Arthroscopically Assisted Anterior Cruciate Ligament Reconstruction: Comparison of Bone-Patellar Tendon-Bone Versus Hamstring Tendon Autograft

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Background : *The bone-patellar tendon-bone (BPTB) and the hamstring tendons are commonly used for arthroscopially-assisted anterior cruciate ligament(ACL) reconstruction.*

Purpose : *To compare the results of arthroscopically-assisted ACL reconstruction using bone-patellar tendon-bone and hamstring tendons grafts in terms of postoperative knee stability, knee functions and clinical rating scale, and patient satisfaction.*

Hypothesis : *There was no difference in the outcomes of the two grafts.*

Study Design : *Retrospective non-randomized clinical trial.*

Material and Method : *Two groups of patients, 45 in the BPTB group and 30 in the hamstring group, were followed for at least one year.*

Results : *The two groups had similar pre-operative data except the hamstring group which had a significantly shorter duration of injury before operation (9.5 versus 18 months, $p < 0.05$). There was no difference in median pre-operative Lysholm knee score (74 in the BPTB group versus 75 in the hamstring group, $p > 0.05$) and the post-operative one (95 in the BPTB group versus 99 in the hamstring group, $p > 0.05$). There was also no difference in the median pre-operative HSS knee score (58 in the BPTB group versus 61 in the hamstring group, $p > 0.05$). Although there was a statistically significant difference in the median post-operative HSS knee score between the two groups (95 in the BPTB group versus 96 in the hamstring group, $p < 0.05$), this was not clinically significant since both scores were rated as an excellent result. Both groups had a significantly improved knee stability and knee functions (Lysholm and HSS knee scores). The hamstring group, however, had significantly higher patient satisfaction (88% in the BPTB group versus 93% in the hamstring group, $p < 0.05$).*

Conclusion : *Both the BPTB and the hamstring tendon grafts resulted in significantly improved knee stability and functions with high patient satisfaction. The hamstring tendon group, however, had a significantly better post-operative patient satisfaction (Visual Analog Scale,VAS).*

Keywords : *Anterior cruciate ligament reconstruction, Bone-patellar tendon-bone, Hamstring tendon*

J Med Assoc Thai 2004; 87(9): 1100-7

Anterior cruciate ligament (ACL) tear is the most common serious ligamentous injury to the knee joint[1,2]. The ACL is the primary stabilizer against anterior translation of the tibia on the femur[3] and is important in counteracting rotation and valgus stress. Anterior cruciate ligament deficiency leads to knee instability. This results in recurrent injuries and increased risk of intra-articular damage, especially the meniscus[4-9]. The goals of the ACL reconstruction are to restore stability to the knee; allow the patient to return to normal activities, including sports; and to delay the onset of osteoarthritis with associated recurrent injuries to the articular cartilage and loss of

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meniscal functions[5,10-13]. During the past decade arthroscopically assisted techniques have been an accepted method of reconstructing the ACL[14-22]. The advantages of arthroscopically assisted anterior cruciate ligament reconstruction include elimination of capsular incisions, decrease in trauma to the fat pad, avoidance of desiccation of the articular cartilage, better visualization of the femoral attachment, and a lower incidence of post-operative patellofemoral pain than with open reconstruction[23]. The primary disadvantage of arthroscopically assisted technique is that the technique has a long learning curve and is a technically demanding prodecure[24].

The bone-patellar tendon-bone and the hamstring tendon are the two most commonly used autografts for reconstruction[25-30]. The bone-patellar tendon-bone autograft has been widely accepted as the gold standard for ACL reconstruction with a high success rate[19,25,31]. However, donor site morbidities and extensor mechanism problems associated with the use of the bone-patellar tendon-bone have led to increasing popularity of the hamstring tendon graft which had advantages of low donor site morbidities, avoidance of extensor mechanism problems and better cosmesis.

The aim of this study was to compare the results of arthroscopically assisted ACL reconstruction using the bone-patellar tendon-bone and the hamstring tendons grafts in terms of post-operative knee stability, knee functions and clinical rating scales, and patient satisfaction.

Material and Method

All patients who underwent single-incision arthroscopically assisted ACL reconstructions using either the bone-patellar tendon-bone or the hamstring autograft without extra-articular augmentation between August 1998 and December 2000 were retrospectively reviewed. Clinical diagnosis was made by positive Lachman and Pivot shift tests. The indication for surgery was an ACL tear confirmed by clinical diagnosis in an otherwise healthy patient who experienced knee instability in daily activities or wished to maintain his or her pre-injury level of activities. Exclusional criteria included contralateral ACL deficiency, bilateral ACL reconstruction, revision ACL surgery, previous knee operation, concomitant extra-articular reconstruction and concomitant medical illness or geographic constraint that precluded follow-up evaluations. All operations were performed by the same surgeon (Tanarat Boonriong). The type of graft tissue used for reconstruction (bone-patellar tendon-bone versus hamstring tendon autograft) was not randomized. Bone-patellar tendon-bone autografts were used for those who wished to return to high-level activities and hamstring tendon autografts for those who had low-level activities or were concerned about cosmesis. The outcome testing in all cases was performed at the latest follow-up (at least one year) by the other independent surgeon (Niran Kietsiriroje).

Surgical technique

The anterior cruciate ligament was reconstructed with a single-incision, arthroscopic assisted techniques as previously described[4,13,15,22,32]. Prophylactic antibiotic, cefazolin, was given prior to the skin incision.

The hamstring tendons were harvested through a small longitudinal anteromedial incision over the pes ancerinus insertion. The graft was then prepared for a quadrupled semitendinosus-Endobutton (Smith Nephew Endoscopy , Massachusetts) construct using the Acufex Graft Master Table II (Acufex Microsurgical, Massachusetts)[32].

The bone-patellar tendon-bone autograft was harvested via a longitudinal incision (usually 4-5 cm in length) over the patellar tendon. The graft was prepared into a bone-patellar tendon-bone construct with the leading suture on the patellar side[4,13,15,22].

The portals used for arthroscopy included the superomedial portal for gravitational inflow canula, high inferolateral for arthroscope and inferomedial for instruments. The notch was prepared using a curette and motorized shaver until the over-the-top position and femoral ACL footprint were clearly demonstrated. Routine notchplasty was not performed. The tibial stump was cleaned leaving a short amount of stump for reference and covering the graft. The tibial guide pin was inserted to the posterior half of the remnant using the Acufex elbow-tipped tibial guide and tibial tunnel reamed according to the size of the graft. During this, cancellous bone graft was collected for filling the donor site in case of patellar tendon autograft. With the knee flexed at 90 degrees, a guide pin was passed through the tibial tunnel to the femoral tunnel position. The femoral tunnel was reamed according to the size of the graft. The depth of the tunnel was 26 mm for hamstring-Endobutton and 30 mm for patellar tendon. In the case of hamstring tendon, the outer femoral cortex was drilled with an Endobutton drill bit and the femoral channel length measured with depth probe for

Endobutton setting. Using a suture passing pin, the graft was passed through the tibial tunnel into the femoral tunnel and the suture passing pin passing out distal to the anterolateral skin of the thigh.

The fixation method for patellar tendon graft was a cannulated interference screw (Silk screws , Smith & Nephew, Massachusett), usually 7 x 20 mm. The femoral site was fixed at 120 degrees knee flexion with the screw guide pin passed through the inferomedial portal. After femoral fixation, tension was applied to the tibial bone block suture and the knee passed through several cycles of flexion-extension to pretension the graft. The tibial site was fixed at 20 degrees knee flexion.

For femoral fixation of the hamsting graft, the Endobutton was deployed at the outer femoral cortex when the second mark on the graft was flush with the femoral tunnel opening. The graft was pulled back to confirm the Endobutton deployment. No further graft pretension was needed. The tibial site was fixed with sutures to the post technique, also at 20 degrees knee flexion.

After the procedure, an intra-articular vacuum drain was placed through the inflow canula portal into the joint. The drain was removed at 24-48 hours postoperatively. The knee was placed in a compressive dressing and hinge knee brace locked in full extension.

Post-operative care

The knee brace was unlocked to allow 0-90 degrees knee motion on the second or third post-operative day and the patient was discharged. Weight bearing as tolerated was allowed with axillary crutches but delayed in patients with concomitant meniscal repair. Full weight bearing without support was allowed as soon as the patients were comfortable. The usual clinical follow-up included review at 10-14 days for wound inspection and suture removal, the brace set to 0-120 degrees at 4 weeks and removed at 6 weeks. Wall sliding semi-squats were allowed as early as possible. Bicycling was allowed at 2-3 months and general strengthening exercises continued. Returning to sports involving jumping, pivoting, or side-stepping was prohibited until 9 months post-operatively but with variable patient compliance.

Clinical evaluation

All patients were followed-up initially by the operating surgeon. All final clinical testings and evaluations were performed by the other independent surgeon from one year post-operation to eliminate potential bias. The evaluations included supine range of motion measurements with goniometer, thigh circumference measurements, effusion, joint line tenderness, McMurray's test, and patellofemoral crepitation, as well as checking for associated complications. Stability testing included the Lachman test, anterior drawer test, posterior drawer test, pivot shift test, and valgus and varus stress test at 0 and 30 degrees flexion. Ligamentous laxity was graded as 1+ (0-5 mm), 2+ (6-10 mm), or 3+ (more than 10 mm). The pivot shift test was graded as 1+ (slip), 2+ (definite movement, jump), or 3+ (transient lock). A single-legged hop for distance was used for functional testing. The test was performed three times and averaged. The clinical rating scales used included the Hospital for Special Surgery (HSS) knee score[33] and the Lysholm Knee Score[34]. The patient satisfaction was evaluated using the patient's self scaling visual analog scale (VAS).

Data analysis

Pre-operative and post-operative data were compared. Median (range) values are presented except for age(mean). The t-test was used to compare the age and chi-square for sex. The Fisher's exact test was used to compare the number of associated injuries and concomitant surgeries in both groups. The comparison of pre- and post-operative data within the group was made using the Wilcoxon's signed rank test. The Mann-Whitney U-test was used to compare the variables between the two groups. A p-value of less than 0.05 was considered statistical significant.

Results

Demographic data:

Seventy-five patients were included in the study. There were 45 patients in the BPTB group and 30 patients in the hamstring group (Table 1). The duration between injury and operation was significantly shorter in the hamstring group. Duration of follow-up evaluation was not different. Both groups had no difference in age and sex distribution. There was also no difference in the type and number of associated injuries and concomitant surgeries (Table 2).

Stability testing:

Manual Lachman and Pivot shift tests were used for stability testings. There was no difference in the number and the distribution of grading of instability in both groups, both pre- and post-operatively

Table 1. Basic data of both groups

Variables	BPTB	HAMSTRING	significance
Number of patients	45	30	
Mean age (years)	28.9 $\pm$ 6.5	26.9 $\pm$ 5.7	*p = 0.167* (t- test)
Sex (female/male)	5/40	4/26	*p=0.772* (chi-square)
Months between injury to operation (median(range))	18 (1-96)	9.5 (1-84)	*p = 0.0107** (Mann-Whitney *U*-test)
Months at follow-up (median(range))	12 (11-38)	18 (11-30)	*p = 0.6352* (Mann-Whitney *U*-test)

* statistical significance

Table 2. associated injuries and concomitant surgery

	BPTB	Hamstring	p-value (Fisher's exact)
Associated injuries			0.434
No	16	10	
Medial meniscal	12	5	
Lateral meniscus	13	8	
Both menisci	2	1	
Articular cartilage	1	3	
Cartilage and meniscus	1	3	
Concomitant surgery			0.250
No	15	15	
Meniscectomy	28	13	
Debridement	2	2	

(Table 3). Both groups showed significant improvement of instability.

Knee score:

For the Lysholm knee score, there was no difference between each group both pre- and post-operatively. Both groups had significant improvement of the Lysholm knee score at follow-up (Table 3). Although there was no difference in the pre-operative HSS knee score in both groups, the hamstring group had a significantly better HSS knee score (although not clinically significant) at follow-up. Both groups, however, had significant improvement of the HSS knee score.

Table 3. Comparison of outcome variables of both groups

Variables	BPTB				Hamstring				p-value (Mann-Whitney U-test)
Manual Lachman test	0	1+	2+	3+	0	1+	2+	3+	
-pre-operative	0	3	28	14	0	3	22	5	0.1647
-at follow-up	21	23	1	0	19	11	0	0	0.1420
significance pre-vs post-op (Wilcoxon's signed rank test)	*p < 0.0001*				*p< 0.0001*				
Pivot shift test	0	1+	2+	3+	0	1+	2+	3+	
-pre-operative	2	15	27	1	4	7	19	0	0.7539
-at follow-up	40	4	1	0	26	4	0	0	0.8029
significance pre-vs post-op (Wilcoxon's signed rank test)	*p< 0.0001*				*p< 0.0001*				
Lysholm score [median (range)]									
-pre-operative	74 (37-95)				75 (43-90)				0.3604
-at follow-up	95 (74-100)				99 (75-100)				0.2116
significance pre-vs post-op (Wilcoxon's signed rank test)	*p < 0.0001*				*p < 0.0001*				
HSS score [median (range)]									
-pre-operative	58 (31-78)				61 (38-75)				0.3247
-at follow-up	95 (71-99)				96 (66-100)				0.0150*
significance pre-vs post-op (Wilcoxon's signed rank test)	*p < 0.0001*				*p < 0.0001*				
Patient's satisfaction at follow-up(VAS) [median(range)]	88 (15-100)				93 (50-100)				0.0286*

* statistical significance

Patient satisfaction:

The patients in the hamstring group were significantly more satisfied with the outcomes than in the BPTB group (Table 3).

Complications:

Three patients in the BPTB group had complications. One patient developed septic arthritis at 3 weeks post-operatively. He presented with a high fever with marked knee pain and effusion. Aspiration of the knee revealed purulent discharge. Open debridement, profuse lavage and intravenous antibiotics were given. The graft could be preserved. Bacteria culture was negative. He recovered uneventfully with 1+ Lachman and was satisfied with the outcome. One patient had a meniscus tear from re-injury and required arthroscopic meniscectomy. The other had recurrent laxity at follow-up but he was satisfied with the knee function and denied revision surgery.

All patients in the BPTB group experienced temporary numbness lateral to the skin incision but there was no sign of neuroma complications. All numbness completely recovered within one year.

There was no significant complication in the hamstring group.

Discussion

Results of the present study clearly showed that both bone-patellar tendon-bone and hamstring tendon grafts could effectively improve knee stability and functions after anterior cruciate ligament reconstruction. At follow-up evaluation, both groups had similar subjective outcomes as assessed by the Lysholm knee score. Although the HSS knee score had been significantly improved from pre-operative values in both groups, it was significantly higher in the hamstring group as well as the patient satisfaction score. However, the higher postoperative HSS knee score in the hamstring group should be considered as only statistically significant but not clinically significant since both scores of 95 and 96 were considered as an excellent result[33]. In a similar study, Corry, et al found that the two grafts did not differ in terms of clinical stability, range of motion and general symptoms[13]. The hamstring group had less thigh atrophy in the first year although it was not different by 2 years. The hamstring tendon group also had a lower graft harvest site morbidity[13]. These might be some of the reasons for a higher patient satisfaction in the hamstring group in the present study which followed the patient for about one year. Although both groups had comparable associated injuries and concomitant surgeries, the duration of injury was longer in the bone-patellar tendon-bone group may indicated more repeated microtrauma (not visible with the arthroscope) to the knee structure and, therefore, led to less favorable functional outcomes of the knee[10]. In the study of arthroscopic anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft, Akgun, et al found that the best results could be obtained if the reconstruction was done in the subacute period between 3-5 weeks post-injury[35]. The patients in the bone-patellar tendon-bone group would have more desire to return to sports activity or higher functional demand than in the hamstring group, therefore higher expectation. Donor site morbidity is a major drawback of the bone-patellar tendon-bone graft. All patients in the bone-patellar tendon-bone group of the present study had experienced a disturbance of anterior knee sensation which continued for a period of time although it returned to normal within one year of the follow-up period. In contrast, there was no sensory disturbance in the hamstring group. The hamstring group had also presumably better cosmesis. As the authors used the patient's self assessment visual analog scale (VAS) to measure the patient satisfaction with the overall outcomes, it would appear that the patients in the hamstring group had higher satisfaction regarding the above mentioned factors.

There have been many prospective randomized control studies comparing the two groups published in recent years. Results from these studies showed that the two groups had similar outcomes at the 2-5 year period[27-29,36,37]. The present study, the only one performed in Thailand and to our knowledge in Asia, added more supporting evidence. On the contrary, with similar prospective randomized comparisons, Beynnon, et al found that after three years of follow-up, the objective results of anterior cruciate ligament reconstruction with a bone-patellar tendon-bone were superior to those of reconstruction with a two-strand semitendinosus-gracillis tendon graft with regard to knee laxity, pivot shift grade, and strengths of the knee flexor muscle[30]. However, the two groups had comparable results in terms of patient satisfaction, activity level, and knee functions. Results from the present study and these prospective randomized studies were still conflicting but there was a trend toward similar outcomes.

From the most recent literature review, the authors found only two reports of metaanalysis regarding the choice of the graft for anterior cruciate ligament reconstruction. In 2001, Yunes, et al were the first to report a meta-analysis conducted from controlled trials of patellar tendon versus hamstring tendons for ACL reconstruction[38]. They found that the patellar tendon patients had a greater chance of attaining a statically stable knee and nearly a 20% greater chance of returning to preinjury activity levels. They concluded that although both techniques yielded good results, patellar tendon reconstruction led to higher postoperative activity levels and greater static stability than hamstring reconstruction. In 2003, using the same and extended numbers of controlled trial, Freedman, et al found that the rate of graft failure in the patellar tendon group was significantly lower and a significant higher proportion of patients in the patellar tendon group had a side-to-side difference of less than 3 mm on KT-1000 arthrometer testing than in the hamstring tendon group[39]. There was a higher rate of manipulation under anesthesia or lysis of adhesions and of anterior knee pain in the patellar tendon group and a higher incidence of hardware removal in the hamstring tendon group. They concluded that patellar tendon autografts had a significantly lower rate of graft failure and resulted in better knee stability and increased patient satisfaction compared with hamstring tendon autografts. However, patellar tendon autograft reconstruction resulted in an increased rate of anterior knee pain[39].

Conclusion

Both the BPTB and the hamstring tendon grafts resulted in significantly improved knee stability and functions with high patient satisfaction. The hamstring tendon group, however, had a significantly better patient satisfaction (VAS).

Acknowledgement

The authors wish to thank Apiradee Lim for her assistance in all the statistical analysis.

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การผ่าตัดสร้างเอ็นไขว้หน้าข้อเข่าผ่านกล้องส่องข้อ: เปรียบเทียบระหว่างการใช้เอ็นสะบ้ากับเอ็น hamstrings

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ข้อมูลพื้นฐาน *: เอ็นสะบ้าและเอ็น hamstrings เป็นเส้นเอ็นที่ใช้บ่อยที่สุดในการการผ่าตัดสร้างเอ็นไขว้หน้าข้อเข่าผ่านกล้องส่องข้อ*

วัตถุประสงค์ *: เปรียบเทียบผลการผ่าตัดสร้างเอ็นไขว้หน้าข้อเข่าผ่านกล้องส่องข้อ ระหว่างการใช้เอ็นสะบ้ากับเอ็น hamstrings*

สมมติฐาน *: ไม่มีความแตกต่างของผลการผ่าตัดโดยใช้เอ็นทั้งสองแบบ*

รูปแบบการวิจัย *: การศึกษาเชิงวิเคราะห์เปรียบเทียบ(แบบย้อนหลัง)*

วิธีการศึกษา *: ทำการผ่าตัดสร้างเอ็นไขว้หน้าข้อเข่าผ่านกล้องส่องข้อโดยใช้เอ็นสะบ้า (45 ราย) กับเอ็น hamstrings (30 ราย) ติดตามผลการผ่าตัดอย่างน้อย 1 ปี*

ผลการศึกษา *: ข้อมูลพื้นฐานก่อนการผ่าตัดของผู้ป่วยทั้งสองกลุ่มไม่มีความแตกต่างกันยกเว้นกลุ่มที่ใช้เอ็น hamstrings มารับการผ่าตัดเร็วกว่ากลุ่มที่ใช้เอ็นสะบ้าอย่างมีนัยสำคัญ (9.5 เดือนเทียบกับ 18 เดือน, $p < 0.05$) ค่า Lysholm Knee Score ในทั้งสองกลุ่มไม่แตกต่างกันทั้งก่อนและหลังการผ่าตัด (74 คะแนนในกลุ่มที่ใช้เอ็นสะบ้าเทียบกับ 75 คะแนนในกลุ่มที่ใช้เอ็น hamstringsก่อนการผ่าตัด และ 95 คะแนนในกลุ่มที่ใช้เอ็นสะบ้าเทียบกับ 99 คะแนนในกลุ่มที่ใช้เอ็น hamstringsหลังการผ่าตัด, $p > 0.05$) ส่วนค่า HSS Knee Score ก่อนการผ่าตัดไม่แตกต่างกัน (58 คะแนนในกลุ่มที่ใช้เอ็นสะบ้าเทียบกับ 61 คะแนนในกลุ่มที่ใช้เอ็น hamstrings, $p > 0.05$) แม้ว่าจะมีความแตกต่างอย่างมีนัยสำคัญทางสถิติของค่า HSS Knee Score หลังการผ่าตัด (95 คะแนนในกลุ่มที่ใช้เอ็นสะบ้าเทียบกับ 96 คะแนนในกลุ่มที่ใช้เอ็น hamstrings, $p < 0.05$) แต่ความแตกต่างนี้ไม่มีผลสำคัญทางคลินิกเพราะในทั้งสองกลุ่มข้อเข่ามีความมั่นคงเพิ่มขึ้นและการทำงานของข้อเข่าดีขึ้นอย่างมีนัยสำคัญ ผู้ป่วยในกลุ่มที่ใช้เอ็น hamstrings มีความพึงพอใจต่อผลการผ่าตัดโดยรวมมากกว่ากลุ่มที่ใช้เอ็นสะบ้า (ร้อยละ 88 ในกลุ่มที่ใช้เอ็นสะบ้าเทียบกับร้อยละ 93 ในกลุ่มที่ใช้เอ็น hamstrings, $p < 0.05$)*

สรุป *: ทั้งกลุ่มที่ใช้เอ็นสะบ้าและกลุ่มที่ใช้เอ็น hamstrings สามารถให้ผลเพิ่มความมั่นคง การทำงานของข้อเข่าและความพึงพอใจของผู้ป่วยอย่างมีนัยสำคัญ โดยที่กลุ่มที่ใช้เอ็น hamstrings มีความพึงพอใจต่อผลการผ่าตัดมากกว่ากลุ่มที่ใช้เอ็นสะบ้า*