar tendon length could aid the surgeon in graft choice and fixation selection before cruciate ligament reconstruction.

Material and Method

Study population

The inclusion criteria for the present study were (1) patients who were considered to use BPTB graft for arthroscopic cruciate ligament reconstruction and (2) age of 20 years or over. Patients were excluded if they presented with any of either (1) history of using BPTB graft of the same knee, (2) genu recurvatum (hyperextend > 10 degrees) and (3) Patients with patellar alta or patellar baja. Sample size was obtained from doing a pilot study 11 patients calculated for estimating intraclass correlations with desired precision[4]. Twenty four patients were required in the present study. From August 2009 to July 2010, 39 patients received ACL or PCL reconstruction with BPTB graft. Among them, 3 patients were excluded from the present study due to genu recurvatum. Thus, 36 patients (36 knees) were included in the present study. Approval from ethic committee of Phramongkutklao hospital was obtained. The mean age of the patients was 26.97 years (range, 20-50); there were 35 men and 1 woman. Twenty patients had right ACL injury, 12 patients had left ACL injury, and 4 had PCL injury or bicruciate ligaments injury. All 36 patients were sent for preoperative lateral radiographs taken at 30° of knee flexion weight bearing, and extended weight bearing. There was a tool to fix the knee in 30 degrees flexion (Fig. 1). All radiographs were obtained using the same radiographic technique and a calibrated radiopaque maker was placed on each film (Fig. 2). The patellar tendon length was determined by using a plain ruler to measure the distance in millimeters between inferior pole of the patella and the superior aspect of the tibial tubercle on the radiograph. A calibration factor was determined for each radiograph by dividing actual calibration marker length measured from the radiograph (Fig. 3). The patellar tendon length measurements were adjusted by multiplying with the calibration factor to account for magnification. Each lateral radiograph was measured 3 times by 3 different examiners in a blind fashion. The mean lengths were used. After completion of all imaging studies, autogenous BPTB graft were harvested intra operatively and tendinous portion of the graft was measured in its midline with a plain ruler along the

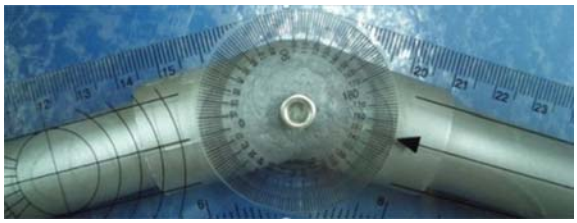

Fig. 1 Thirty degree fixed angle tool

Fig. 2 Obtaining lateral film with the knee flexed 30°. There were fixed angle tool and a calibrated radiopaque marker during the procedure

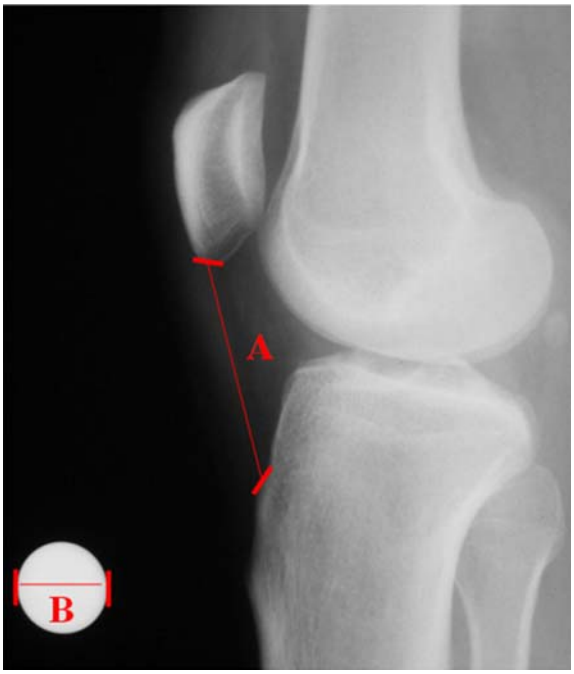

Fig. 3 Lateral knee radiograph obtained with the knee extended weight bearing. The patellar tendon length is estimated by measuring the length of the "A" line between the inferior pole of the patella and the superior aspect of the tibial tubercle. Calibration marker length is from the "B" line

posterior surface of the tendon, the graft were pulled to eliminate redundancy, then the tension was released (Fig. 4). This measurement was compared with similar measurements made from the imaging studies. Analysis using intra-class correlation coefficient and paired t-test was done.

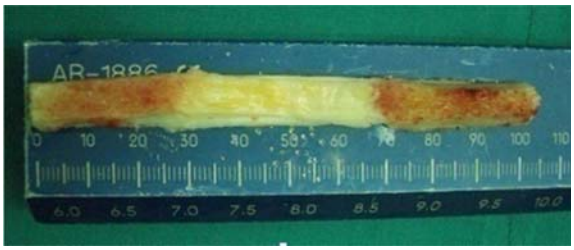

Fig. 4 Measuring true patellar tendon length with a ruler

Results

The actual patellar tendon length of each specimen and the measured patellar tendon lengths from radiographic taken at 30 degrees of knee flexion and extended weight bearing are listed in Table 1.The mean length of the actual patellar tendons was 45.67 mm. The mean length of the patellar tendons from radiographic taken at 30 degrees of knee flexion and extended weight bearing were 43.9 mm. and 42.95 mm, respectively (Table 2). Intraclass correlation coefficient (ICC) was also calculated. ICC between the length of the patellar tendons from radiographic taken at 30 degrees of knee flexion and the length of the actual

Table 1. True patellar tendon length compared with predicted patellar tendon length

Specimen	True patellar tendon length (mm)	Predicted patellar tendon length (mm)	
		Ext Wt bearing	30° flexion
1	40	38.7	40.5
2	55	46.8	45.9
3	48	45.9	45.0
4	40	25.2	35.1
5	40	40.5	38.7
6	52	50.4	46.8
7	48	45.0	44.1
8	40	37.8	36.9
9	37	37.8	36.9
10	50	47.7	45.9
11	48	35.1	30.6
12	45	54.0	53.1
13	43	40.5	38.7
14	55	47.7	45.9
15	40	44.1	42.3
16	50	46.8	45.9
17	40	36.0	36.9
18	43	42.3	39.6
19	40	28.8	40.5
20	40	45.0	37.8
21	55	53.1	54.0
22	40	29.7	40.5
23	46	32.4	37.8
24	40	40.5	48.6
25	50	47.7	48.6
26	50	43.2	44.1
27	40	42.3	42.3
28	35	36.9	36.9
29	50	50.4	45.9
30	50	47.7	50.4
31	50	55.8	58.5
32	45	45.0	43.2
33	55	62.1	63.0
34	54	35.1	48.6
35	50	41.4	43.2
36	40	46.8	47.7

patellar tendons was 0.760. The other pair was 0.717. Their p-values were both less than 0.001 (Table 3).

Discussion

Mean patellar tendon lengths have been previously reported. Denti et al reported the mean patellar tendon length to be 45.48 mm[7]. Miller and Olszewski reported the mean patellar tendon length to be 43.33 mm[11]. David et al reported the mean patellar tendon length to be 45.2 mm[6]. In the present study, the mean patellar tendon length was 45.67 mm, which is close to the previously reported values.

The position of the knee in 30 degrees flexion is widely used when calculating Insall-Salvati ratio[9], Blackburn Peel index[3] and Blumensatt line[2] to ensure that the slack of patellar tendon is taken up. Regarding to paired T-test, mean patellar tendon length from radiographic taken at 30 degrees of knee flexion and extended weight bearing were 43.90 mm and 42.95 mm respectively. The difference is less than 1 mm which might not be clinically significant, because the proper length for the tendon portion of the graft to be in the joint is at least 40 mm. From Table 2, the true patellar tendon length has more accuracy when using 30 degrees flexed radiograph. But from Table 3, the ICC of 30 degrees flexed radiograph was 0.760 (p-value < 0.001) while of extended weight bearing was 0.717 (p-value < 0.001). Although the prediction of patellar tendon length from 30° flexed film was statistically closer, they were both in intermediate reliability level (0.6 < ICC < 0.8). It also seems not clinically different.

A limitation of this study is that the authors didn't determine the tension of the patellar tendon during measurement. There might be some degree of variability. The authors attempted to compensate for this by pulling the graft to eliminate redundancy and releasing the tension during measurement.

Conclusion

From the present study, the authors conclude that preoperative knee extended weight bearing radiograph alone is enough for evaluation both limb alignment and length of the patella tendon leading to decreasing cost, time and radiation exposure of patients.

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Potentialconflicts of interest

None.

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Table 2. Results of paired t-test

Position of the knee	Mean ± SD	Paired Differences	p-value
30° flexion	43.90 ± 6.67	- 1.77 ± 5.53	0.064
Patellar tendon length	45.67 ± 5.89		
Ext weight bearing	42.95 ± 7.80	- 2.72 ± 6.49	0.017
Patellar tendon length	45.67 ± 5.89		
30° flexion	43.90 ± 6.67	0.95 ± 4.66	0.229
Ext weight bearing	42.95 ± 7.80		

Table 3. Results of intraclass correlation coefficient

Position of the knees	ICC	95% CI		p-value
		Lower	Upper	
30° flexion vs. PTL	0.760	0.530	0.878	<0.001
Ext weight bearing vs. PTL	0.717	0.446	0.856	<0.001
30° flexion vs. Ext weight bearing vs. PTL	0.855	0.748	0.921	<0.001

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การศึกษาเปรียบเทียบความใกล้เคียงในการทำนายความยาวของเอ็นลูกสะบ้า ระหว่างภาพถ่ายรังสีด้านข้างในท่ายืนเข่าเหยียดลงน้ำหนักกับท่างอเข่า 30 องศา

นิธิศ รีบุญลาภ, วรพงษ์ พงษ์ภัทรรัตน์, กรกฎ ชรากร

วัตถุประสงค์: *การผ่าตัดโดยใช้เนื้อเยื่อทดแทนจากเอ็นลูกสะบ้า เป็นมาตรฐานในการผ่าตัดรักษาเอ็นไขว้หน้าเข่า ยังไม่มีการศึกษาใดสามารถทำนายความยาวของเอ็นลูกสะบ้าที่แม่นยำได้ ทำให้ในการผ่าตัดอาจมีปัญหาที่ความยาวของเอ็นลูกสะบ้าได้ ปัจจุบันการผ่าตัดเปลี่ยนเอ็นไขว้เข่านั้น มีการประเมินแนวของขาจากภาพถ่ายรังสีเข่าในท่ายืนลงน้ำหนักเหยียดเข่า และประเมินความยาวของเอ็นลูกสะบ้าจากภาพถ่ายรังสีในท่างอเข่า 30 องศา การศึกษานี้ได้เปรียบเทียบความใกล้เคียงในการทำนายความยาวของเอ็นลูกสะบ้า ระหว่างภาพถ่ายรังสีด้านข้างในท่ายืนเข่าเหยียดลงน้ำหนัก กับท่างอเข่า 30 องศา*

วัสดุและวิธีการ: *การศึกษานี้ทำในผู้ป่วยที่มารับการผ่าตัดรักษาเอ็นไขว้เข่าโดยใช้เนื้อเยื่อทดแทนจากเอ็นลูกสะบ้าในโรงพยาบาลพระมงกุฎเกล้า จำนวน 36 ราย โดยวัดความยาวของเอ็นสะบ้าจากภาพถ่ายรังสีทั้ง 2 ท่า เปรียบเทียบกับความยาวจริงของเอ็นลูกสะบ้าจากในห้องผ่าตัด แล้วนำมาวิเคราะห์ข้อมูลแบบ Intra-class correlation coefficient และ paired t-test*

ผลการศึกษา: *การทำนายความยาวของเอ็นลูกสะบ้าจากภาพถ่ายรังสีด้านข้างในท่างอเข่า 30 องศา มีความแม่นยำกว่าในท่ายืนเข่าเหยียดลงน้ำหนัก อย่างมีนัยสำคัญทางสถิติ (ICC 0.760:0.717, p-value < 0.001) แต่ไม่แตกต่างอย่างมีนัยสำคัญทางด้านคลินิก*

สรุป: *การส่งภาพถ่ายรังสีของเข่าในการเตรียมผู้ป่วยก่อนการผ่าตัดเอ็นไขว้เข่า สามารถส่งภาพถ่ายรังสีของเข่าในท่ายืนลงน้ำหนัก เพียงท่าเดียว ในการประเมินทั้งแนวของขาและความยาวของเอ็นลูกสะบ้า เป็นการลดค่าใช้จ่าย เวลาและปริมาณการสัมผัสรังสีของผู้ป่วยได้*