

Quadriceps Tendon Press-Fit Autograft for ACL Reconstruction: A Reliable and Cost-Effective Fixation Technique

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Abstract

Background: Anterior cruciate ligament (ACL) tears are frequent ligamentous injuries that necessitate reconstruction in many cases. The patellar tendon and the hamstring tendon are the most frequently utilized autografts for reconstruction. However, both have certain disadvantages. Femoral tunnel widening after ACL reconstruction is a common phenomenon. Moreover, the literature is still deficient regarding the results of using quadriceps tendon allograft and press fit technique of fixation.

Aim of Study: The aim of this prospective case series study is to evaluate functional and clinical outcomes for quadriceps (QT) as an auto graft for anterior cruciate ligament reconstruction (ACLR) using press fit technique.

Patients and Method: A prospective case series study was undergone to patients at Cairo University Hospital (Kasr El-Aini), collecting data and follow-up were done from January 2022 till November 2024. Forty patients were operated using quadriceps tendon press fit technique and followed-up for one year. Pre- and post-operative clinical assessment using subjective IKDC, IKDC examination form and lysholm scores for all patients to assess post-operative improvement regarding ROM and knee stability. Pre-operative MRI was done for all study members to confirm ACL injury and to address any associated ligamentous or meniscal injuries.

Results: It was found that QT auto graft showed significant improvement of clinical and functional outcomes according to post-operative IKDC subjective (87.9 ± 6.6) lysholm score (93 ± 8). Clinically 95% of the patients had post-operative nearly normal knee examination.

Conclusion: The use of QT auto graft for primary ACLR gives similar clinical and functional outcome as other graft op-

tions in the literature. Also, it was found that press fit technique for graft fixation is a good reliable technique with low cost and more biological than hardware using techniques.

Key Words: Anterior cruciate ligament – Quadriceps – Reconstruction – Press fit.

Introduction

AN anterior cruciate ligament (ACL) is the most frequently injured ligament in the knee joint that is usually injured when engaging in sports activity, but nonsports injuries are not uncommon [1-3]. these injuries results in unstable knee that necessitates reconstruction to regain its function. The patellar tendon and the hamstring tendon are the most frequently utilized autografts for reconstruction. However, both have certain disadvantages. the patellar tendon (PT) graft, commonly known as the Bone-Patellar tendon–Bone [1,4]. BPTB graft. It has the benefit of bone-to-bone healing, which allows tunnel and graft to be easily incorporated, leading to a quicker return to work and athletic activity. But, BPTB carries the potential for morbidity at the donor site, including pain, stiffness, knee discomfort, and fracture of the patella. On the other hand, a hamstring autograft is easily harvested with little hazards at the donor site and is similar to native ACL. However, it has unpredictable graft size, and the hamstring capacity can be affected, which may reduce the athlete performance [5]. Many methods of graft fixation are used biodegradable interference screws, adjustable buttons, metal interference screws, stables, cortical screws, etc. despite the use of all these techniques there is no consensus regarding standard graft option or method of fixation [1].

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Patients and Methods

A prospective case series study was undergone to patients at Cairo University Hospital (Kasr El-Aini), collecting data and follow-up were done from January 2022 till November 2024. All active patients with primary ACL tear aging 18-40y with full active ROM(range of motion). Immature with open physis, arthritic, multi-ligamentous and revision patients were excluded. Forty patients with ACL insufficiency which meet criteria underwent ACLR surgery. The patients were evaluated pre and postoperatively as the following; (history of trauma, clinical and radiological examination and functional scores were obtained in the form of IKDC.

(International Knee Documentation Committee) and Lysholm scores. All patients must have pre-operative plain X-ray and MRI knee to confirm diagnosis and post-operative X-ray (monthly) and computed topography (CT) scan for knee 6-month post-operative (at end of evaluation) to assess bone graft plug healing process. A dose of preoperative intra venous antibiotic (usually 3rd generation cephalosporin) was given with induction of anesthesia (all patient had spinal anesthesia) and post operatively during hospital stay. The knee was examined to confirm preoperative diagnosis, and then a pneumatic tourniquet was applied, then thorough draping of the limb was done. The affected leg was sterilized with Betadine from the tip of toes till just distal to the tourniquet. With the knee semi flexed an anterolateral Para median knee incision was applied with starting point at upper pole of patella and extending about 5cm proximally (Fig. 1-A). Dissection till the tendon was apparent then about 1cm width and 11cm long (including about 1cm from upper pole of patella) was taken proximally and dissect distally till upper pole of patella then oscillating saw is applied to separate a wedge-shaped part of the upper pole of patella (not including the articular surface) attached to the tendon to be used as tibial bone plug (Fig. 1-B,C). Trimming of extra tissue from harvested graft to make it more cylindrical and trimming of bone plug to reach for the appropriate dimensions to be fitted at tibial tunnel (Fig. 1-D).

Then knee arthroscopy is performed. The AL portal was used as a viewing portal for the knee then through the AM portal the shaver was applied to prepare femoral foot print to take the femoral

tunnel and then remnants of the native ACL were shaved to detect tibial foot print. When tibial foot print is clear a C-guide is applied at it (at the central point between 2 prominences of tibial spine) to prepare for tibial tunnel and harvest of tibial bone plug by hollow oscillating reamer to use it in graft preparation. Tibial tunnel is made to be more or less conical in shape with the apex toward the joint (Fig. 1-G). This is achieved by harvesting tibial bone plug with hollow oscillating reamer has the same size for the diameter of the graft then after getting the plug out another conical reamer (miller reamer) (Fig. 1-G) was used to dilate distal part of the tunnel than the proximal part so the bone plug imbedded in the distal part of the graft is fitted into tunnel. Preparation of femoral tunnel by placing hollow oscillating reamer at (intersection of lateral inter condylar ridge and lateral bifurcate ridge) about 30mm only to avoid posterior femoral wall blow out then femoral bone plug used fixation is harvested (Fig. 1-E,F). Graft introduced from distal to proximal and got press fitted at tibial end by bony plug sutured at the tibial end of the graft but the femoral end got press fitted by the bony plug harvested from this site and placed by special impactor. Checking for stability of the graft by probe and then frequent flexion and extension of knee joint done to be sure that there is no impingement of the graft or any limitation of range of movement.

The final steps after ACL graft fixation are hemostasis for graft site, application of drain into knee, closure of portals and graft site.

Before patient is discharged from hospital drain is removed and knee is put into brace for 2 weeks with administration of Antibiotics (a combination of ciprofloxacin with amoxicillin-clavulanic acid for 10 days) and Prophylactic anticoagulants (rivaroxaban 10mg once daily for one week).

Instructions are given to the patient according to standard protocols of rehabilitation [6,7] and shifting from stage to the next according to compliance and response till return to pre-operative knee state.

At end of 6th month CT scan is asked for all patients to assess bone plug healing and tunnel state and final clinical assessment is recorded after one year.

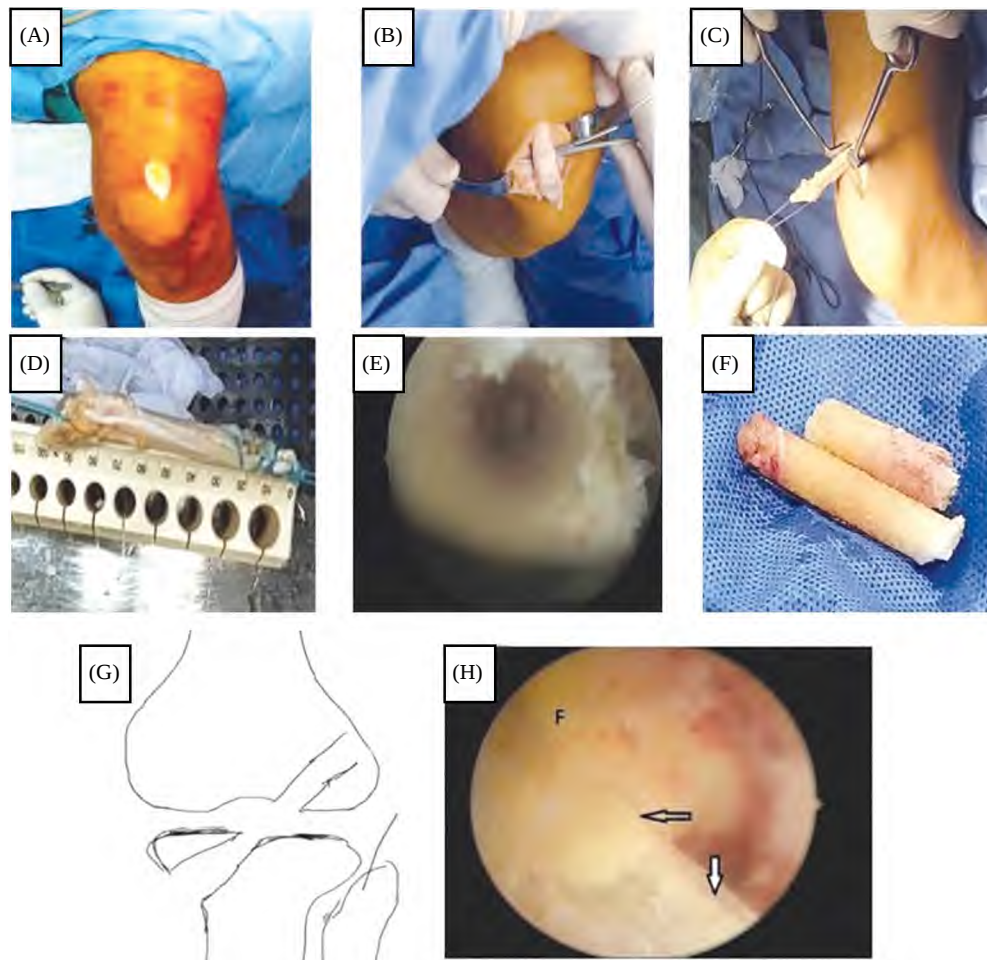


Fig. (1): Steps of quadriceps tendon press fit technique. (A) Incision for QT auto graft. (B) Deep dissection of the harvested part of the QT tendon. (C) Separation of proximal part of the graft from the tendon. (D) Final shape of the graft. (E) Shape of femoral tunnel after plug harvest. (F) Bone plugs used for graft fixation (the longer is used for femoral tunnel, the shorter is impacted into tibial end of the graft. (F) Diagram illustrating conical shape of tibial tunnel. (H) Final shape of the plug (black arrow) in the femoral tunnel holding the graft (white arrow), (F) Femur.

Results

This study was performed in Kasr El-Ainy Hospital from Jan. 2021 till Nov. 2024 with sample size of 40 patients the following results were detected: All participants were males, and the mean age was 25.6 ± 5 . Also, it was found that 21 patients from 40 (52.5%) had injury in left (LT) knee vs. 19 patients (47.5%) in right (RT) side. Traumatic non-contact injury was the most common mode of injury causing ACL tear (60% of patients). About 40% of patients had meniscal injuries (Table 1).

The patients were followed-up for 12 ± 3 months regarding range of motion, rehabilitation, incidence of complications and finally after end of rehabilitation the clinical scores were obtained as the following. According to IKDC subjective form mean score became 87.9 ± 6.6 instead of 59.2 ± 5.1 . Using lysholm score it was raised from 45.3 ± 9.8 preoperatively to 93 ± 8 post-operatively. Results for assessment of patient using IKDC subjective

form, IKDC examination form and lysholm score are summarized in the following tables.

The following tables illustrate the detailed IKDC score and examination preoperatively and after one year of follow-up showing the difference in the knee functions pre and post-intervention (Tables 2-4).

These two tables show the detailed items of lysholm score preoperative and finally after one year of follow-up. Tables (5,6).

This table concludes the significant improvement of clinical scores after the surgery. Table (7).

This technique showed some complications; intraoperative in the form of plug fracture, femoral tunnel blow out and others postoperative as DVT, superficial infection, effusion, stiffness, giving way and locking. The most frequent complication was the knee effusion and only 2 cases required aspiration in the out patient clinic. These complications are illustrated in details in Table (8).

Table (1): Demographic and clinical data.

	Number of patients n=40 (%)
Age (Mean $\pm$ SD)	25.6 $\pm$ 5
Side:	
Left knee	22 (55)
Right knee	18 (45)
Mode of injury:	
Traumatic contact	6 (15)
Traumatic non-contact	24 (60)
Non traumatic sudden	6 (15)
Non traumatic gradual	4 (10)
Associated mensial pathology:	
LM tear	4 (10)
MM degeneration	6 (15)
MM tear	6 (15)
Procedure:	
ACL reconstruction	24 (60)
ACL reconstruction+MM meniscectomy	6 (15)
ACL reconstruction+LM meniscectomy	2 (5)
ACL reconstruction+MM repair	6 (15)
ACL reconstruction+LM repair	2 (5)

LM: Lateral meniscus. MM: Medial meniscus.

Table (2): Pre operative subjective IKDC score form.

	Number of patients n=40 (%)
1- Pain:	
Light activities	14 (35)
Moderate activities	24 (60)
Strenuous activities	2 (5)
2- Swelling:	
Very	16 (45)
Moderate	12 (30)
Mild	10 (25)
3- Locking:	
Present	30 (75)
No locking	10 (25)
4- Giving away:	
Light activity	20 (50)
Moderate activities	20 (50)
5- Up stairs:	
Extremely difficult	2 (5)
Moderately difficult	20 (50)
Minimally difficult	18 (45)
6- Down stairs:	
Extremely difficult	4 (10)
Moderately difficult	28 (70)
Minimally difficult	8 (20)
7- Squatting:	
Extremely difficult	6 (15)
Moderately difficult	24 (60)
Minimally difficult	10 (25)

Table (2): Count.

	Number of patients n=40 (%)
- Jumping:	
Unable to do	6 (15)
Extremely difficult	26 (65)
Moderately difficult	6 (15)
Minimally difficult	2 (5)
	Mean $\pm$ SD
Total grade /87	52 $\pm$ 4
Percentage	59.23 $\pm$ 5.05

Table (3): Post-operative IKDC subjective score form.

	Number of patients n=40 (%)
1- Pain:	
Moderate activities	2 (5)
Strenuous activities	6 (15)
Very strenuous	32 (80)
2- Swelling:	
Moderate	2 (5)
Mild	10 (25)
No swelling	28 (70)
3- Locking:	
Present	4 (10)
No locking	36 (90)
4- Giving away:	
Moderate activities	4 (10)
Strenuous activities	4 (10)
Very strenuous	32 (80)
5- Up stairs:	
Minimally difficult	8 (20)
No difficulty	32 (80)
6- Down stairs:	
Moderately difficult	2 (5)
Minimally difficult	10 (25)
No difficulty	28 (70)
7- Squatting:	
Moderately difficult	2 (5)
Minimally difficult	12 (30)
No difficulty	26 (65)
8- Jumping:	
Unable to do	0 (0)
Moderately difficult	0 (0)
Minimally difficult	12 (30)
No difficulty	28 (70)
	Mean $\pm$ SD
Total grade /87	77 $\pm$ 6
Percentage	87.9 $\pm$ 6.6

Table (4): Pre & post operative IKDC knee examination form score.

	Preoperative n=40 (%)	Postoperative n=40 (%)
1- Effusion:		
Normal (A)	0 (0)	32 (80)
Nearly normal (B)	4 (10)	8 (20)
Abnormal (C)	22 (55)	0 (0)
Severely abnormal (D)	14 (35)	0 (0)
2- Lachman test:		
Normal (A)	0 (0)	38 (95)
Nearly normal (B)	0 (0)	2 (5)
Abnormal (C)	28 (70)	
Severely abnormal (D)	12 (30)	
3- Anterior drawer test:		
Normal (A)	0 (0)	40 (100)
Abnormal (C)	40 (100)	0 (0)
Severely abnormal (D)	0 (0)	0 (0)
4- Pivot shift test:		
Normal (A)	0 (0)	32 (80)
Nearly normal (B)	2 (5)	8 (20)
Abnormal (C)	28 (70)	0 (0)
Severely abnormal (D)	10 (25)	0 (0)
5- One leg hoop test:		
Normal (A)	2 (5)	26 (65)
Nearly normal (B)	0 (0)	14 (35)
Abnormal (C)	16 (40)	0 (0)
Severely abnormal (D)	22 (55)	0 (0)
6- Final evaluation:		
Normal (A)	0 (0)	30 (75)
Nearly normal (B)	0 (0)	8 (20)
Abnormal (C)	32 (80)	2 (5)
Severely abnormal (D)	8 (20)	0 (0)

Table (5): Pre-operative lysholm Score.

	Number of patients n=40 (%)
1- Limp:	
Constant limp	2 (5)
Slight limp	30 (75)
No limp	8 (20)
2- Support:	
Crutches with some wt. bearing	30 (75)
No crutches	10 (25)
3- Locking:	
Locking frequently	6 (15)
Locking occasionally	22 (55)
No locking but catching	6 (15)
No locking or catching	6 (15)
4- Instability:	
Often gives away with daily activity	2 (5)
Occasionally gives away with daily activity	22 (55)
Frequently gives away with vigorous activity	16 (40)
Rarely gives away	0 (0)

Table (5): Count.

	Number of patients n=40 (%)
5- Pain:	
Marked pain with walking less than 1 mile	4 (10)
Marked pain with walking more than 1 mile	20 (50)
Marked pain with vigorous activity	16 (40)
6- Swelling:	
Swelling with ordinary activity	26 (65)
Swelling with vigorous activity	14 (35)
7- Stairs:	
Climb one at time	32 (80)
Slight problem	8 (20)
8- Squatting:	
Squatting is impossible	2 (5)
Cannot bend knee more than 90	14 (35)
Slight problem	22 (55)
No problem	2 (5)
	Mean $\pm$ SD
Total grade	45.3 $\pm$ 9.8

Table (6): Postoperative lysholm score.

	Number of patients n=40 (%)
1- Limp:	
Slight limp	2 (5)
No limp	38 (95)
2- Locking:	
No locking but catching	14 (35)
No locking or catching	26 (65)
3- Instability:	
Rarely gives away	8 (20)
Never giving away	32 (80)
4- Pain:	
Marked pain with vigorous activity	2 (5)
Intermittent pain with vigorous activity	12 (30)
No pain	26 (65)
5- Swelling:	
Swelling with vigorous activity	10 (25)
No swelling	30 (75)
6- Stair climbing:	
Slight problem	10 (25)
No problem	30 (75)
7- Squatting:	
Slight problem	2 (5)
No problem	38 (95)
	Mean $\pm$ SD
Total	93 $\pm$ 8

Table (7): Pre- and post-operative results among group B.

	Mean $\pm$ SD	p-value
- Pre-operative subjective IKDC (Total grade)	52 $\pm$ 4	<0.001
- Post-operative subjective IKDC (Total grade)	77 $\pm$ 6	<0.001
- Pre-operative subjective IKDC (Percentage)	59.2 $\pm$ 5.1	<0.001
- Post-operative subjective IKDC (Percentage)	87.9 $\pm$ 6.6	
- Pre-operative lysholm (Total grade)	45.3 $\pm$ 9.8	
- Post-operative lysholm (Total grade)	93 $\pm$ 8	
<i>Preoperative IKDC examination form Final evaluation:</i>		
Abnormal (C)	16 (80)	<0.001
Severely abnormal (D)	4 (20)	
<i>Postoperative IKDC examination form Final evaluation:</i>		
A Normal	15 (75)	
B Nearly normal	4 (20)	
C Abnormal	1 (5)	

SD: Standard deviation. p-value <0.05 is considered significant.

Table (8): Intra and post-operative complications detected in our study and how they were be managed

Complication	Incidence		Management
	No	Percent	
Plug fracture	2	2.5	Femoral fixation using interference screw
Femoral tunnel blow out	2	2.5	Femoral fixation using suspensory system
DVT	2	2.5	F.U with vascular surgery
Superficial wound infection	2	2.5	Administration of antibiotics no debridement was needed
Post-operative knee effusion	12	15	
Grade A	0		
Grade B	8		Follow-up
Grade C	4		2 case Follow-up 2 case aspiration
Grade D	0		
Limited knee flexion	2	2.5	Follow-up with massive physiotherapy (did not need intervention)
Giving a way	4	5	Q muscle strengthening exercise (stable knee with clinical exam)
Locking	4	5	4 cases give catching not locking with examination

Discussion

This series studied the reliability and hazards of using quadriceps tendon autograft and its fixation by bone plug press-fit technique. The study was performed over 40 patients in Kasr Al-Ainy hospital over 3 years with 12 $\pm$ 3 months follow-up. After one year follow-up there was significant improvement of clinical scores lyshohlm, IKDC subjective and examination scores. However, there was some intraoperative and postoperative complications that was managed properly intraoperative or at the out-

patient clinic without impact on the later outcome. This thesis focused on both clinical and functional outcomes to prove that the press-fit quadriceps graft has comparable outcome to other graft types.

In 2017 Cavaignac et al. [8] study compared hamstring to quadriceps graft and showed that post-operative IKDC score for both groups were (80 $\pm$ 17 vs. 84 $\pm$ 13 p-value 0.2) respectively which also revealed that QT auto graft has a good outcome that may be better than HT auto graft in primary ACLR.

Lee et al., in 2016 [9] also showed in their study which had at least 2 years of post-operative follow up with 96 patients into 2 groups that HT auto graft group candidates had post-operative IKDC subjective mean score (77.9 ± 12.2) while QT auto graft group candidates had mean score (80.2 ± 10.0) with p -value < 0.01 .

The only difference between results of both studies (Cavangic et al. & Lee et al.) concerns the laxity measured with KT-1000 arthrometer (QT: 1.1 ± 0.9 mm for the cavangic study vs. 2.1 ± 1.9 mm for Lee et al., HT: 3.1 ± 1.3 mm for the cavangic study vs. 1.9 ± 1.8 mm for Lee et al).

In 2022 Maria et al. [10] study showed that HT group had mean IKDC subjective score (91.23) while QT group had mean IKDC subjective score (86.28) with p -value 0.38. In her study Maria et al [10] concluded that ACLR with a QT auto graft had led to similar clinical and functional outcomes to those achieved with a HT graft. The QT should be considered a valid alternative for ACLR. She also found that using QT as an auto graft for ACLR has lower post-operative complication rate. It was observed that despite difference in results between 3 studies the final outcome of both groups was similar clinically and functionally.

Also, Sarzaeem et al., [11] concluded that PF technique is an efficient procedure. Its outcome was comparable with the interference screw group. Furthermore, it has unlimited bone-to-bone healing, no need for removal of hardware, ease for revision and cost effectiveness. He had 158 patients with an average age of 29.8 years were treated for torn ACL. 82 patients underwent reconstruction with BPTB autograft with a PF fixation technique, and in 76 cases an interference screw was used. At the time of final follow-up, 71 patients in PF group and 65 patients in interference screw group were evaluated in terms of return to pre-injury activity level, pain, knee stability, range of motion, IKDC score and complications. At 12-month follow-up, 59 (83%) and 55 (85 %) in press-fit and screw group, respectively had good-to- excellent IKDC score ($p > 0.05$). The mean laxity assessed using a KT-1000 arthrometer improved to 2.7 and 2.5 mm in PF and screw group, respectively. Regarding Lachman and pivot shift test, there was a statistically significant improvement in the integrity of the ACL in both the groups, but no significant differences were noted between groups. There were no significant differences in terms of femur circumference difference, effusion, knee range of motion, pain and complications. This study needs to be compared with other methods of fixation and graft type, longer follow-up and incidence of failure are required.

Finally summarizing results for different studies comparing usage of either HT or QT auto graft is listed in Table (9) below.

Conclusion:

According to results of studies shown in our discussion and our study, it was found that press fit technique using quadriceps tendon has a similar result for other techniques for ACLR grafts and fixation methods regarding clinical and functional outcome. It was found also that QT auto graft is a valid alternative for ACLR with good clinical and functional outcomes in spite of differences in methods for assessment in each study and with different methods for fixation of ACLR auto graft. Using QT auto graft as a source for primary ACLR as it gives the same clinical and functional outcome as using HT auto graft which is considered the most preferred source for ACLR auto graft with no remarkable differences regarding knee stability or post-operative knee functional and clinical scoring systems. Press fit technique is a good option for graft fixation in ACLR and showed good results in post-operative knee follow-up with many advantages; biological healing-support, no foreign material with MRI-control without artifact and no bone defects for easy revision in the same technique.

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رقعة وتر العضلة الرباعية بتقنية التثبيت بالحشر لإعادة بناء الرباط الصليبي الأمامي: تقنية تثبيت موثوقة وفعالة من حيث التكلفة

على مدار عقود متتالية تطورت طرق إعادة بناء الرباط الصليبي الأمامي سواء على مستوى نوع الرقعة المستخدمة أو طرق تثبيت هذه الرقعة فنجد انه يمكن استخدام رقعة صناعية أو رقعة طبيعية من الجسم (ذاتية) أو من أجسام أخرى وتعد الرقعة الطبيعية الذاتية هي الأفضل في النتائج ويمكن الحصول عليها باستخدام أوتار العضلة الخلفية للفخذ، العضلة الأمامية للفخذ، وترعظمه الرضفة أو وتر العضلة الشظوية الأطول بالساق. كما تم استخدام العديد من الطرق لتثبيت هذه الرقعة وذلك عن طريق استخدام المسامير القشرية، المسامير التداخلية، الخيوط والأزرار، الدبابيس، الشرائح المعدنية الصغيرة أو باستخدام الرقعة العظمية عن طريق الحشر والتي أثبتت نتائج جيدة في متابعة الحالات.

وبعد إجراء الجراحة يحتاج المريض للخضوع الى برنامج تأهيلي على عدة مراحل للعودة لممارسة أنشطة اليوم العادي أو ممارسته الأنشطة الرياضية المختلفة.

وقد تمت هذه الدراسة على عينة من المرضى تبلغ ٤٠ مريض باستخدام جزء من وتر العضلة الأمامية للفخذ مع جزء من عظمه الرضفة باستخدام طريقه حشر الرقعة العظمية الذاتية لتثبيت الرباط البديل. وتمت متابعة المرضى على مدار عام كامل من خلال مجموعة من الاستقصاءات والاختبارات المعدة لتقييم حالات اصابات مفصل الركبة والتي تم استخدامها قبل وبعد الجراحة. وقد خلصت هذه المقارنات إلى أن استخدام جزء من وتر العضلة الأمامية للفخذ مع جزء من عظمة الرضفة يعطى نفس نتائج استخدام الرقع البديلة مثل العضلات الخلفية وايضاً مثل طرق التثبيت الاخرى.