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Anatomical single bundle anterior cruciate ligament reconstruction using the hamstring tendon graft to restore knee function in patients with sport injury, falling trauma or road traffic accident

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ABSTRACT

The purpose of this study was to evaluate the effect of anatomic single bundle ACL reconstruction using the hamstring tendon to restore knee function in patients with anterior cruciate ligament (ACL) injury. This was a prospective study with 30 patients (3 women and 27 men, aged 20-40 years) who underwent the arthroscopic single bundle ACL reconstruction using semi-tendinosus and gracilis autograft fixed with an interference screw with anatomical femoral tunnel placement at the Orthopaedic Surgery Department of Sohag University Hospital. All patients were followed up at 2 weeks, 6 weeks, 3 months and 6 months to assess their progress in the rehabilitation program and to address any complications. They were examined preoperatively for knee stability and associated injuries (i.e., meniscal injury), knee X-ray and MRI. All patients were assessed using the Lysholm score, the IKDC score, the Lachman score, and the pivot shift score preoperatively and six months postoperatively, and the results were compared. For data analysis, we used the Statistical Program for the Social Sciences (SPSS). Our study showed highly statistically significant differences between the preoperative and postoperative Lysholm scores, the IKDC score, the Lachman score, and the pivot shift score in favor of the postoperative scores ($p < 0.001$**). Anatomic single bundle ACL reconstruction using the hamstring tendon is an effective technique for restoring knee function and in patients with deficient ACL.

KEYWORDS

Anterior Cruciate Ligament (ACL); Knee Arthroscopy; Knee Injury; Hamstring Tendon Graft

1. INTRODUCTION

Rupture of the anterior cruciate ligament (ACL) is an injury that is frequently sustained in sport activities, and its reconstruction is essential for patients to return their previous physical activities (Marcacci et al., 2003). Femoral tunnel creation during ACL reconstruction is usually performed through the previously reamed tibial tunnel. The transtibial technique (TT), can lead to the creation of a non-anatomic aperture with vertical femoral tunnel position (Robinb & Lubowitz, 2014). If the graft is placed close to the central axis of the femur and tibia (at the 11-o'clock position), will not adequately resist externally applied rotational loads. If the graft is placed more laterally (at the 10-o'clock position), it reconstructs the posterolateral bundle and improves rotatory knee stability (Loh et al., 2003).

By increasingly recognized importance of femoral tunnel position on restoration of native knee kinematics, the use of the anteromedial portal (AMP) for establishment of the femoral tunnel is gaining clinical and research interest. The AMP technique is meant to allow for more anatomic, lower placement of the femoral tunnel and better re-creation of the native origins of the anteromedial (AM) and posterolateral (PL) bundles on the femoral condyle (Lim et al., 2012). Sukur et al. (2016) by comparing transtibial and anteromedial drilling techniques for single-bundle anterior cruciate ligament reconstruction, found that the AMP technique is significantly superior to the TT technique in creating anatomical femoral tunnel placement during single-bundle ACL reconstruction. Recently, several biomechanical studies showed that the single bundle ACL grafts placed in the center of their anatomic insertions can provide nearly normal kinematics of the knee comparable to double bundle reconstruction (Sastre et al., 2010). Moreover, double bundle reconstruction techniques are technically more demanding and necessitate longer operative times and more extensive bone loss, thereby potentially rendering revision surgery more difficult (Kim et al., 2013). Sastre et al. (2016) reported that single bundle ACL (SBACL) reconstruction in anatomical insertion site produced results comparable to those obtained using the double bundle technique, as determined by KT-1000 measurements, International Knee Documentation Committee score, and pivot shift test results. The hamstring tendon is currently an important source of autologous tendon grafts, and its harvesting is more convenient than are other methods and can achieve the same effect (Demirag et al., 2012).

The purpose of this study is to evaluate the effect of anatomic single bundle ACL reconstruction using the hamstring tendon to restore knee function in patients with anterior cruciate ligament (ACL) injury.

2. METHODS

2.1. Study Design and Participants

This was a prospective study with 30 patients (3 women and 27 men aged 20-40 years) who underwent the arthroscopic single bundle ACL reconstruction using semi-tendinosus and gracilis autograft fixed with an interference screw with anatomical femoral tunnel placement (10- o'clock position for the right knee or 2-o'clock position for the left knee) at the Orthopaedic Surgery Department of Sohag University Hospital. The preoperative and six months postoperative Lysholm score, IKDC score, Lachman test, and pivot shift test were compared, and the improvement and effectivity of the technique were assessed.

Inclusion criteria were: (1) patients with clinical, radiological, arthroscopic evidence of ACL deficiency with or without associated meniscal tear which is symptomatic even after conservative therapy of adequate duration; (2) young and middle aged, active, motivated patients involved in vigorous activities, unwilling to change their active lifestyle; (3) the acute inflammatory phase of the injury has subsided with full range of motion and good quadriceps strength with no extensor lag; (4) a normal contralateral knee.

Exclusion criteria were any factor that affects the result directly or indirectly: (1) patients with any other associated ligament injuries of the knee, open physis, articular cartilage lesion exceeding grade 3; (2) previous surgery in the affected knee and patients having remote infection that might have seeded in the joint; (3) patients with other systemic diseases compromising their pre-anesthetic fitness).

2.2. Clinical Examination

The affected side was evaluated for pain, knee effusion, range of knee motion (active and passive), and wasting of the thigh compared with the normal side. Special tests of instability were performed to diagnose anterior cruciate ligament deficiency: (1) Lachman test; (2); Anterior drawertest; (3) Lateral pivot shift maneuver. Associated structures injuries were assessed by performing the following clinical tests: (1) McMurray's test (for menisci); (2) Valgus/Varus stress test (for collateral ligaments); (3) Posterior drawer test (for posterior cruciate ligament); (4) Reverse pivot shift test (for posterolateral complex).

2.3. Radiological Evaluation

Routine X-ray was used for both knees (anteroposterior and lateral views). MRI was performed for the injured knee to confirm ACL tear and demonstrate other knee injuries.

2.4. Preoperative Investigation and Labs

Routine preoperative laboratory testing including: complete blood count, blood glucose, PT, PTT and INR, renal and liver function tests, and serology for HBV-HCV-HIV).

2.5. Surgical Technique

The patient was placed in the supine position. A side support was applied at the level of mid-thigh, the distal foot rest was adjusted to maintain the affected knee at 90° of knee flexion, and a pneumatic tourniquet was applied. All patients were operated under spinal or general anesthesia. Antibiotic was given before tourniquet inflation. All knees were examined under general anesthesia and findings were compared with the contralateral side and the previous preoperative examination.

A thorough diagnostic arthroscopy was performed to confirm the diagnosis and evaluate other pathological conditions. Any meniscial tears were managed by partial meniscectomy before ACL reconstruction. The ACL stump was then debrided to preserve some fibers on the tibial side for proprioception. The tendons of the pes anserinus were palpated gently by rolling them under the thumb or index finger. A 4 cm incision was marked for the tendon harvest. The incision for harvesting is made down through the subcutaneous fat layer, exposing the Sartorius fascia. A straight transverse incision is made in this fascia at the level of the proximal portion of the gracilis tendon. A right-angled clamp is now placed under the tendon mass and scissor used to dissect the hamstring tendons off of the tibia in an inside–out fashion. Using the Mayo scissors, the fascial bands release extending from both tendons to free them before release with the tendon stripper. Grafted tendon then given to assistant for preparation. Then knee was placed at 70–90° of flexion for drilling tibial tunnel. While viewing through the anteromedial (AM) or anterolateral (AL) portal a director ACL tip aimer set at a 55° angle was inserted through the AM or accessory anteromedial (AAM) portal into the knee joint. Then the tibial guide pin was drilled followed by reaming according to size of the graft. The tunnel length should be 30 to 35 mm to allow for fixation near the articular surface. After selecting and confirming the desired location for the ACL femoral tunnel immediately behind the footprint of native ACL, he landmarks for a correct placement of guide are the passage between the notch roof and lateral notch wall, and the superior border of cartilage of the posterior part of the lateral femoral condyle. The identification of these key points allows to place femoral tunnel at 10- o’clock position for the right knee or 2-o’clock position for the left knee at level of native ACL. A microfracture awl was used to mark the location along the lateral wall of the notch. A femoral aimer was inserted through the AAM portal and the knee was slowly flexed to 120° or more. The guide pin slowly drilled through the lateral femoral condyle and the femoral socket that corresponds to the diameter of the ACL graft drilled. A probe was used to assess the integrity of the posterior wall. The edges of the tunnel chamfered to prevent wearing of the graft by sharp edge, then a six strand sigle bundle ACL graft was passed into the knee joint using the graft passing sutures. Fixation in the femoral tunnel accomplished with a bioscrew interference fixation technique using a screw equal to the diameter of the femoral tunnel. Tension was maintained for 3 minutes while cycling the knee from 0 to 90° for a minimum of 30 cycles before securing the fixation distally with a bioscrew 1 mm larger in diameter than the tibial tunnel size.

Final testing for full range of movement especially complete extension was conducted. Both Lachman and pivot shift tests were carefully done. Finally, the knee joint is thoroughly irrigated and the fascia, subcutaneous tissue, and skin are closed for the graft site. For arthroscopic portals over the drainage in the knee joint, skin closure was performed, then a dressing and crepe bandages were applied and the limb was immobilized in a long knee brace.

2.6. Postoperative Care

Patients remained in the hospital for an average of 24 hours. The suction drainage was removed two days after the operation. All patients received the same types of antibiotics (3rd generation cephalosporin injection for 3 days and oral broad-spectrum antibiotic for 12 days).

2.7. Rehabilitation Program

The accelerated rehabilitation program was used for all patients.

2.8. Follow-Up

All patients were followed up at 2 weeks, 6 weeks, 3 months and 6 months to assess their progress in the rehabilitation program and to address any complications. At 6 months, all patients were evaluated using the Lysholm score, IKDC score, Lachman and pivot shift test. Preoperative outcomes were compared with postoperative outcomes.

2.9. Complications

Three patients had superficial infection at grafting site, which was controlled by oral antibiotics and dressing. Two patients had paraesthesia over the anteromedial portion of tibia which settled subsequently. One patient had quadriceps muscle weakness that improved with aggressive physiotherapy.

2.10. Statistical Analysis

For data analysis, we used the Statistical Program for the Social Sciences (SPSS). The following statistical analyses were used: descriptive, chi-square and t-test. A p-value of < 0.05 was considered statistically significant.

3. RESULTS

Our study included 30 patients with ACL injury with a mean age of 27.6±5 years and an age range of 20 to 40 years. There were 16 patients (53.3%) with right knee ACL tear, while 14 (47.7%) patients had left knee ACL tear. According to the mechanism of injury, 20 patients (66.7%) had a sport injury, 7 patients (23.3%) had a fall trauma and 3 patients (10.0%) had an RTA. The main symptoms were giving way in 19 patients (63.3%), locking in 4 patients (13.3%), and pain in 7 patients (23.3%). According to the associated injury, there were 15 patients (50%) with isolated ACL injury, 11 patients (36.6%) with medial meniscial injury, 3 patients (10.0%) with lateral meniscial injury and one patient (3.3%) with both meniscial injury (Table 1).

Table 1. Characteristics of the participants.

	n(%)
Age (Mean±SD)	27.6±5.0
Sex	
Female	3(10.0)
Male	27(90.0)
Side of knee ACL tear	
Left	14(46.7)
Right	16(53.3)
Mechanism of injury	
Sport injury	20(66.7)
Falling trauma	7(23.3)
RTA	3(10.0)
Main symptoms	
Giving way	19(63.3)
Locking	4(13.3)
Pain	7(23.3)
Associated injury	
Isolated	15(50.0)
Lat. M	3(10.0)
Lat. M & MM	1(3.3)
MM (one bucket handle tear)	11(36.6)

NOTE: SD (standard deviation); RTA (road traffic accident); MM (medial meniscial injury); Lat. M (lateral meniscial injury)

Regarding the preoperatively Lysholm score, a total of 27 patients (90.0%) had a poor score and only 3 patients (10.0%) had a fair Lysholm score, whereas postoperatively, 6 patients (20.0%) had an excellent score, 21 patients (70.0%) had a good score, and only 3 patients (10.0%) had a fair score. So, we have a high statistically significant improvement between preoperative and postoperative Lysholm score ($p < 0.001$) (Table 2).

Table 2. The difference between the preoperative and the postoperative Lysholm score

Lysholm satisfaction score	Preoperative (n=30)		Postoperative (n=30)		p
	No.	%	No.	%	
Unsatisfactory	30	100.0	3	10.0	<0.001**
Poor (<65)	27	90.0	0	0.0	
Fair (65 - <84)	3	10.0	3	10.0	
Satisfactory	0	0.0	27	90.0	
Good (84 – <91)	0	0.0	21	70.0	
Excellent (91-100)	0	0.0	6	20.0	

**Statistically significant difference (p<0.05), ** High statistically significant difference (p<0.01).*

The comparison between the preoperative and postoperative Lysholm scores subdomains is presented in Table 3. The mean of the preoperative Lysholm score was 51.63±12.45 and ranged from 32 to 71, whereas the mean of the postoperative Lysholm score (six months after follow up) was 88.03±5.12 and ranged from 74 to 96, thus showing a high statistically significant improvement between preoperative and postoperative Lysholm score for each subdomain ($p < 0.001$) (Table 3).

Table 3. Comparison between preoperative & postoperative of Lysholm score subdomains

Lysholm score subdomains	Preoperative	Postoperative	p
	Mean±SD	Mean±SD	
Limp	2.53±1.72	4.8±0.61	<0.001**
Support	4.13±1.36	5±0	0.002**
Pain	12±5.81	20.67±2.17	<0.001**
Instability	13.83±4.86	24.33±1.73	<0.001**
Locking	8.13±3.84	12.83±2.52	<0.001**
Swelling	5.47±2.92	8.4±1.99	<0.001**
Stair climbing	4.07±2.49	7.73±2.02	<0.001**
Squatting	2.67±1.4	4.27±0.45	<0.001**
Total	51.63±12.45	88.03±5.12	<0.001**

** Statistically significant difference (p<0.05), ** High statistically significant difference (p<0.01).*

Regarding the preoperative IKDC score, 28 patients (93.3%) had a poor score and 2 patients (6.7%) had a fair score, while postoperatively, 5 patients (16.7%) had an excellent score, 22 patients (73.3%) had a good score, and 3 patients (10%) had a fair score (Table 4). The preoperative Lachman test was near normal, abnormal, severely abnormal in 1, 20, 9 patients, and normal, near normal in 27, 3 patients postoperatively (Table 5). The preoperative pivot shift test was near normal, abnormal, or severely abnormal in 2, 22, and 6 patients, respectively, whereas it was normal and near normal in 28 and 2 patients postoperatively, respectively (Table 6). We have a highly statistically significant improvement between the preoperative and postoperative results for all three tests (IKDC test, Lachman test and pivot shift test) ($p < 0.001$).

Table 4. Distribution of the studied cases according to the IKDC score (n = 30).

Satisfaction	**Preoperative (n=30)**		**Postoperative (n=30)**		**X^2**	**P**
	No.	**%**	**No.**	**%**		
Poor	28	93.3	0	0.0	55.200	<0.001**
Fair	2	6.7	3	10.0		
Good	0	0.0	22	73.3		
Excellent	0	0.0	5	16.7		

** Statistically significant difference (p<0.05), ** High statistically significant difference (p<0.01).*

Table 5. Distribution of the studied cases according to the Lachman test (n = 30)

Satisfaction	**Preoperative (n=30)**		**Postoperative (n=30)**		**X^2**	**P**
	No.	**%**	**No.**	**%**		
Normal	0	0.0	27	90.0	57.00	<0.001**
Near normal	1	3.3	3	10.0		
Abnormal	20	66.7	0	0.0		
Severely abnormal	9	30.0	0	0.0		

** Statistically significant difference (p<0.05), ** High statistically significant difference (p<0.01).*

Table 6. Distribution of the studied cases according to the Pivot shift test (n = 30)

Satisfaction	**Preoperative (n=30)**		**Postoperative (n=30)**		**X^2**	**P**
	No.	**%**	**No.**	**%**		
Normal	0	0.0	28	93.3	56.00	<0.001**
Near normal	2	6.7	2	6.7		
Abnormal	22	73.3	0	0.0		
Severely abnormal	6	20.0	0	0.0		

** Statistically significant difference (p<0.05), ** High statistically significant difference (p<0.01).*

4. DISCUSSION

ACL reconstruction is one of the most common orthopedic procedures (Mall et al., 2014). The objective of ACL reconstruction is to reestablish knee function and prevent future meniscal and chondral damage, which can lead to secondary degenerative changes in the knee joint (Beynnon et al., 2005). Recent studies have shown that placing the tunnels in an anatomic position is important to the successful restoration of normal knee function after ACL reconstruction (Kopf et al., 2010). Many clinical and cadaveric studies have questioned the ability of conventional transtibial drilling technique to restore the ACL footprint (Herbort et al., 2010). Hence, for drilling the center of femoral tunnel in anatomic, ACL reconstruction has been recommended through an AAM portal established (Kumar et al., 2017).

Loucas et al. (2014) in a systematic review comparing clinical and radiological outcomes of anteromedial portal versus transtibial technique in ACL reconstruction concluded that the transportal drilling technique results in better objective knee laxity and mostly better Lysholm scores but equal IKDC scores. Low overall complication and revision rates were seen in both techniques. Kumar et al. (2017) found that anatomic single bundle ACL reconstruction using AAM portal is a reproducible technique which gives acceptable results at short term follow-up. It has the advantage of reducing rotational instability by placing the graft in a more horizontal position as against during conventional transtibial reconstruction (Kumar et al., 2017).

Our study showed a highly statistically significant difference ($p < 0.01$) in preoperative (51.63±12.45) and postoperative (88.03±5.12) Lysholm scores, with 27 patients having a poor score preoperatively and 3 patients having a good score, while 27 patients (90%) had a satisfactory outcome postoperatively (6 excellent and 21 good) and 3 patients (10%) had an unsatisfactory outcome (moderate) with no poor result in the postoperative Lysholm score. All patients were also assessed with the IKDC score. It was found that there was a highly statistically significant difference ($p < 0.01$) between the preoperative and postoperative IKDC score. A total of 5 patients (16.7%) had an excellent score and a good score, 22 patients (73.3%) had a good score, and 3 patients (10.0%) had a mediocre score, with no poor score in the postoperative IKDC score.

Shaikh et al. (2020) who used anatomic reconstruction of the anterior cruciate ligament with a single bundle, reported excellent and good results in 48 patients (88.89%) (Lysholm score > 84) and fair or poor results in six patients (11.11%) (Lysholm score < 83). The results are comparable to our study. Furthermore, Hussin et al. (2018) in their comparative study between the modified transtibial and anteromedial portal techniques for anterior cruciate ligament reconstruction using hamstring tendon found that there was no significant difference in subjective effects or clinical examination between the two groups. In the transport technique, the IKDC score improved significantly preoperatively (54.7) and postoperatively (93.7) and the Lysholm score improved significantly preoperatively (58.8) and postoperatively (93.8). The result is better than in our study, which may be due to the longer follow-up period (12 months) and the higher preoperative score. Inácio et al. (2014) determined a mean postoperative Lysholm score of 87.81 and a mean subjective IKDC score of 83.72 in their study of ACL reconstruction by AM portal and femoral fixation with Rigid Fix. The results of their study are comparable to our study in terms of final outcome. In addition, Kim et al. (2011) treated patients who had a complete ACL tear with single-bundle anatomic ACL reconstruction in their study. The final Lysholm score after surgery showed an excellent result in 19 patients (57.6%), a good result in 12 patients (36.4%), a mediocre result in one patient (3%), and a poor result in one patient (3%).

By comparing transtibial and anteromedial drilling techniques for anterior cruciate ligament reconstruction with a bundle, Sukur et al. (2016) found that the AMP technique was significantly superior to the TT technique in creating anatomic placement of the femoral tunnel during ACL reconstruction with a bundle. There is no evidence to support the superiority of either technique in terms of clinical outcomes. However, the AMP technique provides faster recovery in terms of return to normal life and return to jogging in the short-term. In their study for anteromedial technique assessment of the postoperative IKDC (93.1) and Lysholm scores (95.4) showed a significant improvement in 2 years follow up ($p < 0.05$). In all previous studies and in our study, there is a significant improvement in postoperative subjective outcome in both Lysholm and IKDC scores In our study, anatomic placement of the femoral tunnel restored both anterior tibial translation and rotational stability at six months, with improvement in both the Lachman test and the pivot shift test.

Guglielmetti et al. (2014) performed a reconstruction of ACL in 38 patients through transportal technique in 6 months follow up. Lachman test grade 0, 1, 2, 3 was 33 (86.84%), 4 (10.53%), 1 (2.63%), 0 respectively and pivot shift test grade 0, 1, 2, 3 was 33 (86.84%), 4 (10.53%), 1 (2.63%), 0 respctively. Our result is a little better than the result of their study for the same duration of follow-up. Moreover, Sun et al. (2013) in a study of anatomic ACL reconstruction in the Asian population in 32 patients with a 6-strand autogenous hamstring graft after 2 years of follow-up, showed that 26 patients (81.25%) were negative and 6 patients (18.75%) were positive for grade 1 Lachmann test. 31 patients (96.88%) were negative and 1 patient (3.12%) had a positive grade 1 pivot shift test. Rezazadeh et al. (2016) performed unicuffed ACL reconstruction using the hamstring by anteromedial drilling techniques in 50 patients after 1 year of follow-up. The grade of the anterior drawer test was 46 patients (92%), 3 patients (6%), and 1 patient (2%), respectively; the grade of the Lachman test was 48 patients (96%), 1 patient (2%), and 1 patient (2%), respectively; and the grade of the pivot- shift test was 49 patients (98%), 1 patient (2%).

The results in the above studies are comparable to our results when grade 0 and grade one (normal and near normal) are added, which is a good result. The improvement in grade 0 over grade one may be due to a longer follow-up period than in our study.

5. CONCLUSIONS

Anatomic single bundle ACL reconstruction using the hamstring tendon is an effective technique for restoring knee function and improving Lysholm score, IKDC score, Lachman test, and pivot shift test in short term outcome in patient with deficient ACL. Its result is better than conventional transtibial technique and comparable to anatomic double bundle ACL reconstruction, which is technically more demanding and requires longer operative time.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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