مجلة جامعة بني وليد للعلوم الإنسانية والتطبيقية
Bani Waleed University Journal of Humanities and Applied Sciences
تصدر عن– جامعة بني وليد – ليبيا
Website:https://jhas-bwu.com/index.php/bwjhas/index
المجلد العاشر ـ العدد الثالث ـ 2025 ـ الصفحات (13– 23)
ISSN3005-3900

Anatomic Single-Bundle Anterior Cruciate Ligament Reconstruction Using Hamstring Tendon: An Arthroscopic Approach

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إعادة بناء الرباط الصليبي الأمامي التشريحي أحادي الحزمة باستخدام وتر العضلة الخلفية للفخذ: بواسطة المنظار

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تاريخ الاستلام: 17–05–2025 تاريخ القبول: 23–06–2025 تاريخ النشر: 01–07–2025

Abstract

Background: Anterior cruciate ligament (ACL) injuries are among the most prevalent knee injuries, and they are particularly common in young, athletic people who play demanding sports. Hamstring tendon autografts have gained widespread acceptance in ACL reconstruction due to their favorable biomechanical properties, dependable long-term outcomes and low morbidity at the donor site. This study's objective was to outline the arthroscopic method for hamstring tendon autograft-based anatomic single-bundle ACL restoration. Discuss its clinical rationale, and review the current evidence supporting its efficacy in restoring knee function and stability. **Methods:** In this clinical investigation, 24 patients (75% male, 25% female) with an average age of 30.16±5.9 years were treated at the Orthopedic Surgery in Abu-Salim Trauma Hospital in Libya. Among them, 16 cases (66.7%) had right ACL tears, while 8 cases (33.3%) had left ACL tears. Regarding the mechanism of injury, 14 cases (58.3%) were due to sports injuries, 7 cases (29.2%) resulted from road traffic accidents (RTA), and 3 cases (12.5%) were caused by falls down stairs. A minimum of 12 months and a maximum of 48 months passed between the injury and intervention, with a mean time of 29.79 ± 8.14 months. **Results:** After surgery, the grade of Lysholm score increased dramatically, with 17 patients (70.8%) obtaining excellent outcomes. 5 patients (20.8%) classified as good, and 2 patients (8.3%) as fair. The mean IKDC score also demonstrated significant improvement, rising from 45.83 ± 7.46 preoperatively to 78.12 ± 6.04 postoperatively ($p < 0.05$). 19 patients (79.2%) had no postoperative complications, 4 patients (16.7%) developed superficial infections, and 1 patient (4.1%) experienced a serious infection. **Conclusion:** Anatomically reconstructing the anterior cruciate ligament with the hamstring tendon is more effective at simulating the anatomy of the ACL and producing favorable clinical results.

Keywords: Anterior Cruciate Ligament, **ACL reconstruction, Hamstring Tendon ,An Arthroscopic Approach, Lysholm score.**

الملخص

تُعد إصابات الرباط الصليبي الأمامي (ACL) من أكثر إصابات الركبة شيوعًا، وهي شائعة بشكل خاص لدى الشباب الرياضيين الذين يمارسون رياضات تتطلب مجهودًا بدنيًا كبيرًا. وقد حظيت الطعوم الذاتية لأوتار الركبة بقبول واسع في عمليات إعادة بناء الرباط الصليبي الأمامي نظرًا لخصائصها البيوميكانيكية المميزة، ونتائجها الموثوقة على المدى الطويل، وانخفاض معدلات الإصابة في موقع التبرع. هدفت هذه الدراسة إلى توضيح الطريقة التنظيرية لاستعادة الرباط الصليبي الأمامي التشريحي أحادي الحزمة باستخدام طعم ذاتي لوتر العضلة الخلفية للفخذ. ناقش الأساس السريري لهذه الطريقة، واستعرض الأدلة الحالية التي تدعم فعاليتها في استعادة وظيفة الركبة واستقرارها.

والطريقة: في هذه الدراسة السريرية، عولج 24 مريضًا (75% ذكور، 25% إناث) بمتوسط عمر 30.16 ± 5.9 سنة في قسم جراحة العظام بمستشفى أبو سليم للحوادث في ليبيا. من بينهم، عانت 16 حالة (66.7%) من تمزقات في الرباط الصليبي الأمامي الأيمن، بينما عانت 8 حالات (33.3%) من تمزقات في الرباط الصليبي الأمامي الأيسر. أما بالنسبة لآلية الإصابة، فقد كانت 14 حالة (58.3%) ناجمة عن إصابات رياضية، و7 حالات (29.2%) ناجمة عن حوادث مرورية، و3 حالات (12.5%) ناجمة عن السقوط من السلالم. انقضت مدة لا تقل عن 12 شهرًا ولا تزيد عن 48 شهرًا بين الإصابة والتدخل الجراحي، بمتوسط زمني 29.89 ± 8.14 شهرًا. النتائج: بعد الجراحة، ارتفع تقييم ليشولم بشكل ملحوظ، حيث حصل 17 مريضًا (70.8%) على نتائج ممتازة. صُنِّف 5 مرضى (20.8%) على أنه جيد، ومريضان (8.3%) على أنه مقبول. كما أظهر متوسط تقييم IKDC تحسنًا ملحوظًا، حيث ارتفع من 45.83 ± 7.46 قبل الجراحة إلى 78.12 ± 6.04 بعد الجراحة (قيمة الاحتمال < 0.05). لم يُعانِ 19 مريضًا (79.2%) من أي مضاعفات بعد الجراحة، بينما أُصيب 4 مرضى (16.7%) بعدوى سطحية، بينما عانى مريض واحد (4.1%) من عدوى خطيرة. الاستنتاج: إن إعادة بناء الرباط الصليبي الأمامي تشريحياً باستخدام وتر العضلة الخلفية للفخذ أكثر فعالية في محاكاة تشريح الرباط الصليبي الأمامي وإنتاج نتائج سريرية إيجابية.

الكلمات الدالة: الرباط الصليبي الأمامي، إعادة بناء الرباط الصليبي الأمامي، وتر العضلة الخلفية للفخذ، بواسطة التنظيري، درجة ليشولم.

Introduction

Anterior cruciate ligament (ACL) injuries are among the most frequent ligamentous injuries affecting the knee, particularly in young, active individuals involved in pivoting sports**[1]**. Management of ACL tears has evolved from non-anatomic reconstruction techniques to anatomic approaches that aim to replicate the native ligament's anatomy and biomechanics**[2].**

Anatomic single-bundle ACL reconstruction has gained popularity due to its focus on restoring the native ACL footprint and tension patterns, improving rotational stability and knee kinematics **[3].** Advances in arthroscopic instruments and imaging techniques have enabled more precise tunnel placement and graft positioning, which reduce graft failure risk and postoperative complications**[4].**

Hamstring tendon autografts are widely used due to their biomechanical strength, low donor site morbidity, and reliable long-term outcomes **[5].** When combined with an arthroscopic anatomic technique, this method offers a minimally invasive yet effective option for ACL reconstruction**[6].**

According to recent research, the aim of this study is to outline the surgical procedures for arthroscopic anatomic single-bundle ACL restoration utilizing a hamstring tendon autograft and to emphasize the therapeutic advantages of this procedure.

Methods:

This clinical study included 24 patients who had ruptured anterior cruciate ligaments (ACLs) (18 males and 6 women) at the Orthopedic Surgery in Abu-Salim Trauma Hospital in Libya. Between January 2023 and June 2023, Using hamstring tendon autograft, all patients underwent arthroscopic anatomic single-bundle ACL repairs, with an average follow-up of two years. Informed written consent was given by each patient. The World Medical Association's Code of Ethics for Research Involving Humans includes the Declaration of Helsinki, which was followed in the conduct of this study.

Patients without a history of anterior cruciate ligament (ACL) reconstruction who have sustained an initial ACL injury who were between the ages of 18 and 45 were involved in this investigation. Patients who have radiological evidence of degenerative joint changes, such as narrowing of the joint space, Coupled ligamentous damage, clinical knee malalignment (deformities of the valgus or varus), open growth plates indicating skeletal immaturity, or a history of prior knee surgery were excluded.

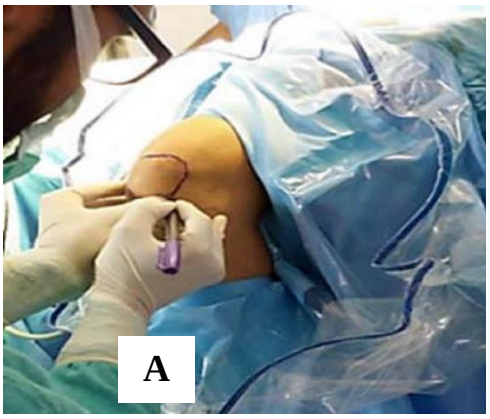
Preoperative Assessment:

A physical examination and a thorough history of the current condition were performed, including the mechanism of damage, the affected side (left or right), and any previous treatment received. Before beginning gait-related tasks and following ACL surgery, a skilled, blinded examiner conducted a clinical evaluation in the outpatient clinic. This evaluation included the lateral pivot shift test, the anterior drawer test, and Lachman's test. Knee function was also assessed using the Lysholm Knee Scoring Scale and the International Knee Documentation Committee (IKDC) score.

Anteroposterior and X-rays taken laterally of the damaged and contralateral knee were taken both before and after reconstruction as part of the radiological examination. Prior to surgery, after surgery, magnetic resonance imaging (MRI) was used to assess the graft position and confirm the ACL tear while ruling out other intra-articular abnormalities. tunnel placement, graft signal intensity, and evidence of graft ligamentization. A full blood picture, International normalized ratio (INR), partial thromboplastin time (PTT), prothrombin time (PT), random blood sugar, and liver and kidney function tests were all part of the routine preoperative laboratory studies to make sure the patients were suitable for anesthesia and surgery.

Surgical Procedure

The patient was lying on his back during all procedures, which were carried out under spinal or general anesthesia. To validate the diagnosis of an injury to the anterior cruciate ligament (ACL) and to check for any related intra-articular diseases, first, a standard diagnostic arthroscopy was carried out. Meniscal injuries that were discovered were properly treated before ACL repair could begin. Before the portal was placed, a sterile surgical pen was used to mark the surgical landmarks on the skin, which included the patella, patellar tendon, tibial tubercle, and joint lines **(Figure 1A).** Debridement of the ACL stump was carefully performed, preserving any non-obstructive residual fibers to facilitate potential vascular and cellular ingrowth and maintain proprioceptive function. Before debridement, the remnants of the torn ACL were visible in an arthroscopic image through the medial portal (Figure 1B). To ensure an ideal trajectory for tunnel creation while preventing damage to the medial femoral condyle, Beside the patellar tendon, a typical anteromedial portal was created. Then, using a spinal needle, a far anteromedial portal was created, approximately 2 cm medial to the patellar tendon. Additionally, a typical anterolateral portal was made. To gather the gracilis and semitendinosus tendons, a small incision was performed across the ipsilateral leg's pes anserinus region, which were then prepared as a hamstring autograft (Figure 1C a, b). By using the anteromedial portal to get arthroscopic visualization of the medial wall of the lateral femoral condyle while the knee was in hyperflexion, the natural ACL femoral footprint was accurately recognized. Following the insertion of a guide pin via the distal anteromedial portal in the middle of the femoral ACL insertion location, a femoral tunnel was created using an endoscopic drill bit (Figure 1D a,b). We next drilled a tibial tunnel by placing a guide pin in the center of the tibial ACL footprint, while carefully protecting any remaining ACL tissue (Figure 1E a,b). The femoral tunnel was then used to pass the prepared hamstring graft. An EndoButton device was used to secure the femoral side, and a bioabsorbable interference screw was used to fix the tibial side after 20–30 cycles of graft cycling to reestablish the proper tension. Arthroscopic anterolateral and medial portal views confirmed the position and tension of the graft after fixation **(Figure 1F I, II).** Arthroscopic inspection and probing of the graft were carried out to confirm its proper positioning and fixation, and to exclude any anterior impingement or (PCL) posterior cruciate ligament impingement. The anteromedial portal was used to introduce an intra-articular drain, which was then transmitted subcutaneously and out through the graft harvest incision. Medial fascia closure over the pes anserinus, subcutaneous tissue, and skin was performed in a standard manner, and a compression bandage was applied **(Figure 1G).**



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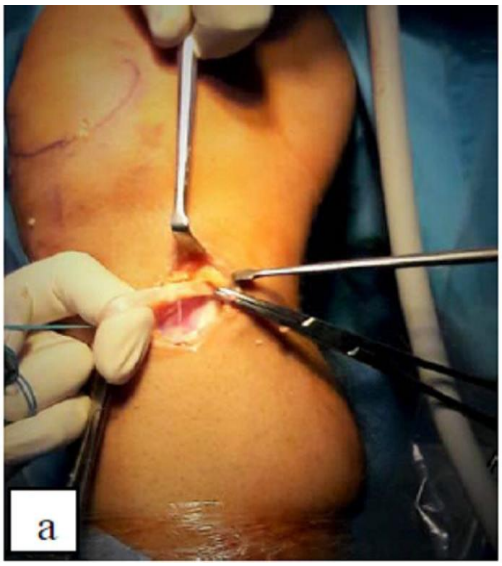

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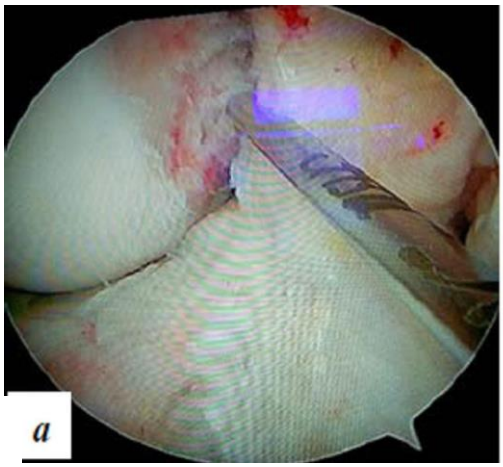
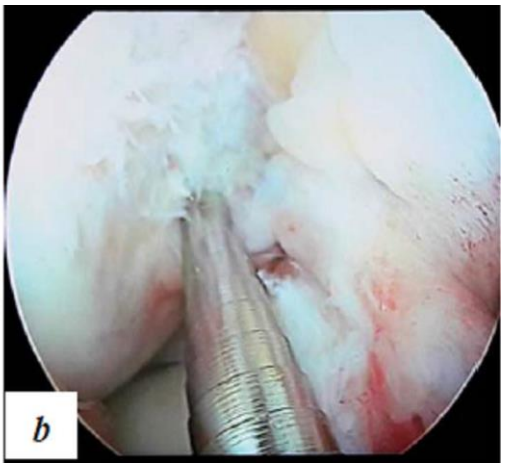
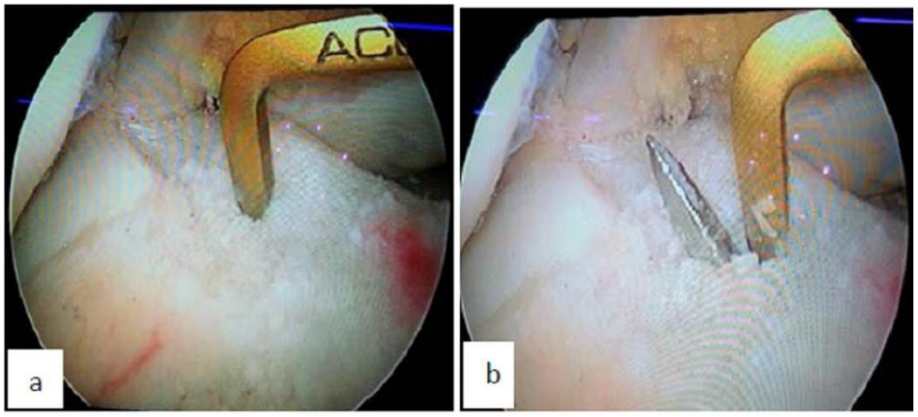




E 

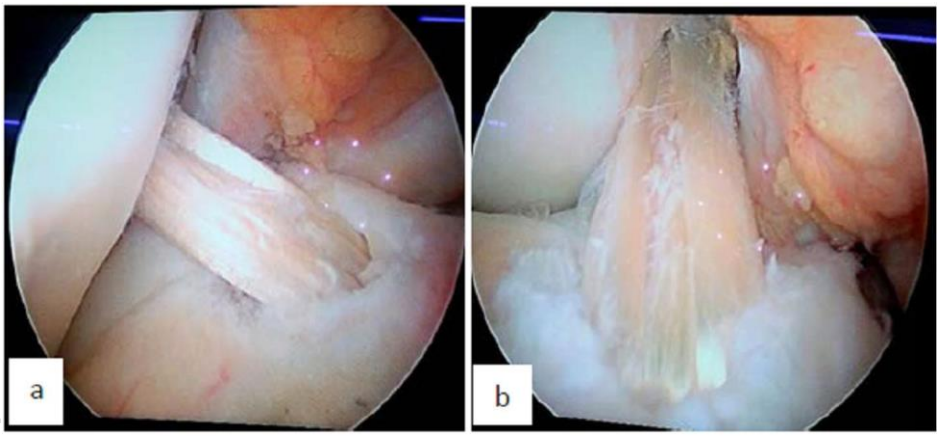
F 

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Figure 1: A) A sterile surgical marking pen is used to mark the patella, patellar tendon, tibial tubercle, and joint lines on the skin while the knee is at a 90-degree flexion. B) Right knee arthroscopic medial portal view showing what's left of the ACL tear. C) a and b. Harvesting Hamstring Graft. D)a.b. Right knee arthroscopic medial portal image, showing the femoral tunnel drilling point at the center of the femoral footprint. E) Arthroscopic view showing the center of the tibial footprint, where the tibial tunnel drilling is located. F) a. Graft's anterolateral portal image following tibial fixation. c. Graft medial portal views following tibial fixation. G) Anterior image of the knee demonstrating graft harvest site and arthroscopic portal closure.

Postoperative Rehabilitation

The accelerated regimen outlined by **Shelbourne and Nitz[7]** was the basis for the postoperative rehabilitation protocol. Range-of-motion exercises were initiated on the first postoperative day, which included joint flexion and extension. Wearing an ACL brace allowed patients without concurrent meniscal repair to remain partially bearing weight during the first two weeks. before progressing to full weight-bearing. Braces were worn for six weeks while maintaining partial weight-bearing continuously in cases involving meniscal repair. After three months following surgery, jogging was authorized, and depending on the clinical healing and functional progress of the patient, full sports participation was allowed six to nine months later.

Follow up:

Every patient was monitored for a duration of two years. Clinical examination was conducted using the Lysholm Knee Scoring Scale and the International Knee Documentation Committee's (IKDC) 2000 subjective knee evaluation form. The radiographic evaluation included standard lateral and anteroposterior (AP) X-ray images of the operated knee, in order to evaluate tunnel alignment and look for any indications of degenerative alterations.

Statistical analysis

The statistical analysis was performed using SPSS version 23 (IBM Corp., Armonk, NY, USA). Qualitative data were shown as numbers and percentages, whereas quantitative data were shown as means ± standard deviation (SD). Two independent groups were compared using the Student's t-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data. The Chi-square (χ^2) test was used to assess correlations between categorical variables. A P-value below 0.05 was considered statistically significant.

Results

Figure 2: Bar chart demonstrating the distribution of individual Lysholm score items among the studied group preoperatively and postoperatively. Significant improvements were observed in all functional components, particularly in instability, pain, and locking sensation. Specifically, The limb score improved from 2.76 ± 1.36 to 4.50 ± 0.88, while the support score went from 4.58 ± 0.82 to 5.00 ± 0.00. From 10.83±3.45, the instability score increased to 22.70±3.29. Moreover, the locking score increased dramatically from 5.91± 2.47 to 14.37± 1.68. Lastly, the capacity to squat improved from 3.00 ± 0.99 to 4.87 ± 0.33. Stair-climbing ability rose from 8.66 ± 1.92 to 9.83 ± 0.81, swelling from 4.58 ± 1.89 to 9.33 ± 1.52, and pain score from 14.37 ± 4.73 to 23.95 ± 2.94.

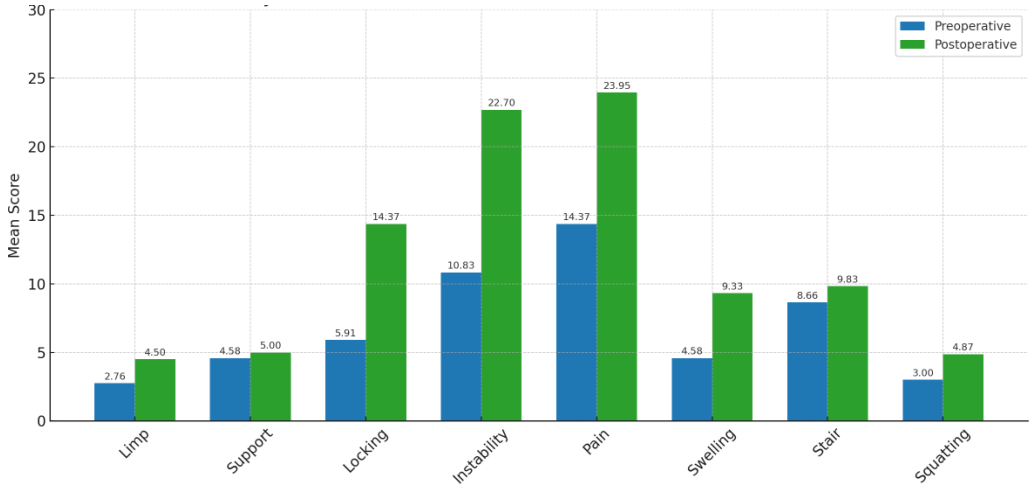

Figure 2: Lysholm score items among the studied group preoperatively and postoperatively

Figure 3: Bar chart illustrating the distribution of total Lysholm knee scores among the group under study both before surgery and at the last postoperative check-up. The scores dramatically improved from 54.33 ± 14.04 to 94.37 ± 8.14 (P < 0.001).

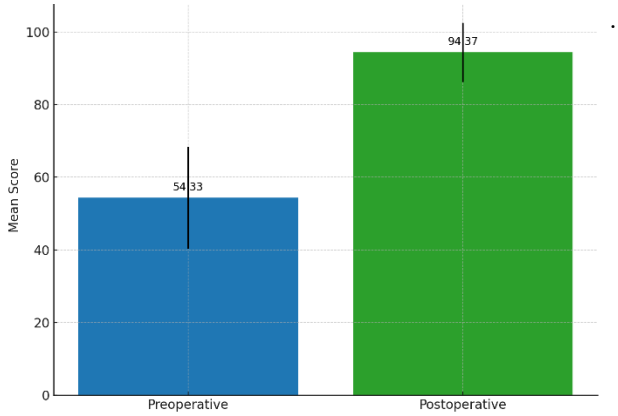

Figure 3: Total Lysholm knee scores among the studied group

Figure 4; showed that the LYSHOLM score grades significantly improved between the pre- and post-intervention periods. Initially, the majority of patients (75.0%) scored in the Poor category. Post-intervention, no patients remained in the Poor category, and the majority (70.8%) achieved an Excellent score.

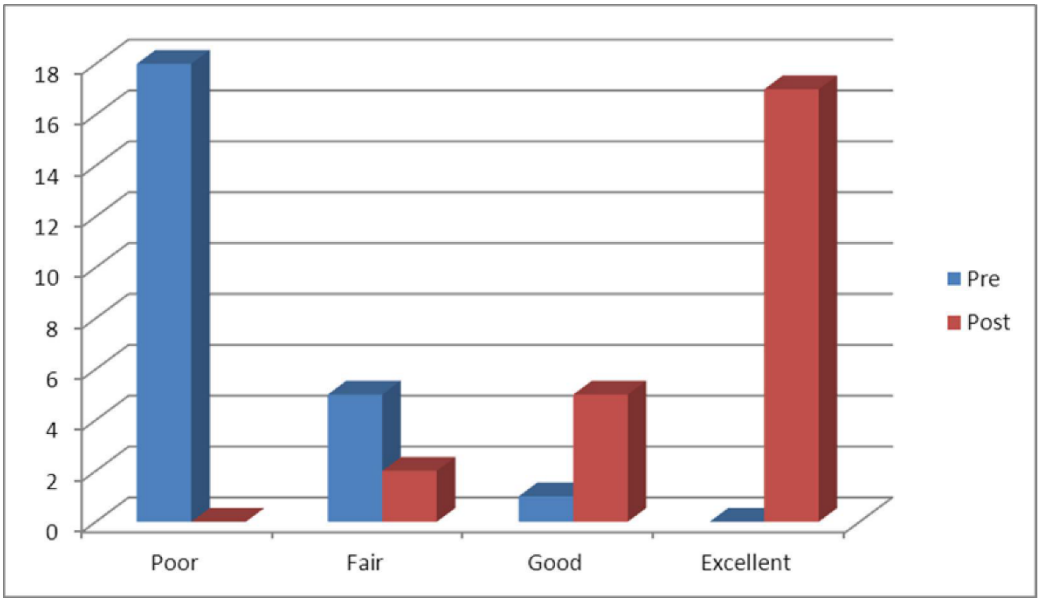

Figure (4): LYSHOLM score Grade distribution among studied group

Figure 5; showed that the IKDC total score revealed a statistically significant improvement from 45.83 ± 7.46 before surgery to 78.12 ± 6.04 after surgery. With a P-value of 0.00 and a paired t-test value of 24.628, The difference was highly significant (P < 0.01).

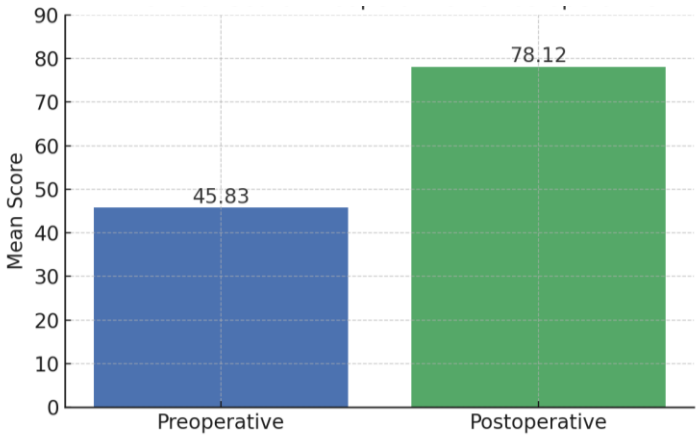

Figure 5: IKDC total score : preoperative vs postoperative

Distribution of postoperative complications among the studied group. Out of 24 patients, 5 cases (20.8%) experienced complications. Specifically, 4 cases developed superficial infections, while 1 case had a deep infection. The remaining 19 cases (79.2%) had an uncomplicated postoperative course as shown in figure 6.

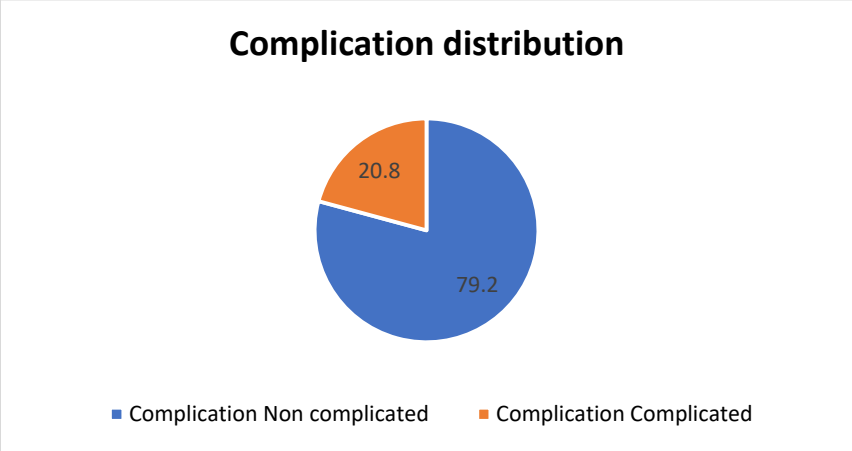

Figure 6: Complication distribution among studied group

Discussion

In the current study, the participants' ages were distributed with a mean of 30.16 ± 5.9 years, ranging from 19 to 40 years. Regarding sex distribution, males constituted the majority at 75.0%. These results are in line with those of **Riad and Ali [8]**, who found that 83.3% of the patients were male and 16.7% were female, with an average patient age of 27.5 years (range: 19 to 42 years). The average age of patients in comparable cases was also 28 years, according to a study by **Smith et al. [9]**, with a similar gender distribution of 80% men and 20% girls. These outcomes are in line with those of earlier studies, including that of **Johnson and Lee [10]**, which indicate that the patient demographic in such cases usually falls within the younger age category with a considerable male predominance.

All score sub-items showed a considerable improvement after surgery, according to the current study. The limb score increased from 2.76±1.36 to 4.50±0.88, whereas the support score improved from 4.58±0.82 to 5.0±0.0. The locking score went up from 5.91±2.47 to 14.37±1.68 to that value. The instability score also

improved significantly, rising from 10.83±3.45 to 22.70±3.29. While the edema score rose from 4.58±1.89 to 9.33±1.52, the pain score improved from 14.37±4.73 to 23.95±2.94. Furthermore, The stair score increased from 8.66±1.92 to 9.83±0.81, and the squatting score increased from 3.0±0.99 to 4.87±0.33.

These findings reflect significant functional and symptomatic improvements across all measured domains following the intervention, consistent with outcomes reported in recent literature. Surgical reconstruction combined with structured rehabilitation has been shown to effectively restore knee stability, reduce pain, and improve function in patients with ligament injuries**[11-13].**

After surgery, **Fahmy et al.** found that the Lysholm score sub-items significantly improved. The limp score improved from a preoperative mean of 3.5 (SD ±0.9) to a postoperative mean of 4.7 (SD ±0.7). The locking feeling in the knee deteriorated from 7.8 (SD ±4.3). preoperatively to 14.8 (SD ±0.9) postoperatively. Swelling scores improved from 3.9 (SD ±2.7) to 9.5 (SD ±1.4), and there was an improvement in the giving way sensation (instability) from 9.0 (SD ±3.7) to 22.3 (SD 2.3). Climbing stairs scores increased from 8.8 (SD ±1.9) to 9.6 (SD ±1.2), and squatting scores improved from 2.9 (SD ±1.1) to 4.8 (SD ±0.4). Overall, the total Lysholm score showed a significant improvement from a preoperative mean of 53 (SD ±13) to a postoperative mean of 93.4 (SD ±16.8) **[14]**.

According to the latest research, the majority of Lysholm scores were poor at pre (75.0%), but outstanding at post (70.8%). This suggests that there was a considerable improvement in the grade of Lysholm scores from before to after.

According to **Senthilkumar and Rajmohan [15],** 80% of the cases showed good to excellent results, and the Grade of Lysholm score improved significantly after surgery. In particular, 8 patients (53.4%) reported outstanding outcomes, 4 patients (26.6%) reported good results, 2 patients (13.3%) reported mediocre results, and 1 patient (6.7%) reported bad results. A more recent study by **Williams et al. [16]** also demonstrated significant improvements in the Lysholm score after surgery, with 75% of patients achieving good to excellent outcomes, further supporting the effectiveness of surgical intervention in this patient population."

In a prospective study by **Kim et al. [17],** patients with complete ACL tears were treated with anatomic single-bundle ACL reconstruction. The postoperative Lysholm score showed promising results, 12 patients (36.4%) had good outcomes, one patient (3%) had acceptable results, 1 patient (3%) had poor results, and 19 patients (57.6%) had exceptional scores. The postoperative mean Lysholm score was 88.3, demonstrating the effectiveness of the single-bundle technique in improving knee function and stability. Similarly, a more recent study by **Patel et al. [16]** reported comparable outcomes, with the majority of patients showing good to excellent improvements in their Lysholm scores following ACL reconstruction."

Five patients (20.8%) were found to be complicated in the current investigation; four of these cases had surface infections, while one had deep infections.

Sherchan et al., [18], reported that complications was reported in 19 patients (19.4%) and 79 patients was non complicated.

According to **Fahmy et al. [14],** 5 patients (16.5%) experienced problems after surgery. One patient (3.3%) had a lateral femoral cortex blowout during surgery, and another case (3.3%) had a superficial wound infection at the graft site after surgery. Additionally, one patient (3.3%) developed tourniquet-induced neuropraxia. Notably, two people (6.6%) experienced surgical neuropraxia of the saphenous nerve. Although these results draw attention to the possible dangers of ACL repair, the overall rate of complications was still quite low. Similar issues were noted in a more recent study by **Garcia et al. [19],** with a somewhat reduced incidence of saphenous nerve damage, underscoring the significance of cautious surgical approach and postoperative surveillance.

To confirm and build on the present findings, future research should concentrate on bigger patient groups with longer follow-up times. Additionally, comparative studies evaluating different surgical techniques and rehabilitation protocols would provide valuable insights into optimizing clinical outcomes in ACL reconstruction.

Limitations:

Our study's main limitations include the brief follow-up timeframe and the tiny sample size. A sample size this small lowers statistical power and restricts how broadly the results may be applied. Stronger conclusions and a better comprehension of the clinical effectiveness and long-term results associated with the anterolateral ligament in ACL restoration would be possible with more robust data from a longer follow-up time and a larger sample size.

Conclusion:

Anatomically reconstructing the anterior cruciate ligament with the hamstring tendon is more effective at simulating the anatomy of the ACL and producing favorable clinical results.

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