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COMPARATIVE FUNCTIONAL OUTCOMES AFTER ANTERIORCRUCIATE LIGAMENT RECONSTRUCTION USING AQUADRUPLED HAMSTRING TENDON AUTOGRAFT WITHFIXED-LOOP VERSUS ADJUSTABLE-LOOP FEMORALCORTICAL SUSPENSION

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ABSTRACT

Background: Femoral fixation of soft-tissue grafts using cortical suspension has become an established component of arthroscopic anterior cruciate ligament (ACL) reconstruction. Fixed-loop constructs have a preset loop dimension, whereas adjustable-loop constructs permit alteration of loop length during the procedure. Although laboratory investigations have identified mechanical differences between these systems, it remains uncertain whether such differences result in clinically detectable differences in postoperative recovery [7,9-13].

Methods: A hospital-based observational study was undertaken involving 30 patients, aged 20–60 years, with ACL injury
confirmed by clinical assessment and imaging. All participants underwent arthroscopic reconstruction using a quadrupled hamstring tendon autograft [1,5]. Femoral fixation was performed with a fixed-loop device in 15 patients and an adjustable-loop device in the remaining 15. Patient-reported knee function was assessed using the International Knee Documentation Committee (IKDC) subjective score and Lysholm score [2-4]. Evaluations were obtained before reconstruction and subsequently at 3 months, 6 months, and 12 months. Anterior knee stability was evaluated clinically using Lachman grading, and complications occurring during follow-up were recorded.

Results: Both fixation groups showed progressive gains in functional scores following surgery. In patients treated with the fixed-loop device, the mean IKDC score increased from 48.0 ± 5.8 at baseline to 63.0 ± 6.2 at 3 months, 71.5 ± 6.8 at 6 months, and 75.8 ± 6.9 at 12 months. The corresponding measurements in the adjustable-loop group were 47.6 ± 5.5, 63.2 ± 6.5, 72.0 ± 6.9, and 77.1 ± 7.2. Lysholm scores in the fixed-loop group increased from 48.7 ± 6.1 before surgery to 65.2 ± 6.8, 73.9 ± 7.1, and 79.8 ± 7.5 at the three subsequent assessments. In the adjustable-loop group, the values were
50.1 ± 6.5, 66.5 ± 7.2, 74.5 ± 7.4, and 80.9 ± 7.8, respectively. None of the between-group comparisons demonstrated statistical significance at the reported assessment points ($P > 0.05$). Lachman grading improved from grade II before surgery to grade I after reconstruction in all 30 participants. No postoperative complication was documented during the observation period.

Conclusion: Within this 30-patient cohort, either form of femoral cortical suspension was associated with improved subjective knee function and restoration of clinical anterior stability following ACL reconstruction with a quadrupled hamstring autograft. Neither fixation strategy demonstrated a measurable functional advantage over the other. Interpretation is limited by the small cohort and duration of follow-up; adequately powered prospective studies incorporating quantitative laxity assessment and longer observation are required.

KEYWORDS: Anterior cruciate ligament; ACL reconstruction; hamstring tendon autograft; femoral cortical fixation;fixed-loop; adjustable-loop; cortical suspension; IKDC; Lysholm score.

INTRODUCTION

Injury to the anterior cruciate ligament is an important cause of persistent knee instability, particularly in individuals who participate in physically demanding activities. Failure of the ACL may result in repeated episodes of instability, restriction of functional activity, associated meniscal damage, and subsequent degenerative changes within the knee. For patientswith symptomatic instability, arthroscopic reconstruction is an established surgical treatment intended to restore stabilityand improve functional performance [1,5].Among the available graft choices, quadrupled hamstring tendon autografts are frequently used for ACL reconstruction.Their use is supported by satisfactory mechanical characteristics and the potential to reduce certain donor-site problems associated with bone–patellar tendon–bone graft harvesting [1,5].

The outcome of reconstruction is influenced by several factors, including accurate placement of the bone tunnels, appropriate preparation of the graft, and maintenance ofadequate fixation during the interval required for biological incorporation [6,7].

Femoral cortical suspension achieves indirect graft fixation by positioning a cortical button against the lateral femoral cortex, with the soft-tissue graft suspended within the femoral socket. In a fixed-loop construct, the loop dimension is established before implantation and therefore depends on accurate determination of the femoral socket dimensions. Adjustable-loop systems, in contrast, allow the loop to be altered after deployment of the cortical button, potentially facilitating graft advancement, seating, and subsequent tension adjustment [7,9,10]. The possibility of loop lengthening or displacement when subjected to repeated loading has nevertheless generated considerable biomechanical interest [9-11,13].

Experimental studies have identified differences in the mechanical response of fixed- and adjustable-loop constructs, particularly with respect to displacement during cyclic loading and fixation behavior [9-11,13]. Whether these laboratory differences have a meaningful effect on patient recovery is less certain, as clinical investigations have generally reported similar functional and stability outcomes between the two approaches [12].

The present study was therefore designed to evaluate whether the type of femoral cortical suspension device influences postoperative functional recovery and clinical knee stability following ACL reconstruction with a quadrupled hamstring tendon autograft. Outcomes were compared between patients treated with fixed-loop and adjustable-loop femoral fixation.

MATERIALS AND METHODS

Study Design and Participants

This observational study was performed in the Department of Orthopaedics at Sree Balaji Medical College & Hospital, Chennai, India. Patient recruitment and follow-up extended over 18 months, from July 2024 through December 2025. Thirty eligible patients were included in the study, with 15 patients undergoing reconstruction using each of the two femoral fixation configurations.

Eligibility Criteria

Patients aged 20–60 years with an ACL tear established by clinical examination and radiological investigations were considered for inclusion. Individuals with complete ACL disruption accompanied by meniscal pathology were also eligible.

Patients were excluded when they had ferromagnetic implants, pacemakers or aneurysm clips, neoplastic disease involving the knee, inflammatory knee disorders, or infection of the knee joint.

Clinical and Radiological Assessment

A comprehensive clinical history was obtained for every participant, followed by examination of the involved knee. Knee motion was documented and ligamentous stability was evaluated using Lachman, anterior drawer, posterior drawer, varus stress, and valgus stress testing. McMurray testing was performed to assess associated meniscal pathology.

Plain radiographs, including anteroposterior and lateral views, were obtained before surgery. MRI of the knee was subsequently used to confirm ACL disruption and evaluate associated intra-articular abnormalities, particularly meniscal lesions.

Surgical Technique

All participants underwent arthroscopic ACL reconstruction with a quadrupled hamstring tendon autograft [1,5]. The femoral side was secured using either a fixed-loop or adjustable-loop cortical suspension implant. After preparation of the graft and formation of the femoral and tibial tunnels, the graft was advanced into the femoral socket under arthroscopic visualization. The cortical button was then positioned against the lateral femoral cortex to establish suspensory fixation [7,9].

In the adjustable-loop group, the loop was tensioned following deployment of the button to obtain satisfactory seating of the graft within the femoral socket. The reconstructed graft was subsequently preconditioned through repeated knee flexion and extension before completion of tibial fixation. A bioabsorbable interference screw was used for tibial fixation.

Outcome Measures

Postoperative functional status was quantified using two established knee-specific outcome instruments: the IKDC subjective knee evaluation form and the Lysholm knee score. The IKDC instrument provides a patient-reported assessment of symptoms, knee function, and activity limitations [2], while the Lysholm system provides an additional measure of symptoms and functional performance [3,4].

Measurements were obtained before surgery and repeated at 3 months, 6 months, and 12 months after reconstruction. Clinical anterior stability was graded using the Lachman test. All complications identified during follow-up were recorded.

Ethical Considerations

The study was performed under institutional ethical oversight, and written informed consent was obtained from each participant before enrolment. Ethical approval was obtained in accordance with the dissertation documentation.

Institutional Ethics Committee approval number: 002/SBMCH/IHEC/2024/2257.

RESULTS

Demographic and injury characteristics

The largest age category was 31–40 years (13/30, 43.3%), followed by 20–30 years (9/30, 30.0%) and 41–50 years (8/30, 26.7%). There were 19 men and 11 women. The fixed-loop group included 10 men and 5 women; the adjustable-loop group included 9 men and 6 women.

The left knee was affected in 17 patients and the right knee in 13. Road traffic accidents were the most common mechanism of injury (15 patients), followed by falls (8 patients) and sports-related injuries (7 patients). Seventeen patients had associated meniscal pathology: 11 medial meniscal tears and 6 lateral meniscal tears.

Table 1. IKDC subjective score, mean ± SD.

Follow-up	Fixed-loop	Adjustable-loop	Between-group P
Preoperative	48.0 ± 5.8	47.6 ± 5.5	>0.05
3 months	63.0 ± 6.2	63.2 ± 6.5	>0.05
6 months	71.5 ± 6.8	72.0 ± 6.9	>0.05
1 year	75.8 ± 6.9	77.1 ± 7.2	>0.05

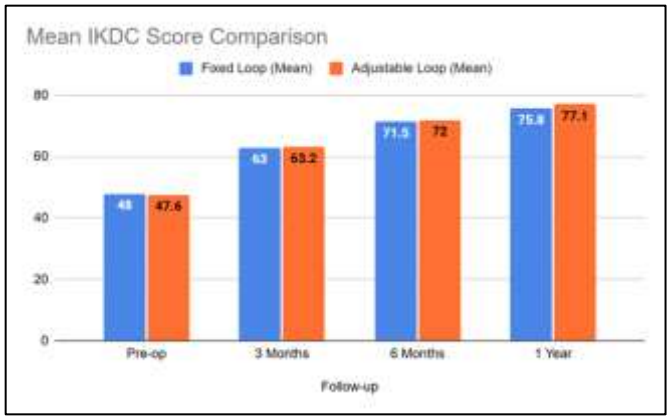


Chart 1: Mean IKDC Score Comparison

IKDC scores increased progressively in both groups. The fixed-loop group improved from 48.0 ± 5.8 preoperatively to 75.8 ± 6.9 at 1 year, while the adjustable-loop group improved from 47.6 ± 5.5 to 77.1 ± 7.2. No statistically significant between-group difference was reported at any time point.

Table 2. Lysholm knee score, mean ± SD.

Follow-up	Fixed-loop	Adjustable-loop	Between-group P
Preoperative	48.7 ± 6.1	50.1 ± 6.5	>0.05
3 months	65.2 ± 6.8	66.5 ± 7.2	>0.05
6 months	73.9 ± 7.1	74.5 ± 7.4	>0.05
1 year	79.8 ± 7.5	80.9 ± 7.8	>0.05

Chart 2: Mean Lysholm Score Comparison

Lysholm scores showed a similar progressive improvement. The fixed-loop group increased from 48.7 ± 6.1 preoperatively to 79.8 ± 7.5 at 1 year, while the adjustable-loop group increased from 50.1 ± 6.5 to 80.9 ± 7.8. No statistically significant between-group difference was reported at any follow-up point.

Table 3. Lachman test grading in the overall cohort.

Lachman grade	Preoperative	Postoperative
Grade I	0	30
Grade II	30	0

All 30 patients were graded as Lachman grade II preoperatively and grade I postoperatively, indicating improvement in clinically assessed anterior knee stability. The available dataset did not provide separate group-wise Lachman distributions or objective arthrometric measurements.
No postoperative infection, clinically apparent graft failure, postoperative stiffness, or other complication was documented in either group during the study follow-up.

DISCUSSION

In this study, both groups demonstrated continued improvement in knee function after reconstruction with a quadrupled hamstring tendon autograft. At the 12-month assessment, the mean IKDC and Lysholm scores were slightly greater among patients treated with adjustable-loop fixation than among those treated with fixed-loop fixation; however, this numerical difference was not statistically significant. Thus, within the limits of the present cohort, neither femoral fixation configuration demonstrated a clear advantage in terms of functional recovery [9-12].
The preoperative functional scores were comparable between the two groups, suggesting that the degree of functional limitation before surgery was broadly similar. Subsequent assessments demonstrated progressive improvement in both groups. Such postoperative improvement is consistent with the functional recovery expected after ACL reconstruction using hamstring tendon autografts [1,5]. The comparable scores observed between the fixation groups are also consistent with previously published clinical evidence evaluating femoral cortical suspension techniques [12].
The principal technical distinction between the two implants relates to loop configuration. In the fixed-loop system, the loop length is established before graft passage, making accurate measurement of the femoral socket important for achieving satisfactory graft placement. The adjustable-loop construct permits alteration of the loop after deployment of the cortical button, thereby allowing the surgeon to modify graft seating and tension during the procedure [7,9,10]. This adjustability may be advantageous when the final graft or socket dimensions are difficult to determine precisely before fixation.
Considerable attention has been directed toward the mechanical properties of these fixation systems. Petre et al. demonstrated differences in displacement characteristics between fixed- and adjustable-loop constructs during cyclic loading [9]. Noonan et al. investigated an adjustable-loop suspensory device and emphasized the potential importance of retensioning and knot tying in maintaining fixation [10]. In their systematic review and meta-analysis, Houck et al. identified biomechanical differences between the two types of devices [11]. Singh et al. further evaluated fixed and adjustable systems under high-load conditions and prolonged cyclic testing [13]. These findings demonstrate that the devices do not behave identically under laboratory conditions; however, the presence of a biomechanical difference does not necessarily establish a corresponding difference in patient outcomes.
The clinical results of the present study are consistent with this distinction between laboratory performance and clinical effectiveness. Choi et al. reported similar clinical and radiological outcomes following hamstring ACL reconstruction using fixed-loop and adjustable-loop cortical suspension devices [12]. Likewise, the present study found no statistically significant difference in either IKDC or Lysholm scores between the two groups at the evaluated follow-up points. Therefore, the mechanical differences reported in experimental studies did not appear to produce a measurable difference in patient-reported function during the first postoperative year.
Improvement was also observed in clinical anterior knee stability. All 30 patients had grade II Lachman findings before reconstruction and grade I findings postoperatively. This change indicates an improvement in anterior tibial restraint following ACL reconstruction. Nevertheless, Lachman grading provides a clinical rather than quantitative assessment of laxity. In the absence of KT-1000, KT-2000, or another instrumented arthrometric assessment, small differences in anterior translation between the two fixation groups could not be determined.
Meniscal pathology was present in 17 patients in the study cohort, with medial meniscal involvement occurring more frequently than lateral meniscal involvement. The presence of associated meniscal lesions may affect postoperative symptoms, rehabilitation progression, and functional recovery. Consequently, the improvement in IKDC and Lysholm scores should be interpreted as the overall outcome following ACL reconstruction rather than as an effect attributable solely to the femoral fixation device. Recovery may additionally have been influenced by rehabilitation compliance, baseline activity, graft characteristics, tunnel placement, and biological incorporation of the graft.
No postoperative complications were recorded in either group during the available follow-up. This finding indicates a satisfactory short-term clinical course in the study population, but the absence of complications should be interpreted cautiously because the cohort consisted of only 30 patients. A sample of this size has limited capacity to identify infrequent adverse events. Furthermore, follow-up was restricted to 1 year and therefore does not provide sufficient information regarding later graft failure, revision surgery, femoral tunnel widening, graft incorporation, return to sporting activity, or development of post-traumatic osteoarthritis.
Taken together, the findings of this study indicate that both forms of femoral cortical suspension can be used effectively during ACL reconstruction with a quadrupled hamstring tendon autograft, with satisfactory short-term functional and clinical outcomes. The fixed-loop construct provides a predefined fixation configuration, whereas the adjustable-loop system allows the loop to be modified intraoperatively to facilitate graft positioning and tensioning [7,9,10]. Since no significant difference in functional outcome was demonstrated, selection between the two systems may reasonably be based on the characteristics of the femoral socket, graft dimensions, surgical technique, surgeon familiarity, and requirements encountered during the procedure.

LIMITATIONS

Several limitations should be considered when interpreting the findings of this study.

- Small sample size (n = 30), limiting generalizability
- Short follow-up duration (up to 1 year), insufficient for long-term assessment
- Single-centre study
- Non-randomized observational design (risk of selection bias)
- Absence of objective laxity measurement (e.g., KT-1000)
- Reliance on subjective scoring systems (IKDC, Lysholm)
- Lack of blinding (observer bias possible)
- Variability in rehabilitation compliance
- Influence of associated injuries (meniscal/chondral)
- No radiological assessment of tunnel widening or graft incorporation

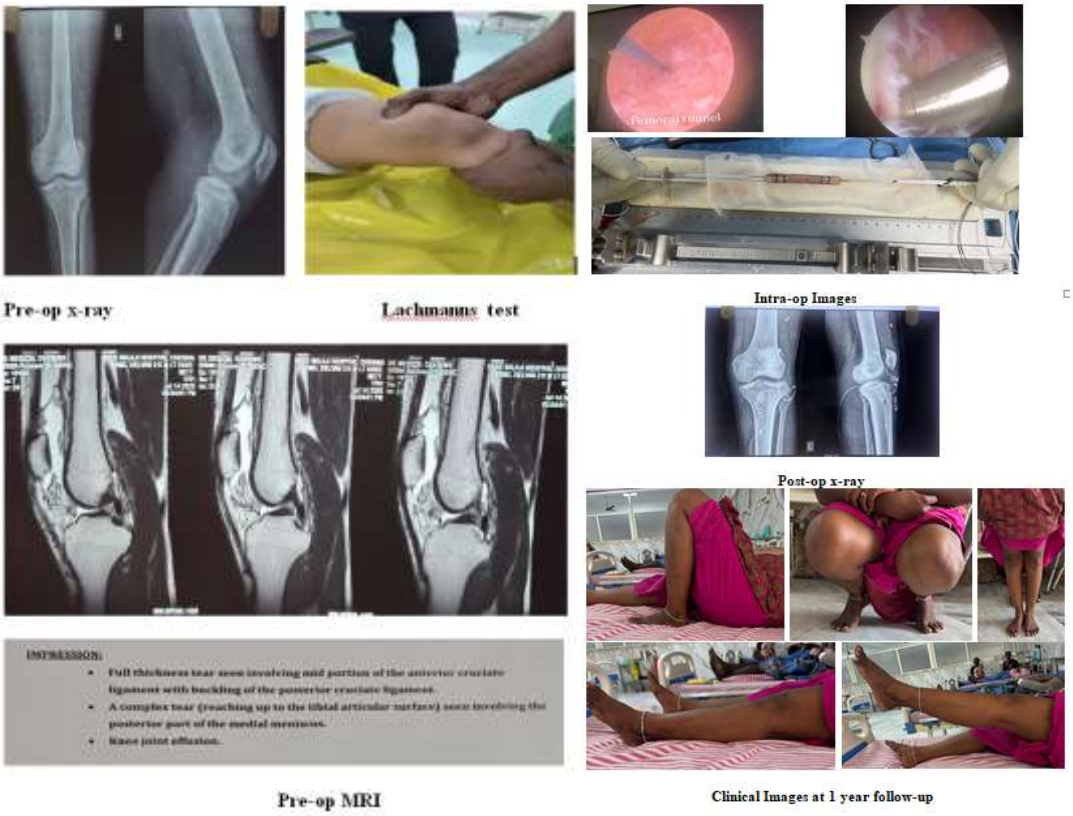
CONCLUSION

- Both fixed-loop & adjustable-loop femoral fixation-devices provide reliable & stable fixation
- Significant improvement in IKDC and Lysholm-scores observed in both groups
- No statistically significant difference in functional outcome or knee stability
- Adjustable-loop devices offer intraoperative flexibility and improved graft seating
- Fixed-loop devices provide consistent biomechanical stability
- Complication rates were minimal and comparable
- Both techniques are safe and effective
- Choice of fixation method may be based on surgeon preference and intraoperative factors

CASE ILLUSTRATIONS

CASE 1

Age/Sex- 45 Female
Mode of Injury- RTA
Diagnosis- Left Knee ACL tear + Medial Meniscus tear
P/D - ACL reconstruction with Adjustable Loop + Medial Meniscus repair



CASE -2

Age/Sex - 26 Male
Mode of Injury - RTA
Diagnosis - Left Knee ACL tear + Lateral Meniscus tear
P/D - ACL reconstruction with Adjustable Loop + Lateral Meniscus repair

Case-3

Age/Sex - 36 Male
Mode of Injury - Sports
Diagnosis - Left Knee ACL tear
P/D - ACL reconstruction with Fixed Loop

Case 4

Age/Sex - 41 Male
Mode of Injury - RTA
Diagnosis - Right Knee ACL tear + Medial Meniscus tear
P/D -ACL reconstruction with Fixed Loop + Medial Meniscus repair

Pre op x ray

Pre-op MRI

Post op x ray

Intraop images

Clinical Images at 1 year of Follow-up

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