Clinical Comparison between Six-Strand Hamstring Tendon and Patellar Tendon Autograft in Arthroscopic Anterior Cruciate Ligament Reconstruction: A Prospective, Randomized Clinical Trial

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Objective: *Many randomized clinical trials demonstrated that 4-strand hamstring tendon grafts have comparable results both subjectively and objectively with the patellar tendon grafts. The authors hypothesized that the increment of hamstring tendons strength with 6-strand graft could improve the knee stability compared to the result from using the gold standard patellar tendon.*

Material and Method: *Thirty-four patients were prospectively randomized into two groups for arthroscopic anterior cruciate ligament reconstruction. Seventeen patients underwent reconstruction with 6-strand hamstring tendons and the remaining seventeen were treated with bone-patellar tendon-bone graft. Patients were followed-up under the similar rehabilitation protocol for at least 12 months. At the time of final follow-up, all the patients in both groups were evaluated in terms of patient's satisfaction, activity level, and knee stability.*

Results: *Fifteen patients in bone-patellar tendon-bone graft (two lost to follow-up) and thirteen patients used 6-strand hamstring tendons(four were converted to 4-strand hamstring tendons) were evaluated at a mean of 19 months (range 12-31 months). The mean of KT-2000 side-to-side laxity measurement in 6-strand hamstring group (0.96 mm) is less than BPTB group (1.22 mm) significantly ($p < 0.05$). Eleven of 13 patients (84.62%) that received the 6-strand hamstring tendons could return to sport activities compared to 10 of 15 patients (66.67%) that received BPTB graft. Hamstring group have a lower prevalence of donor-site morbidity resulting in less difficult in kneeling.*

Conclusion: *The authors concluded that using 6-strand hamstring tendons could improve knee stability in the early clinical outcomes. With no difference in subjective assessment, anterior cruciate ligament reconstruction used hamstring tendons have less donor-site morbidity, which is more compatible to Asian life-style.*

Keywords: *Anterior cruciate ligament, Bone-patellar tendon-bone graft, Patellar ligament, Reconstructive surgical procedures, Tendon transfer, Transplantation autologous*

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The autogenous bone-patellar tendon-bone graft is used as a gold standard graft for intra-articular reconstruction of the anterior cruciate ligament. The result of anterior cruciate ligament reconstruction with a bone-patellar tendon bone autograft is excellent in midterm and long-term studies but an important concern is the fact that the prevalence of donor-site morbidity especially the anterior knee pain has been reported to be higher than that following reconstruction with a hamstring autograft[1-4]. Recently, clinical trial demonstrated that anterior cruciate ligament reconstruction with a 4-strand hamstring tendon provides patients with an excellent midterm clinical outcome[5,6].

The average semitendinosus tendon length in Thai patients is 25.61-29.95 cm[7] which could be

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folded to a 6-strand graft. By biomechanical theory, increment of hamstring tendon strength with a larger cross sectional area might improve the knee stability compared to the result from using the gold standard patellar tendon[8-10].

The objective of the present study was to perform a prospective, randomized, controlled comparison of the outcome between bone-patellar tendon-bone graft and 6-strand hamstring graft for replacement in patients with a complete tear of the anterior cruciate ligament.

Material and Method

Patients and entry criteria

Between January 2002 and August 2004, consecutive male and female patients between sixteen and fifty years of age who sought treatment for a unilateral tear of the anterior cruciate ligament at the Department of Orthopaedics, Phramongkutklao Hospital and College of medicine were asked to participate in the present study. Patients were excluded if they had had a previous operation on either knee, or concurrent fracture, or injury of the posterior cruciate ligament, lateral collateral ligament, or posterolateral corner of the knee, or a grade-III tear of the medial collateral ligament, or osteochondral injury stage III-IV, or osteoarthritis. The investigation was approved by the ethic committee on human research.

Thirty-four patients with a mean age of 29.79 years (range, sixteen to forty-seven years) provided informed consent and participated. The patients were randomized with a random number table and the demographic data of the studies group is shown in Table 1. The surgeries were carried out by the same surgeon (S P) using identical techniques.

Surgical technique

Hamstring (semitendinosus-gracilis) grafting

The semitendinosus and gracilis tendons were harvested through a 5 cm longitudinal incision over the pes anserinus with a tendon stripper. The length of each tendon was ranging from 25 to 32 cm. The grafts were prepared to 6-strand with vicryl No.1 by Krackow sutures, and distally with Ethibond by baseball sutures. The mean length of the graft was 8.33 cm (7.8-8.6 cm) and the mean diameter was 9.54 mm (8-11 mm) (Fig. 1). The tibial guided-pin was directed to the junction of the middle and posterior thirds of the normal site of attachment of the anterior cruciate ligament on the tibia. The guided-pins were reamed to an appropriate size. Seven-millimeter offset femoral guide passed through the tibial tunnel at the 11.00 o'clock position for right knees or the 1.00 o'clock position for left knees (over-the-top position). Again, reaming was done. The graft was fixed in both tunnel with bioabsorbable interference screw (poly-L-lactic acid screw), after ten cyclic loaded tensioning of the graft (Fig. 2).

Bone-patellar tendon-bone grafting

The bone-patellar tendon-bone graft was constructed from the central third of the tendon of the ipsilateral knee. The tunnels were placed in exactly the same manner as the tunnels for the hamstring grafts. The graft was fixed in the same manner with bioabsorbable interference screws (poly-L-lactic acid screw).

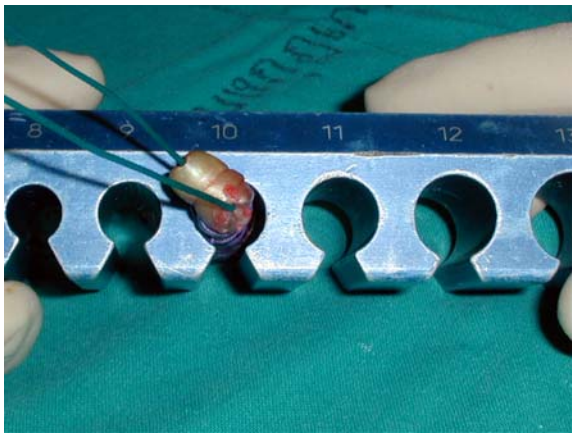

Fig. 1 6-strand hamstring grafts

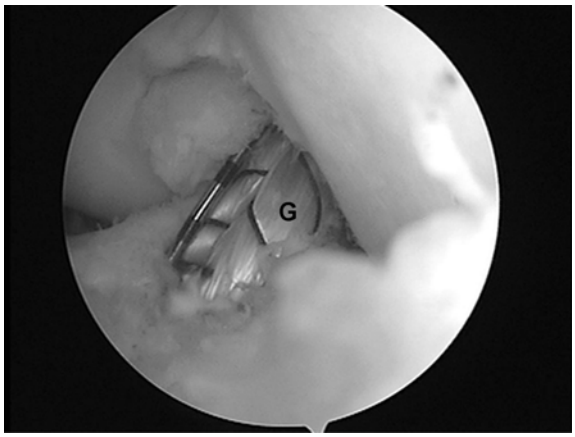

Fig. 2 6-strand hamstring graft (G) after fixed with bio-absorbable screw

Postoperative rehabilitation program and evaluations

The postoperative regimen was identical for the two groups of patients with brace-free regimen[11]. All patients were followed by another author (A L) for a minimum of twelve months (mean 19 months). All knees were examined before surgery and at six-month intervals after surgery. The primary objective outcome was anterior-posterior knee stability, which was measured with a KT-2000 arthrometer (Medmetric, San Diego, California) at 20 lbs and maximum manual anteroposteriorly directed loads. The subjective assessment was assessed with International Knee Documentation Committee form (IKDC) 2000ed. and Lysholm score. After nine months, the patient was allowed to return to sports if he had no effusion, and had a full range of motion.

Statistical methods

Before the investigation was initiated, the sample size was estimated on the basis of the hypothesis that increment of hamstring tendons strength with 6-strand graft could improve the knee stability compared to the result from using the gold standard patellar tendon. There was no difference in anterior-posterior knee laxity between the treatment groups. A clinically relevant difference between groups was considered to be a 0.25 mm increase in anterior knee laxity compared with the contralateral side[9]. The variance, as has been seen in a previous trial, was set at 0.04mm[12]. A power calculation was performed with a confidence level of 95% (= 0.05) and a power of 90% combined with an expected loss-to-follow-up rate of 20% at one year. Comparison between groups for the continuous outcome measures (KT-2000 side-to-side laxity measurements) was independent samples t-test.

Results

Of the 17 patients who underwent the reconstruction with 6-strand hamstring autograft, four were converted to 4-strand hamstring autograft due to inadequate length of the graft and were excluded at this point. The mean diameter of the 6-strand hamstring tendon graft is 9.54 mm and mean length of graft is 8.33 cm. In BPTB group, two of seventeen were lost to follow-up. Mean length of BPTB graft is 8.51 cm. The average follow-up time for the two groups of patients was 19 months. No significant differences were seen in demographics and intraoperative findings of the patients in both groups (Table 1).

Clinical assessment

At the mean time of 19 months follow-up, evaluation of anterior-posterior knee laxity with use of the KT-2000 arthrometer at the 20 lbs load show significant decreasing knee laxity postoperatively. BPTB group side-to-side difference was decreased from 6.8mm preoperative to 1.22 mm (range, 0.3-2.7 mm) postoperative ($p < 0.05$). 6-strand hamstring tendons group side-to-side difference was decreased from 7.1 mm preoperative to 0.96 mm (range, 0.2-1.6 mm) postoperative ($p < 0.05$). With the 20 lbs load on KT-2000 arthrometer, patients in 6-strand hamstring tendons group have less side-to-side difference (average 0.96 mm) than BPTB group (1.22 mm), significantly ($p < 0.05$). And 6-strand hamstring tendons group also have less side-to-side difference (average 1.37 mm, range 0.3-2.2 mm) than BPTB group (1.69 mm,

Table 1. Baseline data of the treatment groups

	BPTB	Hamstring
Average age at surgery (years)	29.93	28.65
Gender	15 male, 2 female	16 male, 1 female
Average height (cm)	168.93	170.47
Side of injury		
Right	9	11
Left	8	6
Timing until surgery (range in months)	20.0 (3-30)	35.46 (2-108)
Associated injuries		
Medial meniscus	3	8
Lateral meniscus	6	6
Osteochondral injuries (Outerbridge I-II)	4	5
Average time of follow-up (range in months)	19.26 (12-25)	18.94 (12-31)

range 0.3-3.2mm), significantly ($p < 0.05$) at maximum load on KT-2000. The results of the pivot shift examination did not differ between the treatment groups at the one-year follow-up visit. Two of 13 patients in 6-strand hamstring group have grade I positive of pivot shift test. Two of 15 patients in BPTB group have grade I positive of pivot shift test. The passive and active ranges of motion were similar between the treatment groups at one-year follow-up intervals. One had 5° extension deficit and one had less than 10° flexion deficit in 6-strand hamstring group. Two had less than 10° flexion deficit in BPTB group. The remaining patients in the present study had full range of motion. Grading by IKDC examination form (2000 edition), only one patient was graded as C level in the treatment groups.

Patient subjective assessment

Patients were evaluated with two scoring system, IKDC subjective form (2000 edition) and Modified Lysholm score. Postoperative score are much higher than preoperative score in both treatment groups, either scoring systems as shown in Fig. 3 or 4.

Eighty-six percent (13 of 15) of the patients with a bone-patellar tendon-bone graft reported a kneeling pain at one-year follow-up and five of 13 were unable to kneel. Only 15.4% (2 of 13) with a hamstring graft reported a kneeling pain. One patient in BPTB group experienced patellar tendinitis, which disturbed his activity for a period of 23 months. By the one-year follow-up visit, 86% (13 of 15) of the patients with a bone-patellar tendon-bone graft stated loss of skin sensation at infrapatellar area compared to 30.8% (4 patients) in the hamstring group. Graft failure occurred to one of BPTB group at 21 months post-operative due to a traumatic rupture. By the final follow-up, eight of 15 in BPTB group had average amount of thigh atrophy of 0.57 cm. Seven of 13 in the hamstring group had average amount of thigh atrophy of 0.48 cm.

Fig. 3 Mean IKDC subjective form score of preoperative and postoperative in both treatment groups

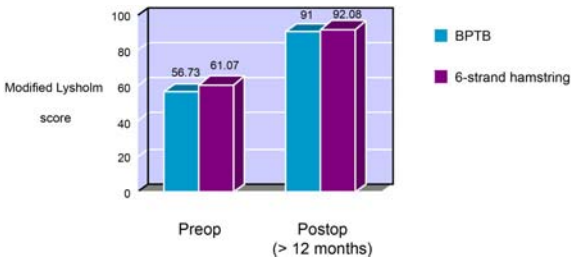

Fig. 4 Mean Lysholm score of preoperative and post-operative in both treatment groups

Activity

The IKDC form is used to grade the level of activity, with level I indicating very strenuous activity (jumping or pivoting as in basketball or soccer); level II, strenuous activity (heavy physical work, skiing, playing tennis); level III, moderate activity (moderate physical work, running or jogging); level IV, light activity (walking, house work); and level V, sedentary activity. At the final follow-up evaluation, two patients (13.3%) in the bone-patellar tendon-bone group could participate in level-I activities; eight (53.3%), in level-II and III activities; five (33.3%), in level-IV activities. In the hamstring group at the time of the final follow-up, four patients (30.8%) were involved in level-I activities; seven (53.8%), in level-II and III activities; and two (15.4%), in level-IV activities.

Discussion

Recently, many randomized clinical trials demonstrated that anterior cruciate ligament reconstruction with 4-strand hamstring tendons provides patients with an excellent midterm clinical outcome after surgery compared to BPTB graft[12-18]. Corry et al[17] compared between BPTB graft versus 4-strand hamstring tendons, which both were fixed by interference screw. The results were measured by KT-1000. Average side-to-side laxity in BPTB group was 1.0 mm whereas in hamstring group was 1.7 mm, which was not significantly different. In another study by Gobbi[18], the average side-to-side laxity in BPTB group fixed with screw post and hamstring tendons group fixed with endobutton were 1.7 mm and 2.3 mm respectively, which was not significantly different.

In the present study, the 6-strand hamstring tendon graft which was taken by a simply standard

hamstring harvesting technique provides significantly decrease antero-posterior laxity of the reconstructed knee compared to standard using BPTB graft under the identical surgical techniques and fixation devices. These results were demonstrated by arthrometer (KT-2000) measurement and were confirmed by overall percentage of patients returning to their original sport activities. Several factors may explain the excellent stability data in this series, although it cannot be determined with certainty which of them may or may not be most important.

The failure load of an evenly tensioned four-strand hamstring tendon graft has been reported to be about 4,090 N[9]. This exceeds that reported for a 10-mm patellar tendon graft (2,977 N)[8] and an intact ACL (2,160 N)[19]. The mean diameter of 6-strand hamstring tendons in the present study is 9.54 mm, which is larger than 8 mm of 4-strand hamstring tendon[12]. Theoretically, ultimate load to failure of the 6-strand hamstring tendons should be higher corresponding to the cross-sectional area.

From a biologic standpoint, it is well accepted that healing of the tendon to bone is more difficult to achieve and requires more time (usually eight to twelve weeks) than does healing of bone to bone (usually four to six weeks)[20-24]. The factors that may determine the strength and stiffness of the tendon-fixation device-bone complex after implantation are the tendon graft-tunnel interface and the fixation device itself. A recent study in dogs has demonstrated that pullout strength was enhanced by increasing the length and the press-fit of the tendon within the tunnel. With doubling the length of the tunnel, there was a 60% gain in terms of load to failure[19,21]. Fixation is also influenced by the total contact area of thread, which is determined by the outer diameter of the thread and especially the length of the screw. Therefore, our patients in the 6-strand hamstring group, the authors increased the tendon-bone tunnel interface with the larger diameter graft compared to 4-strand hamstring tendon. The mean length of graft is 8.33 cm, which is longer than 7.5 cm of 4-strand semitendinosus graft[25] and comparable to 8.51 cm of BPTB graft. These factors allowed us to use a larger and longer interference screw.

In a meta-analysis by Freedman et al[26], the incidence of anterior knee pain was also higher in the patellar tendon group than in the hamstring group. The present study showed a much higher rate of kneeling pain in the BPTB group, 86% (13) compared to 15.4% (two) in the hamstring group at one year. These problems may be significant in the cultures of Asian countries.

Some of the limitations of the present study are the small sample size and blinding. The present study reported short-term clinical outcomes with the mean of follow-up period of 19 months.

In conclusion, the present results show that increasing cross-sectional area of hamstring tendons by using 6-strand graft can improve knee stability demonstrated by KT-2000 and reflected by the patient's activity in the early clinical outcomes. Anterior cruciate ligament reconstruction with hamstring tendons have less donor-site morbidity resulting in less difficulty in kneeling, which is more compatible to Asian life-style. However, there are no differences in terms of subjective assessment.

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การเปรียบเทียบผลทางคลีนิกระหว่างการใช้เอ็นแฮมสตริงค์ 6 ทบกับเอ็นลูกสะบ้าในการผ่าตัดส่องกล้องสร้างเอ็นไขว้หน้าหัวเข่า

อาทิตย์ เหล่าเรืองธนา, สมศักดิ์ ปัตยะกร, ธไนนิธย์ โชตนภูติ, อรรคพัฐ โกสิยตระกูล

ปัจจุบันมีการศึกษาเปรียบเทียบมากมายที่แสดงให้เห็นว่าการทำผ่าตัดผ่านกล้อง เพื่อสร้างเอ็นไขว้หน้าของหัวเข่าขึ้นใหม่โดยใช้เอ็นแฮมสตริงค์ 4 ทบให้ผลการรักษาดีเทียบเท่ากับการใช้เอ็นลูกสะบ้า จากการที่ผู้นิพนธ์ฉบับนี้พบว่าเอ็นแฮมสตริงค์ที่เก็บได้จากผู้ป่วยส่วนใหญ่มีความยาวเหลือมากพอที่จะทบได้เป็น 6 ทบ โดยไม่เป็นการเพิ่มความเสียหาย หรือ ความเสี่ยงใด ๆ ต่อผู้ป่วย จึงทำการศึกษาเปรียบเทียบแบบสุ่มกลุ่มตัวอย่างแบ่ง ผู้ป่วยเป็นกลุ่มละ 17 คน โดยกลุ่มหนึ่งใช้เอ็นแฮมสตริงค์ 6 ทบ อีกกลุ่มหนึ่งใช้เอ็นลูกสะบ้า ผู้ป่วยทุกรายได้รับการตรวจติดตามหลังผ่าตัดอย่างน้อย 12 เดือน ตัวชี้วัดหลักของการศึกษาคือ ความมั่นคงของข้อเข่าซึ่งชี้วัดด้วย KT-2000 ตัวชี้วัดรองได้แก่ กิจกรรมและความพึงพอใจของผู้ป่วยโดยประเมินจาก IKDC and Lysholm score มีผู้ป่วย 13 ราย ในกลุ่มที่ใช้เอ็นแฮมสตริงค์ 6 ทบ และ 15 ราย ที่ใช้เอ็นลูกสะบ้ามารับการรักษาติดตามผล โดยค่าเฉลี่ยของ ระยะเวลาที่มาติดตามผลคือนาน 19 เดือน พบว่าเข่าของกลุ่มที่ได้รับการผ่าตัดโดยใช้เอ็นแฮมสตริงค์ 6 ทบมีความมั่นคงมากกว่ากลุ่มที่ใช้เอ็นลูกสะบ้าอย่างมีนัยสำคัญ รวมทั้งมีจำนวนผู้ป่วยที่กลับไปเล่นกีฬาได้ในสัดส่วนที่มากกว่า และยังมีปัญหาแทรกซ้อนเรื่องอาการเจ็บด้านหน้าหัวเข่าน้อยกว่าอย่างชัดเจน แม้ว่าผลการประเมินคะแนนความพึงพอใจจะแตกต่างอย่างไม่มีนัยสำคัญก็ตาม จึงสรุปได้ว่าการทำผ่าตัดผ่านกล้องเพื่อสร้างเอ็นไขว้หน้าของหัวเข่า ขึ้นใหม่โดยใช้เอ็นแฮมสตริงค์ 6 ทบ สามารถคืนความมั่นคงให้ข้อเข่าได้มากกว่าการใช้เอ็นลูกสะบ้า และมีภาวะแทรกซ้อนน้อยกว่า ซึ่งมีความเหมาะสมกับการใช้ชีวิตประจำวันที่ต้องมีการคุกเข่าของชาวเอเชีย