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Physiological Joint Stability and Clinical Outcomes of Braided Suture Techniques in Posterior Cruciate Ligament Reconstruction

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ABSTRACT

PCL plays a critical role in maintaining the stability of the posterior knee joint, highlighting the importance of accurate diagnosis and effective treatment for such injuries. **Objectives:** To determine the stability of the knee joint in patients with posterior cruciate ligament rupture after the autologous hamstring and braided suture reconstruction. **Methods:** A Quasi-experimental study was conducted from June 2024 to June 2025 at Shahida Islam Medical Complex. This study included 120 patients with posterior cruciate ligament rupture and was divided into control (group A) and study group (Group B) (n=60 each). Group A underwent single-bundle autologous hamstring reconstruction, while group B underwent the same procedure with an added braided thread treatment. Evaluations were performed both before and after surgery, including assessments of complications, joint mobility, gait analysis, knee joint stability (tested with the KT2000), and knee function as measured by Rasmussen scoring. **Results:** Group B showed significantly better treatment rates compared to Group A ($p<0.05$). One year after the surgical operations, Group B exhibited notable improvements in stride speed, joint function, stride length, and Rasmussen scores ($p<0.05$). The cases also showed significantly reduced gait asymmetry and favorable outcomes from the KT2000 test $p<0.05$). **Conclusions:** The combination of autologous reconstruction of the hamstring tendon single bundle by using braided thread enhances clinical outcomes for individuals with PCL tears. This treatment significantly improves joint stability and knee function over the long term, demonstrating its effectiveness as a promising therapeutic option.

INTRODUCTION

Cruciate ligament ruptures are among the most prevalent knee joint injuries in sports. Posterior cruciate ligament (PCL) injuries, though less frequent than anterior cruciate ligament injuries, still present significant clinical challenges [1]. Physiologically, the PCL is a key restraint to posterior tibial translation and contributes to rotational control and joint congruence, particularly in deep flexion [2]. The PCL plays a critical role in maintaining the stability of the posterior knee joint, highlighting the importance of accurate diagnosis and effective treatment for such injuries [3]. Surgical intervention is a well-established method for addressing cruciate ligament ruptures, but the outcomes of different surgical approaches can vary significantly, particularly concerning their impact on joint stability [4]. In recent years, reconstruction of single-bundle autologous hamstring tendons for PCL injuries has gained attention, proving to be effective in initial treatment phases [5, 6]. While early outcomes indicate good stability,

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studies have suggested that long-term stability of the graft diminishes over time, thus necessitating further advancements in treatment methods to maintain graft stability over extended periods [5]. Braided sutures, a non-absorbable material, have seen increased use in surgeries due to their superior tissue compatibility and strength [6-8]. Despite their growing application, there is limited research on the use of braided sutures in the context of posterior cruciate ligament reconstruction, particularly regarding their influence on joint stability. The results will offer valuable information on the effectiveness of this combined method, assisting in the development of optimal treatment plans for patients undergoing PCL reconstruction surgical operations.

This study aimed to explore the combined effect of single-bundle hamstring and braided suture reconstruction on knee joint stability in individuals with PCL tears.

METHODS

The quasi-experimental study was conducted at Shahida Islam Medical Complex from June 2024 to June 2025, after taking ethical approval with IRB no: SIMC/ET.C./0055/24. The sample size was calculated with Open Epi version 3.01 (open-source epidemiologic calculator) by estimating a 1.0-mm difference in posterior tibial translation between groups as measured by the KT2000 arthrometer at a 30-lb load [6]. Using an expected standard deviation of 1.5 mm from previous studies, a two-sided of 0.05, and 80% power, a minimum of 36 patients per group was required. Allowing for an anticipated 20–25% loss to follow-up, we aimed to recruit 60 patients per group. The patients were 20-65 years old, diagnosed with PCL rupture and undergoing PCL reconstruction. The rupture was diagnosed clinically by the drawer test and further confirmed by MRI. Individuals with other ligament injuries, a history of knee joint disease or trauma, previous knee surgery, bilateral injuries, or chronic illnesses were excluded from the study. After obtaining written informed consent, the study population was divided into two groups, control (Group A) and cases (Group B), based on the patient's choice of ongoing departmental PCL reconstruction surgeries. Before making the choice, patients were thoroughly informed about the surgery procedure and its outcome in their language and were assured they understood it well. Group A underwent reconstruction of the single-bundle hamstring reconstruction (autologous). Patients were given epidural anesthesia and the double Endo-Button technique following standard preoperative assessments. The knee was accessed using an anterolateral arthroscopic portal to allow optimal visualization and precise instrumentation. The portal was positioned approximately 1-2 cm distal and 1-2 cm anterior to the lateral femoral epicondyle for clear access to the knee joint. The arthroscope was inserted through this portal for comprehensive examination of the adjacent tissues and structures. In cases of meniscal injuries, repairs were performed before the PCL reconstruction. The autogenous hamstring tendon of the patient was then harvested, braided, and sutured at both ends to form a four-strand graft with a 9mm diameter. The tibial tunnel was carefully created using a reverse drill to ensure precise tunnel placement. For tibial fixation, an interference screw (or the specific device used in your procedure) was inserted to secure the graft at the tibial insertion point. This was done after passing the autogenous hamstring tendon through the tibial and femoral tunnels, ensuring a stable and secure fixation. The graft was tightened with the knee in an extended position to restore the stability of the joint. In Group B, the braided suture technique was employed to enhance the strength and stability of the graft. The braided suture (Ethicon thread) was woven into the hamstring tendon by creating a flat knot. The tendon was braided to the desired length and wrapped around the braided wire to form a robust four-strand graft with a total diameter of 9mm. The suture was securely tied to ensure optimal graft tension and stability. This incorporation of the braided suture allowed for enhanced fixation and durability of the graft within the tibial and femoral tunnels. All other steps in the procedure were identical to those performed in Group A (Figure 1).

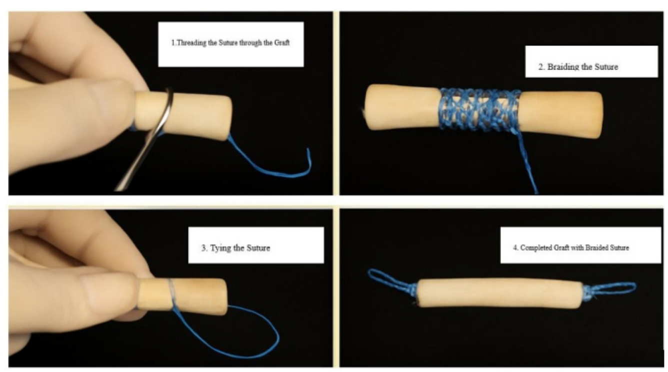

Figure 1: Step-wise Approach for Group B Surgery

The primary outcomes assessed included the overall treatment success rate (excellent and good outcomes), complication rate, gait, knee joint activity, and stability (by the KT2000 test). The treatment outcomes for both populations of patients were evaluated using the scoring system of the knee joint function developed by the Special Surgery Hospital (SSH) in New York, USA. This scoring system comprises 6 positive points and 1 negative point, with a maximum possible score of 100. The classification system is as follows: scores of more than 85 points are considered Very Good, from 70 to 84 points are considered good, from 60 to 69 points are considered medium, and scores below 59 points are considered bad outcomes [6, 9].

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Complication rates, including infections, vascular injuries, nerve injuries, and flexion limitations, were calculated for all populations during hospital stay. The Joint activity for both populations was measured both before and 12 months after surgery. Key indicators, such as the maximum flexion in the knee joint and the range of motion, were assessed using plain radiographic measurements. A 3D gait analysis system was also employed to evaluate gait parameters, including speed of walking, the stride length, and gait asymmetry index, before the surgery and 1 year after the surgery. The Rasmussen score was used to evaluate Knee joint function, which assesses five aspects: pain, mobility, extension of the knee, range of motion of the joint, and joint stability. Each aspect is scored up to 6 points, with higher scores indicating better knee function [7]. The posterior translation of the tibia at 15, 20, and 30 pounds, preoperatively and one year postoperatively, was determined by the KT2000 arthrometer. Displacements in forward and rear were measured, and the average of three readings was recorded. All evaluations and tests were performed by two experienced professionals. The data were analyzed using the 26.0 version of SPSS. In descriptive statistics, continuous variables were shown as the Mean ± SD, and categorical variables were expressed as a percentage (%). To compare the populations, an independent sample t-test was used for continuous variables, while the Chi-square test was applied to examine the association between categorical variables. Baseline characteristics of participants who completed follow-up and those lost to follow-up were qualitatively compared to assess potential attrition bias. A p-value of <0.05 was considered statistically significant.

RESULTS

The study population was statistically age, gender, and BMI matched. Qualitative inspection of baseline demographic and clinical variables showed no noticeable differences between participants who completed follow-up and those lost to follow-up. Because no postoperative data were available for patients lost to follow-up, additional statistical analysis was not possible. Further, the difference between disease duration, lesion location, and the cause of injury was also non-significant in both groups ($p>0.05$)(Table 1).

Table 1: Baseline Characteristics of the Study Population

Parameters	Group A (n=60)	Group B (n=60)	T-score	p-value
Gender, n (%)				
Male	40 (66.67%)	40 (66.67%)	0.17	0.674
Female	20 (33.33%)	20 (33.33%)		
Age				
Years	36.39 ± 10.02	36.63 ± 11.26	0.113	0.904
BMI				
Kg/m^2	24.09 ± 3.11	25.42 ± 2.56	0.071	0.968
Course of Disease				
Months	5.36 ± 1.69	5.34 ± 1.81	0.163	0.864
Injury Side				
Right	21 (35%)	22 (36.67%)	0.038	0.837
Left	39 (65%)	38 (63.33%)		
Cause of Injury				
Accidental	38 (63.33%)	41 (68.33%)	0.161	0.682
Natural	22 (36.67%)	19 (31.67%)		

An independent sample t-test was applied, and p-values of <0.05 were taken as statistically significant.

At final follow-up, the proportion of patients rated as very good or good was high in both groups (Group A: 86.7%, Group B: 90.0%). The difference between groups was not statistically significant ($\chi^2=0.36$, $p=0.55$)(Table 2).

Table 2: Comparison of the Rates of Treatment and Complication Rate Post-Reconstruction in the Study Population

Parameters	Group A (n=60)	Group B (n=60)	χ^2/p
Very Good	33 (55%)	36 (60%)	–
Good	19 (31.67%)	18 (30%)	–
Mediocre	7 (11.67%)	5 (8.33%)	–
Bad	1 (1.67%)	1 (1.67%)	–
Very Good and Good Rate	52 (86.67%)	54 (90%)	0.36/0.55
Infectious	1 (1.67%)	0 (0%)	1.02/0.316
Vascular Damages	1 (1.67%)	1 (1.67%)	1.03/0.32
Flexion Is Limited	2 (3.33%)	1 (1.67%)	2.04/0.154

Before surgery, there was no statistically significant difference in the joint activity indexes between the two populations ($p>0.05$). However, 12 months after surgery, the joint activity indexes in the study population were significantly higher compared to the control population, with this difference being statistically significant ($p<0.05$). Before surgery, statistically, there were no significant differences observed in the gait parameters among the populations. However, one year after the surgery, the study population confirmed significantly greater speed of walking and stride length, while the gait asymmetry index was significantly reduced in the study population. Before the surgery, statistically, no significant difference was observed in the Rasmussen scores between populations. However, one year after the surgery, the Rasmussen score was significantly higher in the study population as compared to the control population. Before surgery, statistically, there were no significant differences found in the results of the KT2000 test among the groups; however, one year after the surgery, the study population showed significantly lower results of the KT2000 test than those in the control population (Table 3).

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Table 3: Comparison of Joint Activity Indicators (In Degrees), Gait Parameters, Rasmussen Scores, Forward and Posterior Displacement Before and After Surgery in the Study Population

Parameters	Before and After Surgery	Group A 60, 49	Group B 60, 54	χ^2	p-value
Motion Range for Knee	Before Reconstruction	86.79 ± 2.86	85.85 ± 3.05	0.104	0.918
	1 Year After Reconstruction	106.82 ± 3.19	106.79 ± 3.36	4.676	<0.001
Flexion of the Knee Maximum	Before Reconstruction	90.33 ± 2.73	89.76 ± 2.76	0.146	0.841
	1 Year After Reconstruction	106.29 ± 3.16	109.65 ± 3.22	5.075	<0.001
Stride Length (m)	Before Reconstruction	0.64 ± 0.11	0.64 ± 0.10	1.083	0.282
	1 Year After Reconstruction	1.17 ± 0.12	1.23 ± 0.14	2.555	0.012
Speed of Walking (m/s)	Before Reconstruction	1.11 ± 0.13	0.98 ± 0.11	0.922	0.354
	1 Year After Reconstruction	1.25 ± 0.12	1.34 ± 0.14	2.577	0.012
Gait Asymmetry Index	Before Reconstruction	0.33 ± 0.07	0.32 ± 0.08	0.788	0.432
	1 Year After Reconstruction	0.08 ± 0.04	0.07 ± 0.03	6.056	Below 0.001
Pain	Before Reconstruction	3.11 ± 0.62	3.26 ± 0.29	0.333	0.722
	1 Year After Reconstruction	5.51 ± 0.25	5.26 ± 0.39	2.98	0.002
Mobility	Before Reconstruction	2.72 ± 0.43	2.62 ± 0.41	0.385	0.682
	1 Year After Reconstruction	5.22 ± 0.45	5.29 ± 0.26	2.599	0
Extension of the Knee	Before Reconstruction	2.92 ± 0.46	2.92 ± 0.23	1.033	0.289
	1 Year After Reconstruction	5.32 ± 0.22	5.42 ± 0.25	2.753	0.005
Range of Motion for the Joint	Before Reconstruction	2.72 ± 0.25	2.72 ± 0.26	0.279	0.762
	1 Year After Reconstruction	4.25 ± 0.21	4.62 ± 0.40	3.142	0.003
Joint Stability	Before Reconstruction	2.23 ± 0.25	1.93 ± 0.26	1.439	0.14
	1 Year After Reconstruction	5.12 ± 0.39	5.32 ± 0.25	3.353	0.0011
15 Pounds*	Before Reconstruction	3.36 ± 0.62	3.52 ± 0.52	1.276	0.191
	1 Year After Reconstruction	2.58 ± 0.54	2.32 ± 0.52	2.288	0.013
20 Pounds*	Before Reconstruction	6.62 ± 1.92	6.52 ± 2.02	0.146	0.865
	1 Year After Reconstruction	3.52 ± 0.72	3.32 ± 0.62	2.149	0.023
30 Pounds*	Before Reconstruction	9.12 ± 2.22	9.22 ± 2.32	0.26	0.777
	1 Year After Reconstruction	4.52 ± 1.12	4.22 ± 1.02	1.142	0.241
15 Pounds**	Before Reconstruction	0.72 ± 0.12	0.76 ± 0.12	0.969	0.319
	1 Year After Reconstruction	0.71 ± 0.05	0.65 ± 0.06	3.718	<0.001
20 Pounds**	Before Reconstruction	1.95 ± 0.26	2.02 ± 0.25	0.999	0.305
	1 Year After Reconstruction	1.36 ± 0.16	1.21 ± 0.14	5.491	<0.001
30 Pounds**	Before Reconstruction	3.38 ± 0.38	3.37 ± 0.37	0.127	0.881
	1 Year After Reconstruction	1.42 ± 0.7	1.31 ± 0.27	2.085	0.028

Note: Forward and posterior displacement represent anterior and posterior tibial translation, respectively, measured using the KT2000 arthrometer under 15-, 20-, and 30-pound loads. *Forward displacement (15 lb / 20 lb / 30 lb), mm. **Posterior displacement (15 lb / 20 lb / 30 lb), mm

DISCUSSION

The present study included age, gender, and BMI-matched controls and cases, as previous literature has shown different study outcomes due to these variables (Table 1). Although loss to follow-up occurred, baseline variables appeared similar between groups, suggesting that attrition was unlikely to substantially bias the outcome estimate. A study reported that obesity was linked to poorer functional outcomes after knee surgery, suggesting a potential correlation that was not observed in the current study population [10, 11]. Gender differences have been observed in several studies as influencing joint recovery, particularly in ACL injuries, where females tend to experience worse outcomes in terms of functional recovery [10-12]. A recent study found that patients who underwent certain types of advanced rehabilitation post-surgery exhibited significantly better outcomes in terms of mobility and function [7]. Some studies report that the overall efficacy of treatment can be highly dependent on pre-existing health conditions, especially chronic conditions like arthritis or diabetes, which might not have been considered as potential confounders in this study [13]. The study group at post-operative follow-up of 12 months showed significantly better outcomes in terms of knee flexion and motion range. A study on ACL reconstruction patients found significant improvements in knee flexion and range of motion in the first year after surgery [14].

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Similarly, another found that post-surgical rehabilitation significantly influences the range of motion [12]. These results are aligned with the study's findings, highlighting the effectiveness of proper surgical techniques and rehabilitation. However, a recent study noted that joint stiffness remains a prevalent issue even after surgical procedures, particularly in patients with longer disease duration, which could have confounded results if not properly controlled [15]. Previous studies have also shown that Joint stability is closely linked to gait parameters, making the need for durable knee joint stability particularly critical in patients with PCL rupture, which has been validated by the current study findings [10]. One-year post-surgery, the present study population showed significantly greater stride length and walking speed, with reduced gait asymmetry. A study demonstrated that improved gait parameters (speed and stride length) in post-surgical knee patients were predictive of better functional outcomes in the long term [4]. Another study also identified improved gait speed and symmetry as important indicators of successful recovery in musculoskeletal injuries [8]. In the current study, significant improvements in the Rasmussen score were found in the study group after one year, particularly for pain, mobility, and joint stability. In contrast, a study indicated that while improvements in the Rasmussen score are often observed, the degree of improvement can vary widely based on the initial severity of joint damage and patient adherence to post-operative rehabilitation [16]. This could imply that patient-related factors may play a larger role in recovery than the intervention itself. Inter-group differences in gait parameters and KT2000 measures were statistically significant, but the absolute magnitudes were small. Reported MCIDs for gait speed in knee surgery populations are typically on the order of 0.10–0.20 m/s [17]; the current study showed an inter-group difference of ~0.09 m/s. The KT2000 differences were <1 mm, below the 3–5 mm thresholds often cited as clinically relevant for side-to-side laxity [18]. These findings suggest that the braided-suture technique yields subtly superior mechanical stability and gait performance, but the clinical effect size is modest and should be interpreted accordingly. Baseline joint activity indices were comparable; the superior recovery observed in Group B may be explained by the biomechanical and physiological advantages of braided-suture augmentation [19]. The non-absorbable braided suture functions as an internal brace, sharing tensile load with the graft and limiting early graft elongation, particularly at the tibial killer-turn, where peak stress is highest [20]. More consistent posterior tibial control helps maintain normal joint kinematics and reduces abnormal shear forces on healing tissues. This stable mechanical environment likely supports more effective neuromuscular activation, proprioceptive recovery, and symmetrical gait during rehabilitation, contributing to higher joint activity scores in Group B. These mechanisms remain theoretical, as graft strain and rehabilitation parameters were not directly measured. Given these findings, in case of PCL rupture, it is plausible to strengthen the graft in the autologous hamstring tendon by incorporating braided threads, which could help control graft laxity and provide long-term stability. However, related studies on this approach remain limited.

CONCLUSIONS

Posterior cruciate ligament reconstruction with single-bundle hamstring(autologous) and braided sutures combined demonstrated better clinical outcomes. The use of braided sutures improved mechanical stability and knee joint function, which is critical for the overall rehabilitation of PCL rupture. This combined treatment method may present an effective alternative for better recovery in PCL reconstruction.

Authors Contribution

Conceptualization: MS, SF, SI, RR
Methodology: MS, SF, SI, RR
Formal analysis: MS, SF, SI, RR
Writing review and editing: MS, SF, SI, RR

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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