

Morbidity Following Anterior Cruciate Ligament Reconstruction Using Hamstring Autograft

M Soon,¹MBBS, MRCS, P Chang,²MBBS, FRCS, CPC Neo,³BScPh, AK Mitra,⁴MBBS, FRCS, BK Tay,⁴MBBS, FRCS, FRCS

Abstract

Introduction: As anterior cruciate ligament (ACL) reconstruction becomes more frequently performed, the expectation of earlier return to activities becomes higher; hence graft selection becomes more important. The use of hamstring tendon autograft is perceived to have less postoperative morbidities. We evaluate the early postoperative complications in this prospective study. **Materials and Methods:** Seventy-six patients operated by the same surgeon were assessed preoperatively, and 3 and 6 months after surgery. The hamstring and quadriceps strength were measured with Biodex machine and the side-to-side laxity measured using KT-1000 instrument. The patients were also assessed for their subjective complaints using IKDC (International Knee Documentation Committee) Knee Scoring System. **Results:** The strength and endurance index of the quadriceps and hamstrings recovered and improved by the sixth month after surgery. The recovery by the quadriceps muscle is more marked and by the sixth month, it has recovered to more than the preoperative level. As for laxity, the average side-to-side difference at 30 pounds was 2.75 mm by 6 months. Of these patients, the side-to-side difference was less than 5 mm in 66 patients (5 mm as taken to be acceptable for graft success). As for IKDC rating, at the sixth month, 71 patients had normal or near normal knee by their own assessment. No patients had anterior knee pain at rest. Sensory deficits were only present in 3 patients with complaints of numbness over the distribution of the saphenous nerve or its infrapatellar branch. **Conclusion:** Most morbidities are temporal in nature and do not significantly affect the patient's activities.

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Introduction

Rupture of the anterior cruciate ligament (ACL) impairs the stability of the knee, resulting in difficulty with athletic performance, increased risk of subsequent meniscal injury and increased risk of degenerative joint disease.¹ Reconstruction of the ACL is a frequently performed procedure used to restore functional stability in ACL-deficient knees, restoring the normal kinematics of the knee.² As ACL reconstruction becomes more predictable and more frequently performed, there is an increasing expectation of a more rapid return to sporting activities, and even return to activities of daily living (ADL), work

and study. Thus, graft selection involves consideration of the long-term outcome and also early postoperative morbidity.

There is a perception that ACL reconstruction with the hamstring method is associated with lower postoperative morbidity, namely anterior knee pain (AKP), a more rapid return to full range of motion, especially knee extension and a more rapid recovery of quadriceps function.³ However, this technique is not without complications.

The aim of this study was to document the morbidities associated with ACL reconstruction using hamstring tendon autograft. This includes the effect on hamstring and

¹ Registrar

Department of Orthopaedic Surgery
Alexandra Hospital

² Consultant

⁴ Senior Consultant

Department of Orthopaedic Surgery

³ Physiotherapist

Department of Physiotherapy
Singapore General Hospital

Address for Reprints: Dr Michael Soon, Department of Orthopaedic Surgery, Alexandra Hospital, 378 Alexandra Road, Singapore 159964.

quadriceps strength, anterior knee pain (patellofemoral pain) and sensory deficits. The sensory deficits include deficit of the saphenous nerve and its infrapatellar branch. The International Knee Documentation Committee (IKDC) score is also used in the assessment of patients, which takes into account the laxity of the reconstructed knee (which indicates the adequacy of surgery) and patients' subjective complaints.

Materials and Methods

Patient Selection Criteria

Eighty-seven patients had undergone ACL reconstruction using the hamstring tendons from April 2000 to November 2001. Of these, 67 were males and 10 were females. The age range was 16 to 45 years of age, with an average of 24.9 years of age. The height ranged from 1.53 m to 1.87 m, with an average of 1.72 m. The weight ranged from 44 kg to 127 kg, with an average of 72 kg.

All surgeries were performed by the same surgeon. The indication for surgery was ACL rupture confirmed by clinical diagnosis in an otherwise healthy patient who experienced instability in daily activities or wished to maintain his pre-injury level of activity. The patients were assessed preoperatively and then at the third and sixth month postoperatively.

The inclusion criteria were (1) no previous ligament reconstruction performed, (2) a healthy contralateral knee and (3) no diagnosis of re-injury during the follow-up period. Of these 87 patients, 7 had previous ACL reconstruction performed on the contralateral knee and 1 patient had a revision reconstruction to the same knee following re-injury. Three were lost to follow-up. Hence, the number of patients available for analysis is 76.

Surgical Technique

All patients underwent an arthroscopically-assisted single-incision ACL reconstruction performed by the same surgeon. Hence, the technique, graft placement, graft fixation and rehabilitation were identical in patients.

With the patient under general or regional anaesthesia, a single dose of prophylactic antibiotics of 2 g cefazolin was given. A tourniquet was applied high on the thigh and inflated.

The hamstring tendon autograft was harvested at the pes anserinus (combined insertion of the sartorius, gracilis and semitendinosus onto the proximal tibia) with a longitudinal anteromedial incision. The semitendinosus and gracilis tendons were harvested separately using a metal tendon stripper, after ensuring the fascial attachments and accessory attachments were divided under direct vision.

The graft was cleaned of adherent muscle fibres, folded

over twice creating four strands and these were stitched together with Ethibond sutures in a modified 'baseball' suture. Femoral fixation was performed via suspensory method with an EndoButton (Smith and Nephew) attached to the graft with a doubled 3-mm polyester tape. On the tibial end, the two ends of the graft were stitched with no. 5 Ethibond to each tendon, and tied to an Acuflex fixation post (Smith and Nephew). The tibial end of the graft was fixed with the knee at 90° flexion.

Rehabilitation

Postoperative care involved application of a brace and cryo-cuff. The patient was allowed immediate passive knee extension and started on closed-chain quadriceps exercise. He was also allowed protected weight bearing for 2 weeks.

After 2 weeks, the rehabilitation protocol included early stationary cycling (by 4 weeks), avoid resisted terminal knee extension, straight line running on treadmill by 3 months and return to activity by 6 months.

Assessment and Evaluation

The patients were assessed preoperatively and clinical reviews were performed at 3 and 6 months postoperatively. Evaluation included assessment with IKDC (with objective and subjective measures), KT-1000 for anteroposterior displacement at 20 pounds and 30 pounds of force and isokinetic testing of thigh muscles. Anterior knee pain and sensory disturbance were further subjectively assessed by the patients.

IKDC (International Knee Documentation Committee) has been used to describe outcome following ACL reconstruction.⁴ The IKDC rating system consists of 4 subgroups: patient subjective assessment, symptoms, range of motion (ROM) and laxity.¹ Each category is given an overall grade of A (normal), B (nearly normal), C (abnormal) or D (severely abnormal). The final evaluation of A, B, C or D is determined by the worst score rating for the subgroups.

For quadriceps and hamstring strength analysis, the peak extension and flexion torque were isokinetically measured using the Cybex dynamometer at 60 deg/sec (for strength, average value with 5 repetitions) and 240 deg/sec (for muscle endurance, average value with 15 repetitions). The strength index (the ratio of the peak torque of the involved leg to the uninvolved leg, multiplied by 100) was used as the representative parameter for thigh muscle strength.⁵ The endurance index is similarly calculated. This allowed us to analyse any change in muscle strength and endurance following surgery and when the muscle strength and endurance has recovered.

To measure stability, anteroposterior laxity of both knees was measured at 30 degrees of flexion using the KT-1000

with 20 and 30 pounds of force. Comparing the laxity of both knee yields the side-to-side difference (involved knee versus uninvolved knee) and is an indicator of restored knee stability in the knee that underwent reconstruction.⁵

Anterior knee pain is assessed by the presence of patellofemoral symptoms with activity, like prolonged sitting, walking, squatting and running. We assessed whether anterior knee pain is present with strenuous activity, with moderate activity, with light activity or at rest. Likewise sensory disturbance is noted via the presence of paraesthesia or numbness over the front of the knee and determining if its distribution is along the saphenous nerve or its infrapatellar branch.

Results

Demographics

Based on the inclusion criteria, there were a total of 76 patients who were operated from 4 April 2000 to 5 November 2001. Of these, 66 were male and 10 were female. The average age at operation was 25.2 years (range, 16 to 45 years). The average height of these patients was 1.72 m (range, 1.53 to 1.87 m) and the average weight was 71.7 kg (range, 44 to 127 kg). The number of patients with partial meniscectomy (medial or lateral) performed was 37; 39 did not have a meniscectomy done. The graft harvested was semitendinosus in 65 of these cases and semitendinosus and gracilis in 9 cases.

Thigh Muscle Strength (Table 1)

The preoperative quadriceps strength index was 80.4%. This dropped to 66.1% after 3 months but climbed to 91.8% by 6 months. The quadriceps endurance index also showed a similar trend, with a preoperative index of 86.6%, 3-month index of 77.9% and 6-month index of 96.9%.

The preoperative hamstring strength index was 85.7%. That decreased to 72.7% at 3 months and increased to 88.9% at 6 months. The hamstring endurance index was

Table 1. Strength and Endurance Index

Strength and endurance index	Preoperative	3 months	6 months
Quadriceps strength index	80.4%	66.1%	91.8%
Quadriceps endurance index	86.6%	77.9%	96.9%
Hamstring strength index	85.7%	72.7%	88.9%
Hamstring endurance index	94.4%	81.5%	95.6%

Table 2. KT-1000 Measurements

KT-1000	Preoperative	3 months	6 months
With 20 lbs of force	4.58 mm	3.47 mm	2.57 mm
With 30 lbs of force	6.01 mm	3.27 mm	2.75 mm

94.4% preoperatively, that dropped to 81.5% at 3 months and improved to 95.6% at 6 months postoperative period.

Knee Joint Stability (Table 2)

Using KT-1000, the side-to-side difference preoperatively at 20 pounds was 4.58 mm. At 3 months postoperatively, this dropped to 3.47 mm and to 2.57 mm at 6 months.

The average side-to-side difference at 30 pounds was 6.01 mm, at 3 months it was 3.27 mm and at 6 months it was 2.75 mm. Of these patients who were tested with 30 pounds of force, 41 were less than 3 mm, 25 were from 3 mm to 5 mm and 10 were more than 5 mm.

IKDC and Anterior Knee Pain (Patello-femoral Complaints) (Tables 3 and 4)

The IKDC grading was 25 with C and 51 with D in the preoperative assessment. At the third month, this became 16 with A, 22 with B, 30 with C and 8 with D. This improved at the sixth month, with 29 with A, 42 with B and 5 with C. There was no patient with D grade.

As for graft-site morbidity as assessed by IKDC, at 3 months 64 patients had A, 8 patients had B, 3 patients had C and 1 with D. After 6 months, this improved to 70 with A and 6 with B.

As for anterior knee pain, 9 patients had anterior knee pain with strenuous activity, 3 patients experienced it with moderate activity, 1 patient with light activity and no patients had anterior knee pain at rest.

Three other patients also complained of feeling of "laxity". However, their IKDC grading were all B and there was no subjective complaint of giving way, anterior knee pain or graft site morbidity.

Sensory Deficits

Sensory deficits were only present in 3 patients with complaints of numbness over the scar site and extending

Table 3. IKDC Grading

IKDC grade	Preoperative	3 months	6 months
A (normal)	0	16	29
B (near normal)	0	22	42
C (abnormal)	25	30	5
D (severely abnormal)	51	8	0

Table 4. Graft Site Morbidity

Graft site morbidity (IKDC form)	Preoperative	3 months	6 months
None	-	64	70
Mild	-	8	6
Moderate	-	3	0
Severe	-	1	0

distally. Two of these patients had numbness extending distally in the distribution of the saphenous nerve. The other patient had sensory deficits in the distribution of the infrapatellar branch of the saphenous nerve.

Discussion

Muscle Strength

The main complication of hamstring tendons harvest is hamstring strength recovery.⁶ Multiple studies have shown that although hamstring harvest decreased hamstring strength initially (for a duration of 9 months to 2 years), this loss in strength did not significantly compromise function; also after 2 years of follow-up, there was no significant difference in the strength index of the hamstrings.^{1,3,5,7-10}

In our study, there was a drop in the strength index at 3 months postoperatively. However, the strength index for hamstrings recovered and there was no decrease in hamstring muscle strength noted after rehabilitation by 6 months. This correlates well with the study by Yasuda¹⁰ that showed recovery of isometric hamstring muscle strength after graft harvest from an uninjured limb average 100% by 3 months. We conclude that harvesting of the hamstring tendons reduced hamstring muscle strength in the early phase after surgery, and did not impair recovery of peak flexion torque 6 months after surgery.

As for quadriceps strength, the strength index also shows a similar trend to the hamstrings, with a drop at the third month postoperative period and recovering to beyond the preoperative level at the sixth month postoperative period. Studies have also documented this fact that there is a decrease in quadriceps muscle strength after ACL reconstruction with hamstrings, although this decrease was not considered to be significant.^{1,5,7}

A prospective study was done comparing graft site morbidity using hamstring tendons from ipsilateral and contralateral limbs. They noted that harvesting the hamstring tendons did not affect the strength of the quadriceps tendon. However, the ACL reconstruction procedure itself reduces quadriceps and hamstring strength in the injured limb, regardless of tendon harvest site, at 1 month after surgery.¹⁰ They postulated that arthroscopically assisted reconstruction of the ACL is not completely non-invasive. Intraarticular damage to the bone, including notchplasty and drilling, and extraarticular damage to the muscle and periosteal tissues can cause strength reduction of the muscles. This could explain the initial decrease in quadriceps strength in our cohort of patients.

However, both the strength and endurance index of the quadriceps and hamstrings did recover and improve by the sixth month after surgery. The recovery by the quadriceps muscle is more marked and by the sixth month, it has recovered to more than the preoperative level, indicating

that the ACL surgery does not decrease quadriceps strength. Instead, the increased stability afforded to the knee after surgery may enhance and improve the kinematics of the knee such that quadriceps strength has improved. And with the hamstring muscles, recovery to the preoperative level is expected in our patients. Hence, the morbidity with regards to thigh muscle strength is temporary and full recovery is expected by the sixth month after ACL reconstruction.

Knee Laxity

Studies have shown that KT-1000 arthrometer scores correlated very poorly with activity levels and IKDC scores,¹ possibly indicating that laxity was not directly linked to clinical outcome.

However, another study⁴ has shown that the majority of variance in IKDC was accounted for by the patients' symptoms and laxity.

Generally, if the side-to-side difference is less than 3 mm, the surgery is considered a success. If the difference is 3 to 5 mm, it is acceptable and if the difference is more than 5 mm, it is considered a graft failure. We note that we have 10 patients with a side-to-side difference of more than 5 mm. However, their IKDC scores were as follows: 3 with A grade, 3 with B grade and 4 with C grade. It is possible that isolated measurement of KT-1000 results for stability of the knee is not fully accurate in assessing the success of reconstructive surgery and the patients' assessment of stability of his knee.

However, these results are seen only 6 months after surgery and may not be indicative of the final outcome of the patient after 1 year. Hence, we may be over-reading into the significance of this modality at this point.

Anterior Knee Symptoms

a. Sensory change

A study by Spicer et al⁹ noted that areas of sensory change over the front of the knee were identifiable in 50% of patients and of these, 86% demonstrated sensory change in the distribution of the infra-genicular branch of the saphenous nerve. The postulated injury of the infra-genicular branch can occur during the skin incision, the initial exposure of tendon and drilling of tibial tunnel, or during dissection of tendons proximally and during the passage of the tendon stripper, as the nerve courses superficially to the gracilis.

In our study, sensory change was noted in 3 patients (1.3%) after 6 months. Strict adherence to the surgical techniques mentioned below, especially in keeping the knee flexed during tendon harvest and ensuring that all fascial adhesions are cleared, is important in prevention of neurological injury. However despite this neurological

injury, these 3 patients did not complain of significant limitation of their sporting activities or work.

b. Anatomic considerations

A thorough knowledge of the anatomic relationships of the hamstring tendons facilitates their harvest and reduces harvest-related morbidity. Potential complications include division of tendons, damage to the medial collateral ligament of the knee and neurological injury. It has been noted that neurological injury is possible especially in the distribution of the saphenous nerve and its infrapatellar branch, presenting with parasthesia.⁸

The semitendinosus and gracilis insert as a conjoined tendon onto anteromedial surface of tibia. The sartorius lies superficial to these 2 tendons proximally. Together these 3 tendons form the pes anserinus.

Commonly, the inferior fibres of semitendinosus form an accessory insertion more distally on tibia (this was noted to be present in 24 of 31 knees in a series⁸). The saphenous nerve pursues a posteromedial course towards the medial side of the knee, and emerges between the sartorius and gracilis. This nerve is consistently found lying immediately superficial to the gracilis tendon at the posteromedial joint line. With the knee extended, the nerve is held taut against tendon. With the knee flexed, the tension diminishes. After crossing the gracilis, it pierces the sartorius (which is superficial) and proceeds distally to innervate the medial aspect of the leg.

The infrapatellar branch arises proximal to where the saphenous nerve crosses the gracilis. This then curves beneath the patella to supply the skin over the anterior surface of the proximal tibia. During tendon harvest, an oblique or transverse incision may reduce the risk to injury to the infrapatellar branch.

Also, during the harvesting of the hamstring, flexing the knee and externally rotating the hip to relax the tension of the saphenous nerve on the tendon is important. Another technical point is to free the fascial connection of tendons and any accessory insertion of the semitendinosus, so as to avoid entering the tendon substance during stripping of the tendons.

c. Anterior knee pain (AKP)

It was suggested that anterior knee pain is less common with the hamstring method. Using hamstring tendons and thereby avoiding a direct approach to the front of the knee without interfering with the extensor mechanism should, in theory, reduce the incidence of anterior knee pain.^{11,12}

However, this was not borne out in some series where moderate anterior knee pain was noted even with hamstring reconstruction.^{1,2,5,6,9,13,14} There was no significant difference in studies comparing anterior knee pain with patella tendon harvest and hamstring harvest, and if pain during kneeling

was assessed, this was significantly less common with the hamstring tendon group.¹ In a retrospective study,⁹ 2% had significant symptoms of anterior knee pain that caused limitation with daily activities and 12% had pain during kneeling. It was noted that kneeling was the activity most likely to cause pain. However, most patients were asymptomatic with most normal activities.

Our study had 13 patients with complaints of anterior knee pain; however, only 4 (5%) complained of significant pain that interfered with their sporting activities and the other 9 experienced pain only with strenuous activity (for example, after running 5 km).

Patello-femoral pain, quadriceps weakness and flexion contracture are shown to be related.¹⁵ Sachs et al¹⁵ noted that AKP is a frequent complication at about 25% incidence and is related to both residual extension loss and quadriceps weakness. They felt that it is essential to regain complete ROM and immediate full extension to avoid patello-femoral symptoms and anterior knee pain.

In our patients, there were no significant problems with achievement of extension and quadriceps strength index with our rehabilitation schedule. Hence, we postulate that the small number of patients with significant anterior knee pain is due to early achievement of extension and the quadriceps strengthening.

Conclusion

We assessed the results of ACL reconstruction using hamstring tendons in this prospective series of 76 patients. We noted that quadriceps and hamstring strength decreased initially post-surgery but, by 6 months, both had recovered to their preoperative levels. As for quadriceps strength, this has improved even beyond the preoperative level. With IKDC rating, most patients were satisfied with the results of this surgery by 6 months, with 71 rating their knee as normal or near normal. This is closely correlated with the objective assessment of laxity in the reconstructed knee with an average of 2.75 mm in the side-to-side difference with 30 pounds of force and 66 patients had less than 5 mm side-to-side difference (taken to be acceptable for graft success). However, this is only 6 months after surgery and the laxity may not be an accurate modality to assess knee stability so early after surgery.

We initially thought that sensory changes would be fairly significant in this group of patients. However, only 3 reported sensory changes (2 in the distribution of the saphenous nerve and 1 in the infrapatellar group), and none of these 3 patients reported that they were significantly affected by this. Anterior knee pain is more common, with 4 patients (5%) complaining of knee pain that affect them with light to moderate activity and 9 patients with strenuous activity.

We conclude that most morbidities in ACL reconstruction using the hamstring tendons are temporal in nature and do not significantly affect the patient's activities.

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