Original Article

Single Bundle A.C.L. Reconstruction In Partial Injuries Of A.C.L.

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Abstract

Background: A partial rupture is likely secondary to the fact that the two bundles of the ACL have a synergistic yet distinctly different biomechanical function at different knee flexion angles. Recent interest focused on establishing pre and intraoperative ways of assessing the different types of symptomatic one bundle tears in order to perform an individual ACL augmentation. Treatment of partial ACL tears depends entirely on making an accurate diagnosis and determining degree of impairment. For some patients with partial tears, little morbidity is associated with the injury, and knee stability may be adequate for participation in sports and for all activities of daily living. Treatment in this scenario is largely supportive recommending that the patient take the time to recover from the initial injury and, after rehabilitation, to make a gradual return to sport. Operative intervention is needed in other cases, but such a decision should be taken while considering various factors, this includes: age, activity level, degree of laxity on physical examination, associated injuries, and symptomatic instability. Most clinicians would agree that symptomatic and debilitating instability require a more aggressive approach, likely in the form of operative intervention. The ACL augmentation is performed similar to a (traditional) single bundle technique while sparing the intact ACL fibers. This may support mechanical strength of the reconstruction, especially in the early postoperative period, and may maintain mechanoreceptors, neural elements and blood vessels to allow better proprioception, vascularization and an accelerated rehabilitation with faster return to sports. The aim of this study was to evaluate the results of arthroscopic reconstruction of partial ACL tears. **Objectives:** This work aims to evaluate the results of arthroscopic reconstruction of partial ACL tears. **Materials and Methods:** Twenty five patients with an ACL partial tear were included at this study; anatomic single bundle augmentation using the semi-tendinosus and gracilis auto-grafts was done. All cases (100%) were males. Of the knees involved, 15 were right (60%) and 10(40%) were left. Age ranges from 17 to 40 years and the mean age was 30.28± 5.38 years and the average time between the injury and the surgical interference was 4.6± 3.97 months. Affected bundle among patients was PL in 18 patients (72%) and 7 patients (28%) with affected AM bundle. Follow up on regular basis after reconstruction was done for two years postoperatively. Assessment was done before surgery and at the end of follow up using IKDC objective score , lysholm score,Tegner activity level scale and post operative KT -1000 measurements. **Results:** The overall results of the present study, as measured by the IKDC evaluation system after 24 months follow up, were 11 patients out of 25 patients (44%) had score A and 14 patients out of 25 patients (56%) had score B. The Lysholm score improved from a mean 63.08 ± 9.92 (before surgery) to 92.60 ± 3.88 at the end of follow up.Measurements by Tegner activity level scale (mean activity level before surgery was 5.1± 0.9,mean current activity level was 2.0 ± 0.9 and mean activity level after surgery improved to 5.1± 0.9).Measurements by postoperative K.T 1000 and evaluate the diff. between normal and injured knee after 24 months follow up, were 4 patients out of 25 patients (16%) were 1 m.m. diff. , 10 patients out of 25 patients (40%) were 2 m.m. diff. and 11 patients out of 25 patients were 3 m.m. diff.). **Conclusion:** Diagnosis of symptomatic AM or PL bundle tear is a combination of the patient's history and complaints, clinical examination, MRI, and arthroscopic evaluation. Good results have been achieved with preserving the remanants of the torn ACL and performing augmentation but reliable diagnosis of partial torn ACL and assessing the vaidity of the remanants to be kept and decision to do an augmentation procedure has to be taken after arthroscopic assessment.

Keywords: Bundle, Reconstruction, Injuries

INTRODUCTION

Over the last 15 years, knowledge of tearing and reconstruction of the anterior cruciate ligament (ACL) has evolved considerably. Anatomical studies have made it possible to precisely identify ligament insertions in bones, while biomechanical studies have provided better understanding of the function of each of the ligament bundle. **(1)**

A partial rupture is likely secondary to the fact that the two bundles of the ACL have a synergistic yet distinctly different biomechanical function at different knee flexion angles. The increase in understanding of the individual roles that the AM and PL bundles play in stabilizing the knee has led to a better appreciation of the persistent instability that patients with a rupture of just one of these bundles may experience. Unstable partial ruptures of the ACL can potentially result in altered knee kinematics,

meniscal damage, and subsequent early degenerative changes of the articular cartilage, eventually resulting in post-traumatic osteoarthritis (OA). **(2)**

Diagnosis of partial ACL tears can be challenging. Often, clinical examination findings can be subtle, and radiographic studies may not reveal significant pathology. The most accurate diagnosis is achieved by integrating patient history, physical examination findings and imaging studies.

Patients with a symptomatic AM or PL bundle tear usually complain of unspecific symptoms like recurrent pain and swelling **(3).** More specifically, patients with a symptomatic AM bundle tear describe an anterior instability during activities of daily living and during sports activity similar to a complete ACL tear. On the contrary, patients with a symptomatic PL bundle tear complain of rotational instability with pivoting sports rather than complaining of a significant anterior instability with activities of daily living or sports. **(3)**

Patients with PL bundle injuries only may still perform non pivoting sports activities without major difficulty, but pivoting sports such as soccer or basketball have to be given up because of recurrent problems with rotational instability. **(3)**

Treatment of partial ACL tears depends entirely on making an accurate diagnosis and determining degree of impairment. For some patients with partial tears, little morbidity is associated with the injury, and knee stability may be adequate for participation in sports and for all activities of daily living. Treatment in this scenario is largely supportive recommending that the patient take the time to recover from the initial injury to make a gradual return to sport after rehabilitation.Operative intervention is needed in other cases,but such a decision should be taken while considering various factors,This includes : age, activity level, degree of laxity on physical examination, associated injuries, and symptomatic instability. Most clinicians would agree that symptomatic instability require a more aggressive approach, likely in the form of operative intervention.

The ACL augmentation is performed similar to a (traditional) single bundle technique while sparing the intact ACL fibers. This may support mechanical strength of the reconstruction, especially in the early postoperative period, and may maintain mechanoreceptors, neural elements and blood vessels to allow better proprioception, vascularization and an accelerated rehabilitation with faster return to sports.

This work aims to evaluate the results of arthroscopic reconstruction of partial ACL tears with autograft hamstring tendons,using the traditional methods of evaluation.

Patients and Methods

In this study twenty five patients with a partial torn ACL underwent arthroscopic reconstruction of the affected bundle of ACL, between march 2015 and January 2018.

All cases were males. The mechanism of injury was twisting knee injury. Of the knees involved, 15 were right and 10 were left . Age ranges from 17 to 40 years and the mean age was 30.28± 3.2 years and the average time between the injury and the surgical interference was 4.6± 8 months.

Affected bundle among patients was PL in 18 patients (72%) and 7 patients (28%) with affected AM bundle.

Associated pathology among patients was no associated pathology in 11 patients (44%), Torn lateral meniscus in 2 patients (8%),Torn medial meniscus in 9 patients(36%),Torn both M.M. and L.M.in 1 patient(4%)and ulcer M.F.C. in 1 patient(4%).

Follow up on regular basis after reconstruction was done for two years postoperatively.

The selection criteria of our patients depends mainly upon history taking, analysis of patient complain, the preinjury level of activity as well as clinical examination. x-ray MRI are done routinely for each case.

Arthroscopic examination was done just before proceeding to graft harvesting in all cases to evaluate the A.C.L. and other pathology as meniscal injury and cartilage lesion, the following sheet is used for every patient preoperative and postoperative including the history and examination as well as the investigation and the post operative data.

Selection of the patients was done based on certain inclusion and exclusion criteria:

Inclusion criteria:

1. Acute and chronic partial tears of ACL in functionally unstable patients.
2. Positive signs of tear ACL including anterior drawer, lachman and pivot shift tests.

Exclusion criteria:

1. Skeletally immature patients.
2. Other ligamentous Knee injury (PCL or posterolateral corner injury).
3. Sever O.A.
4. Complete A.C.L. tear diagnosed clinically, M.R.I. and arthroscopically

Assessment sheet

Personal History

1- Name 2- Address and Tel. No:

3- Sex 4- Occupation

5- Age 6- Affected side

7- Sport of interest: A) Type of the sport

B) Level of activity

I. Complaints:

1) Giving way : During usual daily activity.

: During particular movement in activity

: Pain following it.

2) Pain:

*Site : a- Anterior knee pain d- Medial joint line pain

b- Posterior knee pain e- Lateral joint line pain

c- Retropatellar pain

*Intensity in relation to sport

*Factors alleviating and those increasing

*Character of pain

3) Swelling:

*Site : - Suprapatellar

- Infrapatelar

- Diffuse

*Time till appearance after trauma

*Aspiration, color and Knee immobilizer

*Recurrence Time

4) Locking

III- Trauma

Mechanism

- Twisting
- Direct AP
- Angular (Varus or valgus)
- Unknown

*Duration (time elapsed after the trauma)

*Immediate ambulation and immediate management.

IV- Examination

- Clinical examination
  1- Anterior drawer test in neutral, external and internal rotation.
  2- Posterior drawer test.
  3- Lachmann test.
  4- Pivot shift test.
  5- McMurray test.
  6- Valgus stress test at 0° and 30°.
  7- Varus stress test at 0° and 30°.
  8- Tests for effusion.
  9- Measure thigh girth.
- Examination the back of the knee.
- Radiographic examination.
- Plain X-ray both Antero-posterior and lateral positions.
- Magnetic resonance imaging
- Routine intra-operative arthroscopic examination before graft harvesting
- Patients with increased anterior tibial translation at 90° flexion but minimal translation near extension (30°) and small pivot shift should be suspected of having an isolated AMB tear.
- Patients with Grade I–II pivot shift but minimal anterior translation on Lachman and negative anterior drawer should be suspected of having isolated PLB tear.

Operative Data

- Date of surgery
- No. and names of surgeons
- Name of scrapping nurse
- Name of anaesthiology team
- Operation duration

- Operative technique
- Used instrumentations and screws
- Type of the graft
- Fixation method
- Femoral and Tibial
- Operative details
- Complication
- Remarks

Clinical evaluation

- Done 1- Intraoperatively
  2- Postopratively 0,3,6,12, and 24 months
- Using International Knee Documentation Committee (IKDC), Lysholm score, Tegner activity level scale and post operative K.T.1000 measurements.

II - Method of Evaluation

The day before the operation the consent was written and signed by the patient, the patient laboratory was taken the radiological photos are ordered in the file.

All patients were subjected to thorough history taking, proper clinical examination and imaging investigative work up including plain radiograme and MRI. Data were put in the International Knee Documentation Committee (IKDC) evaluation form (objective), lysholm knee evaluation system, Tegner activity level scale and post operative KT -1000 measurements.

A) Ikdc Score:

IKDC score was done preoperatively and at the end of follow up (after two years).

The Knee Examination Form contains items that fall into one of seven measurement domains. However, only the first three of these domains are graded. The seven domains assessed by the Knee Examination Form are:

1. Effusion

An effusion is assessed by ballotting the knee. A fluid wave (less than 25 cc) is graded mild, easily ballotteable fluid – moderate (25-60 cc), and a tense knee secondary to effusion (greater than 60 cc) is rated severe.

2. Passive Motion Deficit

Passive range of motion is measured with a gonimeter and recorded on the form for the index side and opposite or normal side. Record values for zero point/hyperextension/flexion (e.g. 10 degrees of hyperextension, 150 degrees of flexion = 10/0/150; 10 degrees of flexion to 150 degrees of flexion =0/10/150). Extension is compared to that of the normal knee.

3. Ligament Examination

The Lachman test, total AP translation at 70 degrees, and medial and lateral joint opening were assessed with manual, instrumented or stress x-ray examination. Only one should be graded, we relied on manual examination for assessing AP translation. The numerical values for the side to side difference are rounded off, and the appropriate box was marked.

The end point is assessed in the Lachman test. The end point affects the grading when the index knee has 3-5 mm more anterior laxity than the normal knee. In this case, a soft end point results in an abnormal grade rather than a nearly normal grade.

The 70-degree posterior sag is estimated by comparing the profile of the injured knee to the normal knee and palpating the medial femoral tibial step off. It may be confirmed by noting that contraction of the quadriceps pulls the tibia anteriorly.

The external rotation tests are performed with the patient prone and the knee flexed 30° and 70°. Equal external rotational torque is applied to both feet and the degree of external rotation is recorded.

The pivot shift test was performed with the patient supine, with the hip in 10-20 degrees of abduction and starting from full extension of the knee and applying gradual flexion to 30-40 degrees with applying internal rotation and valgus stress. The greatest subluxation, compared to the normal knee, should be recorded.

4. Compartment Findings:

Patellofemoral crepitation is elicited by extension against slight resistance. Medial and lateral compartment crepitation was elicited by extending the knee from a flexed position with a varus stress and then a valgus stress. Grading is based on intensity and pain.

5. Harvest Site Pathology

Tenderness, irritation or numbness at the autograft harvest site were recorded.

6. X-ray Findings

Standing A.P. and Lateral view

7. Functional Test

The patient was asked to perform a one leg hop for distance on the index and normal side. Three trials for each leg were recorded and averaged. A ratio of the index to normal knee was calculated.

B) The Lysholhm Score:

It was also used for pre and post operative evaluation of all patients.

C) Tegner activity level scale:

Is a scale that aims to provide a standardized method of grading work and sporting activities. It was developed to complement the lysholm scale after it was observed that the limitations in function scores in lysholm scale may be masked by a decrease in

activity level.

D) Kt-1000 measurements:

The KT-1000 test is performed to provide an objective assessment of the amount of increased anterior knee translation between 20 and 30 degrees of knee flexion.

In addition to helping diagnose an ACL tear, the KT-1000 test can also be useful to determine the results of one's ACL reconstruction. In general, we strive to have side-to-side differences compared to the opposite normal knee of 3 mm or less. However, in some patients, especially those who are lacking the posterior horn of their medial meniscus, the increase in side-to-side difference may be up to 5 mm. Thus, we generally believe that in patients who have 5 mm, or more, of increased anterior knee translation on the KT-1000 test, that their ACL graft is either torn or stretched out to the point where it is no longer functional.

Surgical procedure

The intraoperative decision to perform a one-bundle ACL augmentation was based on a combination of patients' complaints, clinical, radiological, and intraoperative findings.

1 - Anesthesia:

All patients were operated under spinal anesthesia. Antibiotic was given with induction of anesthesia and before tourniquet application.

2- Examination under general anesthesia:

All knees were examined under general anesthesia. Findings were compared with the contralateral side and the previous preoperative examination, diagnostic arthroscopy was done first routinely to confirm diagnosis of partial ACL lesions.

3. Position of the patient:

The procedure is performed with the patient in supine position with the non-operative leg placed in a well-leg holder in the abducted position. The operative leg is exsanguinated by elevation for 3 minutes; a tourniquet is applied around the upper thigh and insufflated to 350 or 400 mmHg. Finally, the operative leg is placed in an arthroscopic leg holder, which allows good range of motion, sterile preparation, and draping. The surgery is performed in a stepwise fashion.

4. Diagnostic arthroscopy:

A thorough diagnostic arthroscopy consisted of evaluation of the patellofemoral joint, suprapatellar pouch, medial and lateral gutters, medial and lateral compartments, and the intercondylar notch. The menisci, which were carefully evaluated and probed for the presence of tears. All articular cartilage is inspected for detection of any chondral defect.

5. Arthroscopic Assessment of One-Bundle Tears:

The arthroscopic examination of both bundles was performed in various knee flexion angles to consider the different tensioning patterns of the AM and PL. The AM bundle. has relatively constant levels of in situ forces during knee flexion and might be best probed arthroscopically between 70 and 90°. In contrast, the PL bundle has high insitu forces between 0 to 30 of flexion but unfortunately cannt be seen arthroscopically close to extension.Therefore it might be best probed, because the PL bundle tightens up in this position and the femoral PL footprint is usually rotated and exposed in the anterior aspect of the lateral femoral intercondylar wall. An intraoperative Lachman and anterior drawer test under arthroscopic control were also help to establish the right diagnosis.

6. Harvesting of the graft:

A 3-4 cm skin incision is done centered over the tibial insertion of the pes anserine tendons which can be palpated against the posteromedial border of the tibia, 1-2 CM medial to the anterior tibial crest. Incision of the subcutaneous fat and stripping of the fat off the pes anserine with a sponge is done. An incision in the sartorial fascia allows the exposure of the tendons.A right-angled type clamp was used to separate the two tendons from the undersurface of the sartorius fascial flap, which was preserved for later closure. Blunt scissors dissection was used to free the tendon from the undersurface of the sartorius fascia. It is important to bluntly release the interconnecting fascial bands between the two tendons. An open tendon stripper was used and release the tendon from it's muscular attachment proximally. The gracilis tendon is harvested by flexing the knee to 90 degrees and advancing the tendon stripper parallel to the tendon by a slow, steady, rotating motion. The semitendinosus tendon was harvested in a similar fashion; however, there are more extensive fascial connections that extend from the inferior border of the semitendinosus tendon to the medial head of the gastrocnemius. These fascial connections were released to prevent premature amputation of the semitendinosus tendon. In 10 cases harvest the semitendonosis only was enough (length 110 mm, diameter (7-8mm).

7. Preparation of hamstring tendons:

Preparation of the hamstring tendon grafts was facilitated by use of a graft preparation board. Residual muscle fibers on the proximal end of both tendons are removed by blunt dissection with periosteal elevator. Both ends of the graft were then whipstitched using no. 5 non-absorbable sutures. The two tendon grafts are looped around a No. 5 suture. The diameter of the ST-G graft is measured to the nearest 0.5 mm by use of a 0.5-mm incremental sizing block or sizing tubes. A strand graft of the doubled semi-tendonosus and gracilis or semi-tendonosus alone which usually measure average 7 to 8 mm. thickness is used for augmentation procedure. The graft is then pretensioned by use of a graft preparation board and marked according to femoral tunnel length.

8- Management of associated injuries:

Arthroscopy was carried out using anterolateral and anteromedial portals. In case of associated meniscal tear, menisectomy was done according to site, type and shape of the tear and age of the patient.one case has a small ulcer M.F.C.,debridement was done.

9- AM bundle reconstruction:

Arthroscopic procedure starts with the AM bundle debridement carefully done to avoid any damage of PL bundle, the tibial drill guide is set to 60◦ and the tunnel will start 1.5 cm medial to the anterior tibial tuberosity. A K-wire is positioned 4 to 5mm lateral to the medial tibial spine and 4 to 5mm posterior to the anterior rim of the ACL stump.

The anterior landmark is the anterior part of the ACL to prevent any impingement with intercondylar notch. An extension position of the knee can be done once the K-wire is in the joint to test the absence of impingement.

The AM femoral insertion was located using the clock position, 11 o'clock position for a right knee and 1 o'clock for a left knee. Then a guide wire 2.4mm is positioned in the center of the femoral insertion, the knee is flexed to a maximum flexion close to 140◦. The femoral AM tunnel is drilled through the low antero-medial portal with a headed reamer with fixation by femoral interference screw (with fixation by endbutton technique the femoral A.M. tunnel is drilled first by using 4.5 mm cannulated reamer,create a tunnel by drilling over the K-wire and breaking through the femoral cortex and then drilling by a headed reamer). When drilling, the final arrival in the joint has to be done handmade or with low speed to prevent any lesion of the bundle remnant, especially in the tibial side.

10- PL bundle reconstruction.

The position of the tibial tunnel is more medial and starts 3.5 cm medial to the tibial tuberosity. The intra-articular position is located in the posterior part of the tibial ACL insertion 5mm medial to the lateral eminentia intercondylaris. The femoral side is then marked, using the anatomical landmark, positions it at the 9 o'clock position for the right knee or 3 o'clock for the left knee. an average of 5mm posterior to the shallow articular cartilage of the lateral femoral condyle.

The drilling is done as before from the anteromedial portal but it can be difficult, especially in a small knee. An accessory medial portal can be used just above the medial meniscus anterior horn. The medial condyle can be damaged and a headed reamer is necessary.

11-Graft passage:

A wire with a number 5 ethibond suture loop on the eyelet wire was passed through the femoral tunnel using a guide pin leaving the looped tip inside the knee. A grasper used to retrieve the suture loop that was left in the ACL femoral tunnel and pull the suture out of the knee joint through the tibial tunnel. The sutures for the ACL graft are passed through the suture loop and passed out of the lateral thigh. The ACL graft is passed into the knee joint using the graft sutures.

12- Graft fixation:

The graft will be fixed femorally by femoral interference screw (11 cases) or endbutton technique (14 cases). (The knee was held in a maximum flexion close to 140◦)**.**

For the tibial fixation, the graft will be fixed by interference screw (22 cases) or U-loop (3 cases). The knee was held in 20-30 degrees of flexion (in case of PL bundle augmentation), and 70 to 90 degrees in case of AM bundle.

Nothing was done by a notcher to facilitate the entry of the interference screw, and then the graft is fixed to the tibia by interference screw**.** Careful testing for full range of movement especially complete extension was done and test for impingement of the graft by the roof or the medial wall of the lateral femoral condyle. Both Lachman and pivot shift tests were carefully done.

13- Closure:

Irrigation of the knee with cold saline, ablasion of all the bleeding spots to reduce post-operative hematoma formation, drain, closure of the portals, repair of the sartorius fascia, closure of the subcutaneous tissue and finally the skin with absorbable suture were done. Steri-strip was applied and at last, crepe bandages were applied in a Robert-Jones (R-J) manner and hinged knee brace was applied in full extension.

Postoperative care:

The patients stayed in hospital for an average of 4 days. Dressing, wound inspection and suction drain removal was done 48h after surgery and light dressing was applied. Crepe bandages were removed at the time of dressing and replaced with elastic anti-embolism stocking. Strip and stitches were removed 10 to 14 days after the operation by which time the wound had healed well enough to allow baths and showers. Post op. X rays were done after removal of the drain.

Antibiotic is used for 1 week after the operation. An analgesic or patient controlled anesthesia is used for pain control. Oral nonsteroidal anti-inflammatory medication is used to decrease postoperative pain, and swelling unless the patient has a history of peptic ulcer. Antiembolic therapy as a prophylaxis is also, used and maintained for approximately 3 weeks postoperatively.

Ice therapy started immediately postoperatively to control postoperative swelling; weight bearing is allowed from the 1st day as tolerated with aid of axillary crutches, Physiotherapy program started from the 1st post-operative day.

Follow up was done weekly in the first month, then twice monthly for the next 2 months, then monthly for 9 month (total two years).

Results

Twenty five patients whom diagnosed to have partial tear of ACL were included in the current study and anatomic single bundle augmentation of ACL was carried out using semitendinosus and gracilis graft.

All cases were males **(Table.1)**. Of the knees involved, 15 were right and 10 were left **(Table.1)**. Mechanism of injury was twisting knee injury,All not associated with medical diseases, Age ranges from 17 to 40 years and the mean age was 30.28± 3.2 years and the average time between the injury and the surgical interference was 4.6± 8 months. **(Table.1)**. Affected bundle among patients was PL in 18 patients (72%) and 7 patients (28%) with affected AM bundle

Table 1: Sex distribution, Affected side, Descriptive statistics of both age and Interval (-) trauma and operation, Affected bundles of the studied patients

		Frequency	Percent
	Female	0	0
	Male	25	100
	Total	25	100

	Number	Percent
Left	10	40.0
Right	15	60.0

	No.	Mean	SD	Median	Minimum	Maximum
Age (yrs.)	25	30.28	5.38	30.00	17.00	40.00
Interval(-) trauma and operation (months)	25	4.60	3.97	3.00	1.00	18.00

	Number	Percent
A.M.B.	7	28.0
P.L.B.	18	72.0

The median values of Tegner score measured at pre-, current and after surgery were 5.0 (3.0-6.0), 2.0 (1.0-4.0) and 5.0 (3.0-6.0), respectively. There was a statistical significant difference between the three times (p= 0.001), Where the median value of Tegner score measured at current was significantly decreased when compared with its corresponding value measured at both pre- and after surgery (p= 0.001 and 0.001, respectively). On the other hand, there was no statistical significant difference between pre- and after surgery (p= 1.000) (table (2)

Table(2) : Comparison between values of Tegner score measured at different times of surgery in the studied patients.

	Pre	Current	After	p-value
Median (minimum-maximum)	5.0 (3.0-6.0)	2.0 (1.0-4.0)	5.0 (3.0-6.0)	0.001
p value vs pre	----	0.001	1.000	
p value vs current	----	----	0.001	

p> 0.05= not significant.
p≤ 0.05= significant.

The mean (± SD) values of limping in the studied patients measured pre- and post-operation were 5.0 ± 0.0 and 5.0 ± 0.0, respectively. There was no statistical significant difference between the two time of measurements (p The mean (± SD) values of using crutches in the studied patients measured pre- and post-operation were 5.0 ± 0.0 and 5.0 ± 0.0, respectively. There was no statistical significant difference between the two time of measurements (p value= 1.000) (Table 4)

The mean (± SD) values of locking in the studied patients measured pre- and post-operation were 11.56 ± 4.52 and 15.00 ± 0.00, respectively. There was a statistical significant increase in the mean value of locking measured at post-operation when compared with its corresponding value measured at pre-operation (p value= 0.004) (Table 4)

The mean (± SD) values of giving away in the studied patients measured pre- and post-operation were 17.40 ± 4.59 and 24.00 ± 2.04, respectively. There was a statistical significant increase in the mean value of giving away measured at post-operation when compared with its corresponding value measured at pre-operation (p value= 0.001) (Table 4)

The mean (± SD) values of pain in the studied patients measured pre- and post-operation were 12.60 ± 5.80 and 21.80 ± 2.45, respectively.

There was a statistical significant increase in the mean value of pain measured at post-operation when compared with its corresponding value measured at pre-operation (p value= 0.001) (Table 4)

The mean (± SD) values of swelling in the studied patients measured pre- and post-operation were 3.76 ± 2.33 and 8.08 ± 2.04, respectively. There was a statistical significant increase in the mean value of swelling measured at post-operation when compared with its corresponding value measured at pre-operation (p value= 0.001) (Table 4)

The mean (± SD) values of climbing stairs in the studied patients measured pre- and post-operation were 6.80 ± 3.06 and 9.36 ± 1.50, respectively. There was a statistical significant increase in the mean value of climbing stairs measured at post-operation when compared with its corresponding value measured at pre-operation (p value= 0.001) (Table 4)

The mean (± SD) values of squatting in the studied patients measured pre- and post-operation were 0.96 ± 1.31 and 4.36 ±0.49, respectively. There was a statistical significant increase in the mean value of squatting measured at post-operation when compared with its corresponding value measured at pre-operation (p value= 0.001) (Table 4)

The mean (± SD) values of final lysholm score in the studied patients measured pre- and post-operation were 36.08 ± 9.92 and 92.60 ±3.88, respectively. There was a statistical significant increase in the mean value of final lysholm score measured at post-operation when compared with its corresponding value measured at pre-operation (p value= 0.001) (Table 4).

Table (4): I.K.D.C knee examination form (items) in the studied patients measured pre- and post-surgery.

	Pre		Post	
	Number	**Percent**	**Number**	**Percent**
Effusion				
A	0	0.0	13	52.0
B	0	0.0	12	48.0
C	15	60.0	0	0.0
D	10	40.0	0	0.0
Lack of extension				
A	8	32.0	23	92.0
B	6	24.0	2	8.0
C	5	20.0	0	0.0
D	6	24.0	0	0.0
Lack of flexion				
A	19	76.0	24	96.0
B	4	16.0	1	4.0
D	2	8.0	0	0.0
Lachman test				
A	0	0.0	14	56.0
B	3	12.0	11	44.0
C	22	88.0	0	0.0
Anterior drawer test				
A	0	0.0	18	72.0
B	19	76.0	7	28.0
C	6	24.0	0	0.0
Pivot shift test				
A	0	0.0	16	64.0
B	9	36.0	9	36.0
C	16	64.0	0	0.0
Compartment findings				
A	25	100.0	25	100.0
Harvest site				
A	25	100.0	13	52.0
B	0	0.0	12	48.0
X ray findings				
A	25	100.0	25	100.0
Functional test				
A	0	0.0	13	52.0
B	0	0.0	12	48.0
C	24	96.0	0	0.0
D	1	4.0	0	0.0

Table (5): Comparison between values of final I.K.D.C knee examination of the studied patients measured pre- and post-surgery.

	Pre	Post	p value
Median (minimum-maximum)	3.0 (3.0-4.0)	2.0 (1.0-2.0)	0.001

p≤ 0.05= significant.

The previous table shows that there was a significant improvement in Final IKDC score at the end of follow up in comparison to pre operative score table(5).

Table (6**):** Relation between patients with associated pathology and preoperative lack of extension.

		Associated pathology		P - Value
		No pathology (n= 11)	**With pathology (n= 14)**	
Lack of extension	***A (n= 8)***	4 (36.4%)	4 (28.6%)	0.039
	B (n= 6)	0 (0.0%)	6 (42.9%)	
	C (n= 5)	2 (18.2%)	3 (21.4%)	
	D (n= 6)	5 (45.5%)	1 (7.1%)	

Data are expressed as number (%).
p< 0.05= significant.

Preoperatively, the lack of extension grading in patients without associated pathology was distributed as follows 4 patients (36.4%) were grade A, 0 (0.0%) were grade B, 2 (18.2%) were grade C and finally 5 (45.5%) was grade D. While in patients with associated pathology the lack of extension grading was distributed as follows 4 patients (28.6%) were grade A, 6 (42.9%) were grade B, 3 (21.4%) were grade C and finally 1 (7.1%) was grade D. There was a statistical significant difference between both groups (p= 0.039) Table (6).

Table (7**):** Relation between patients with associated pathology and postoperative lack of extension.

		Associated pathology		p-value
		No pathology (n= 11)	**With pathology (n= 14)**	
ack of extensi on	***A (n= 23)***	9 (81.8%)	14 (100.0%)	0.103
	B (n= 2)	2 (18.2%)	0 (0.0%)	

Data are expressed as number (%).
p> 0.05= not significant.

Postoperatively, the lack of extension grading in both patients without and with associated pathology were distributed as follows 9 patients (81.8%) and 14 (100%) were grade A while 2 (18.2%) and 0 (0.0%) were grade B, respectively. They were statistically comparable (p = 0.103). Table (7).

Table (8): Relation between associated pathology and postoperative lack of flexion.

		Associated pathology		p value
		No pathology (n= 11)	With pathology (n= 14)	
Lack of flexion	A (n= 24)	10 (90.9%)	14 (100.0%)	0.440
	B (n= 1)	1 (9.1%)	0 (0.0%)	

Data are expressed as number (%).
p> 0.05= not significant.

Postoperatively, the lack of flexion grading in both patients without and with associated pathology were distributed as follows 10 patients (90.9%) and 14 patients (100%) were grade A while 1 patient (9.1%) and 0 (0.0%) were grade B, respectively. They were statistically comparable (p = 0.440). Table (8).

Table (9): Comparison between pre- and post-operative data in no associated pathology cases.
Or
Relation between presence of no associated pathology and both lack of extension and flexion measured at pre- and post-operation.

	No associated pathology (n= 11)		p value
	Preoperative	Postoperative	
Lack of extension	C (A-D)	A (A-B)	
	3 (1-4)	1 (1-2)	0.015
Lack of flexion	A (A-D)	A (A-B)	
	1 (1-3)	1 (1-2)	0.157

Data are expressed as medium (minimum-maximum).
p< 0.05= significant.
p> 0.05= not significant.

In patients without associated pathology, there was a statistical significant improvement in lack extension grading [1 (1-2)] measured postoperatively when compared with its corresponding grades measured at preoperative [3 (1-4)] (p = 0.015).

Although the lack of flexion grading was improved [1 (1-2)] postoperatively when compared with its corresponding grades measured at preoperative [1 (1-3)], yet it was still insignificant (p = 0.157) (table(9).

Table (10): Comparison between pre- and post-operative data in associated pathology cases.
Or
Relation between presence of associated pathology and both lack of extension and flexion measured at pre- and post-operation.

	Associated pathology (n= 14)		p-value
	Preoperative	Postoperative	
Lack of extension	B (A-D)	A (A-A)	
	2 (1-4)	1 (1-1)	0.004
Lack of flexion	A (A-D)	A (A-A)	
	1 (1-3)	1 (1-1)	0.059

Data are expressed as medium (minimum-maximum).
p< 0.05= significant.
p> 0.05= not significant.

There was a statistical significant improvement in lack extension grading [1 (1-1)] measured postoperatively when compared with its corresponding grades measured at preoperative [2 (1-4)] (p = 0.004). Although the lack of flexion grading was improved

[1 (1-1)] postoperatively when compared with its corresponding grades measured at preoperative [1 (1-3)], yet it was still insignificant (p = 0.059). Table (10).

Complications

Intraoperative complications:

1) In AM bundle augmentation: The femoral tunnel is much more difficult to perform because the femoral AM footprint is located behind the PM, so the bony landmarks are not easy to find. The reference is the posterior part of the lateral condyle. A good trick is to place the shaver in a triangle represented by the notch, the PCL and the PM bundle, to go through, and to use the shaver as a bur in continues rotation and high speed. Go in contact with the condyle and clean a small socket will help you to stabilize the k-wire in a good place when the knee is placed in full flexion.
2) Injury to the other intact bundle when we do tibial or femoral tunnel by head of the reamer by high velocity drilling so we must do low velocity drilling to avoid injury to the intact bundle.
3) Notch impingement, that is, inhibited extension due to abutment of the graft on the roof of the intercondylar fossa in full extension so we must check impingement when we enter the tibial guide wire.
4) Articular cartilage injury of the femoral condyle by the head of the reamer so we must enter the reamer manually until pass the articular cartilage to avoid injury.

Postoperative complications:

Early complications:

1) 12 patients complained of graft site complications in the form of numbness over the anterior surface of the leg. They were managed by reassurance and vitamin B complex tablets and follow up of the symptoms that improved but not completely resolved. At 6 month non of them graded his symptoms as greater than mild.
2) 2 patients had discharge from the graft site in the first visit postoperatively (10 days postop.), culture and sensitivity swabs were taken, broad spectrum antibiotic started after that and dressing every other day. Delayed wound healing occurred in 2 cases (till 3 weeks postoperatively) but all the 2 culture results were negative.
3) 12 patients complained of painful knee swelling in the first visit postoperatively. They are managed by rest with leg elevation and ice therapy at home and limitation of the rehabilitation to ROM exercises till swelling improved, one of them required aspiration under completely aseptic technique in the outpatient clinic to reduce pain and enable them complete rehabilitation program.

Late complications:

The patients with associated pathology as torn MM and LM or ulcer MFC take much more rehabilitation time to return to normal ROM they were complaint of flexion and extension defecit but they return to normal ROM after 8 months physiotherapy except two patients complained of loss of last 5 degrees of extension and one patient complained of loss of last 5 to 10 degrees of flexion despite of significant improvement in ROM at the end of follow up as proved statistically.

Figure (1): MRI showing ACL seems to be partially torn & Scopic view during surgery showing that PL bundle completely torn and AM bundle preserved.

Figure (2): MRI showing ACL seems to be partially torn

Figure (3): Scopic view intra operatively showing preserving of the Am bundle and reconstructed PL bundle and post operative x ray on the right.

32 years old male patient, had twisting injury left knee injury during playing football. He was presented to outpatient clinic about 4 months after initial trauma. He was complaining of giving way only while trying to play football, pain and swelling. Clinical examination revealed: lack of extension, moderate effusion, lachman test was positive with far firm end point(less than 5m.m) and pivot shift test was grade B (clicking).MRI showed partial tear of the ACL. Patient prepared for arthroscopy and decision to perform augmentation versus traditional ACL reconstruction was confirmed intraoperatively by probing the intact AM bundle and PL augmentation was done.His overall preoperative IKDC score was C. And Lysholm score was 53.He was followed for 24 months after surgery, his overall Lyshom score improved to 95 and IKDC objective score became A. The postoperative diff. Between normal and injured knee measured by K.T 1000 was 3m.m

Discussion

Partial ACL tears are common, Patients with a symptomatic AM or PL bundle tear usually complain of unspecific symptoms like recurrent pain and swelling**. (3).** More specifically, patients with a symptomatic AM bundle tear describe an anterior instability during activities of daily living and during sports activity similar to a complete ACL tear. On the contrary, patients with a symptomatic PL bundle tear complain of rotational instability with pivoting sports rather than complaining of a significant anterior instability with activities of daily living or sports.

Patients with PL bundle injuries only may still perform non pivoting sports activities without major difficulty, but pivoting sports such as soccer or basketball have to be given up because of recurrent problems with rotational instability. **(3)**

There is still confusion on the concept of stump or remnants. It is necessary to differentiate among different types of residual fibers. **Chen et al (4)** described four types of residual ACL fibers: type 1 is a partial ACL tear with the anteromedial bundle or posterolateral bundle that still bridges the femur to the tibia; in type 2, the ACL is completely interrupted at the femoral insertion, while in type 3, the ACL is completely interrupted at the tibial insertion. Type 4 is a residual ACL remnant too small to form an envelope around the graft. This classification may be helpful in the selection process of patient that may undergo ACL augmentation, but it has not been validated.

In the current study we preserved the ACL fibers which bridging the femur to the tibia and were under a good tension when probed

arthroscopically.

Barrack et al. (5) defined partial ACL tear when all of the following three criteria is satisfied; significant portion of at least one bundle was in continuity and was potentially functional as judged by palpation with a probe and arthroscopic anterior drawer testing; the Lachman test scored 0 or 1+ (<5 mm); and the pivot shift was negative or only trace-positive; Which were closer to this study findings as most of the patients graded B (<5 mm) or C (5-10mm) as regard to Lachman examination preoperatively and as regard to pivot shift test no patients had gross pivoting(grade D) preoperatively.

The aim of this study was to evaluate the clinical outcome of the ACL augmentation procedure for patients with partial ACL ruptures.

There are three reasons to preserve the remnants of ACL during reconstruction. Mechanically, remaining fibers act as graft protection during the healing. The microvessels present in the native ACL tissue may enhance the vascularization of the ACL augmentation. Mechanoreceptors in the residual ACL fibers may have proprioceptive function that allows better rehabilitation. **(6,7).**

Twenty five patients with an ACL partial tear were included at this study; anatomic single bundle augmentation using the semi-tendinosus alone (or/ and) gracilis auto-grafts was done.

All cases (100%) were males. Of the knees involved, 15 were right (60%) and 10 (40%) were left. Age ranges from 17 to 40 years and the mean age was 30.28± 5.38 years and the average time between the injury and the surgical interference was 4.60± 3.97 months. Affected bundle among patients was PL in 18 patients (72%) and 7 patients (28%) with affected AM bundle.

The overall results of the present study, as measured by the IKDC evaluation system after 2 years follow up, were 11 patients out of 25 patients (44%) had score A (normal knees) and 14 patients out of 25 patients (56%) had score B(nearly normal knees).

In a study by **Buckley et al. (8)** they followed up 25 patients with partial ACL tears, who were confirmed arthroscopically and underwent conservative treatment. Follow-up period was a minimum of 18 months. Eight percent of the patients underwent ACL reconstruction due to early deterioration. At the end of the study, 60% had good or excellent results. Only 44% of the patients resumed sports at their pre-injury level. Moreover, 72% had activity- related symptoms.

Bak et al. (9) followed up 56 patients with isolated partial ACL tears, who were treated conservatively for a minimum of 5 years. Eleven percent of these patients underwent ACL reconstruction due to early progression to complete tears. At the end of the study, 44% had negative Lachman's test. Sixty-two percent of the subjects had good or excellent knee function.

In comparison to the current study, better results achieved with surgical treatment, but in a shorter period of follow up.

Abat et al. (10) reviewed 28 cases of partial ACL tears at an average of 37.3 months (range, 30-46); all the 28 cases were available for follow-up. Eighteen of those 28 cases (64.3%) were AMB reconstructions and the remaining 10 cases (35.7%) were PLB augmentation procedures using autogenous hamstring graft. The series comprised 21males (75%) and 7 females (25%) with a mean age of 30.4 years (range, 16 to 47) at the time of surgery. Twelve surgeries (42.9%) were performed on the right knees whereas the remaining 16 cases (57.1%) were done on the left knee. The median time period from injury to operation was 68 days (range, 15-280 days).

Postoperatively, all patients were classified as IKDC grade A and B which are in line with the current study despite of their longer period of follow up

They concluded that, the technique provided excellent functional scores with normalized stability and a return to previous level of activity with a low rate of minor complications at a minimum 2.5 years' follow-up. Arthroscopic examination was the most reliable tool for properly diagnosing partial ACL lesions.

Sabat et al. (11) reviewed 40 patients had intact ACL fibers in the location corresponding to the anteromedial (AM) or posterolateral (PL) bundle and were diagnosed as partial ACL tears perioperatively. All patients underwent selective augmentation of the torn bundle, while keeping the remaining fibers intact using autogenous hamstring graft. A total of 38 patients (28 males, 10 females) were available with a minimum of 3 years followup. 26 cases had AM bundle tears and 12 cases had PL bundle tears respectively.

At 3 years follow up, 31.6% patients were graded A, 65.8% were graded B and 2.6% was graded C at IKDC objective evaluation; which are closer to the current study as only one patient out of 38 patients was graded C and the rest of patients were graded A and B.

They concluded that the results of anatomic single bundle augmentation in partial ACL tears are encouraging with excellent improvement in functional scores, side to side laxity and return to sports activity.

In comparison to the current study, as all patients were graded either A or B at two years of follow up with no patients were graded as C.

This study confirms that subjective functional outcome as measured by Lysholm knee score and the presence of symptoms (pain, swelling, and instability), was improved significantly at the end of follow up, from a mean of 63.08(SD, 9.92) to 92.60(SD, 3.88).

Abat et al. (10) reviewed 28 cases of partial ACL tears. Their Lysholm score improved from a mean 66.1 (SD, 1.3) to 96 (SD, 1.4) in the AMB group and from 63.5 (SD, 5.4) to 95.6 (SD, 0.6) in the PLB group. **(15).**

All the patients complained, preoperatively, of recurrent giving-way episodes. The pivot-shift test was positive in 7 out of 7 patients with AMB reconstructions and in 18 out of 18 patients with PLB reconstructions. With regard to the Lachman test, it was (-1to 2mm) in one patient and (3-5mm)in 6 patients of all 7 cases of AM bundle group (28%) and (-1to 2mm) in two patients and (3-5mm)in 16 patients of all 18 cases of PLB group (72%).

Siebold and Fu (3) further clarified the difference between AM and PL bundle tears clinically. The AM bundle tears have significantly

increased (1-2) anterior drawer test at 90° of knee flexion, anterior translation in the Lachman test at 30° is rather small (0-1) and pivot shift test is negative or only slightly positive (0-1). Patients with PL bundle tears have positive pivot shift test, anterior drawer test and the Lachman test might be 0-1 **(12,13).** Our experience was in line with the above.

Liu et al. (15) in an experimental study showed that the degree of anterior instability correlates with the amount of partial ACL disruption.

The potential disadvantage of selective bundle reconstruction can be overstuffing of notch and impingement causing loss of motion as reported by **Sonnery-Cottet et al. (14).**

In the current study at 2 years follow up two patients complained of loss of last 5 degrees of extension and one patient complained of loss of last 5 to 10 degrees of flexion despite of significant improvement in ROM at the end of follow up as proved statistically.

In our study 12 (48%) patients complained of mild graft site complications in the form of numbness over the anterior surface of the leg and discharge from graft site (treated by broad spectrum antibiotic).

The possibility of nerve injury during harvesting of their semitendinosus tendon with a tendon stripper cannot be overlooked. The main trunk of the saphenous nerve runs distally on the medial (outer) surfaces of the tendons of the gracilis and semitendinosus muscles along the medial collateral ligament. We should consider horizontal incision instead of vertical incision used in our study to decrease the incidence.

One hundred and twenty patients with a chronic unilateral rupture of the anterior cruciate ligament underwent arthroscopically assisted reconstruction with use of either autologous bone-patellar tendon-bone or doubled hamstring tendon grafts, in a strictly alternating manner

At the two-year follow-up evaluation. In the bone-patellar tendon-bone group, we found a higher prevalence of postoperative kneeling discomfort ($p < 0.01$) and an increased area of decreased skin sensitivity ($p < 0.001$). In the hamstring tendon group, we recorded a higher prevalence of femoral tunnel widening ($p < 0.01$). **(16)**

Papastergiou et al (17) evaluated the incidence rate of iatrogenic injuries to the infrapatellar branch(es) of saphenous nerve during ACL reconstruction with four strand hamstring tendon autograft in a retrospective review of 226 patients. The patients were separated into two groups, vertical incision group and horizontal incision group. In the vertical incision group 39.7% of the patients with disturbed sensitivity in the area of the infrapatellar branch(es) of the saphenous nerve distribution.In patients of horizontal incision group the incidence of nerve injury was 14.9%.

A case report of saphenous neuralgia following arthroscopically assisted anterior cruciate ligament reconstruction with hamstring tendons is presented. The patient complained of paresthesia in the anteromedial region of the lower leg and tenderness at the medial side of the knee without motor or reflex abnormalities. Because saphenous neuralgia can mimic disorders of the knee, peripheral vascular disease, and lumbar nerve root compression, diagnosis can be confirmed by anesthetic blockade. The patient underwent saphenous neurolysis. Six months after surgery, the patient had normal cutaneous sensation at the medial aspect of the lower leg and ankle and she no longer complained of any painful dysesthesia. To minimize the risk of damaging the saphenous nerve when harvesting hamstring tendons, the knee should be flexed and the hip external rotated**. (18).**

Harvesting of the gracilis and semi-tendinosus (ST) hamstring tendons is usually performed by anteromedial approach. Harvesting by a horizontal posterior approach is possible. Based on a series of 90 patients, this technical note describes the perioperative difficulties and the characteristics of the harvested tendon(s) as well as any complications. Only one unsuccessful harvest was reported. Posterior harvesting of the gracilis and ST hamstring tendons is a reliable, reproducible surgical technique with a low rate of complications**. (19).**

Kartus et al. (20) in his study about Complications following arthroscopic ACL reconstruction, all conditions that interfered with rehabilitation during the first 3-month period, were registered as complications. Delayed wound healing occurred in 2.6% of patients (6.6 % in our study) and was managed by wound care.

Also, he reported the incidence of 4.1% of severe post-operative swelling (6.6 %) in our study that was managed conservatively.

Joint degeneration was not noted in any case but this may be due to the short duration of follow up and may appear later on.

Kannusand and Jarvinen (21) reported that 15% of their patients with partial tears presented degenerative lesions after eight years of follow-up.

Table (11**):** The results of the post op. complications of our recent study and international studies done for single bundle ACL reconstruction in partial injuries of ACL:

Name	Delayed wound healing	Postop.swelling	Numbness at site of graft harvest (vertical vs. Horizontal
Kartus J. et al. (1999)	**2.6%**	**4.1%**	**-**
Papastergiou S. et al. (2006)	**-**	**-**	**39.7%:14.9%**
Our study (2020)	**6.6%**	**6.6%**	**48% (horizontal)**

Conclusion

Diagnosis of symptomatic PL or AM bundle tear is a combination of the patient's history and complaints, clinical examination, MRI, and arthroscopic evaluation.

Good results have been achieved with preserving the remanants of the torn ACL and performing augmentation but reliable diagnosis of partial torn ACL and assessing the validity of the remanants to be kept and decision to do an augmentation procedure has to be taken after arthroscopic assessment.

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