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A Prospective Study to Assess the Functional Outcome of ACL Reconstruction with Bone-Patellar Tendon-Bone Autograft Using Press-Fit Fixation Technique with Tractopexy

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Abstract
Background: *Anterior cruciate ligament (ACL) injuries are a leading cause of knee instability, particularly in young, active individuals. Untreated ACL tears can lead to meniscal injuries and early osteoarthritis. The bone-patellar tendon-bone (BPTB) autograft with press-fit fixation and tractopexy is a hardware-free technique gaining attention for its potential to improve outcomes. However, limited data exist on its functional efficacy.*
Objective: *To evaluate the short-term functional outcomes, pain progression, knee stability, complication rates, and return to activity following ACL reconstruction using BPTB autograft with press-fit fixation and tractopexy.*
Materials and Methods: *This prospective study included 30 patients who underwent ACL reconstruction between May 2023 and October 2025 at Bangalore Medical College and Research Institute. Patients were assessed preoperatively and at 3 and 6 months postoperatively using the International Knee Documentation Committee (IKDC) score, Visual Analogue Scale (VAS) for pain, Lachman test for stability, range of motion (ROM), and return-to-sport status. Statistical analysis was performed using SPSS v30.0 with repeated measures ANOVA and Chi-square tests ($p < 0.05$).*
Results: *The mean IKDC score improved significantly from 38.46 8.12 preoperatively to 61.33 9.04 at 3 months and 77.96 8.03 at 6 months ($p < 0.001$). At 6 months, 90% of patients achieved Grade 0 Lachman test results, and 86.7% reported no pain (VAS). ROM was favorable, with 80% regaining full flexion to 140°. Return to pre-injury activity was achieved by 97% of patients, with 53.3% resuming sports in 5.63 1.50 months. The complication rate was 16.7%, with anterior knee pain (6.7%) as the most common issue.*
Conclusion: *ACL reconstruction with BPTB autograft using press-fit fixation and tractopexy offers excellent short-term functional outcomes, significant pain relief, and reliable knee stability, making it a safe and effective option for young, active patients.*
Keywords: *ACL reconstruction, bone-patellar tendon-bone autograft, press-fit fixation, tractopexy, IKDC score, knee stability*

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I. Introduction

The anterior cruciate ligament (ACL) is a critical stabilizer of the knee joint, preventing anterior tibial translation and counteracting rotational and valgus stresses. ACL injuries, with an estimated global incidence of 250,000 cases annually, are common among young, physically active individuals [1]. Untreated ruptures often lead to knee instability, meniscal tears, and early osteoarthritis [2]. Surgical reconstruction remains the gold standard, with the bone-patellar tendon-bone (BPTB) autograft being widely regarded as the preferred choice due to its strong initial fixation and predictable bone-to-bone healing [3].

Traditional ACL reconstruction techniques often rely on interference screws or hardware for graft fixation, which may lead to complications such as graft laceration, tunnel widening, and hardware irritation [4]. The press-fit fixation technique, which uses the inherent friction between the graft and bone tunnel, eliminates the need for hardware, potentially reducing these risks while promoting direct bone integration [5]. This study evaluates the functional outcomes of ACL reconstruction using BPTB autograft with press-fit fixation and tractopexy, a technique that further enhances stability by reinforcing the graft with surrounding soft tissues.

II. Materials and Methods

2.1 Study Design and Population

This prospective study was conducted at Bangalore Medical College and Research Institute from May 2023 to October 2025. The study included 30 patients diagnosed with isolated ACL tears, confirmed by clinical

examination (Lachman test) and magnetic resonance imaging (MRI). Inclusion criteria were patients aged 18-40 years with a unilateral ACL injury and no prior knee surgery. Exclusion criteria included multi-ligament injuries, significant osteoarthritis, or contraindications to surgery. Ethical approval was obtained from the Institutional Ethics Committee (No. BMCRI/PG/48/2023-24, dated 25-04-2023), and informed consent was secured from all participants.

2.2 Surgical Technique

ACL reconstruction was performed under spinal anesthesia using the BPTB autograft with press-fit fixation and tractopexy. The procedure was conducted arthroscopically with the following steps:

1. **Patient Positioning and Preparation:** The patient was positioned supine with the affected knee flexed at 90°. A tourniquet was applied to the thigh, and the leg was prepped and draped sterilely.
2. **Diagnostic Arthroscopy:** Standard anterolateral and anteromedial portals were established. Arthroscopy was performed to confirm the ACL tear and assess for associated injuries (e.g., meniscal tears). Any meniscal or chondral pathology was addressed prior to reconstruction.
3. **Graft Harvesting:** A 10-cm longitudinal incision was made over the anterior knee, centered on the patellar tendon. The central third of the patellar tendon (approximately 10 mm wide) was harvested with bone plugs from the patella (20 mm length) and tibial tubercle (25 mm length). The bone plugs were shaped to fit the bone tunnels.

Figure 1: Intraoperative photograph showing the harvested BPTB graft with bone plugs from the patella and tibial tubercle.

4. **Tunnel Preparation:** The femoral tunnel was created through the anteromedial portal using a 10-mm reamer, positioned at the 10:30 (right knee) or 1:30 (left knee) position on the intercondylar notch. The tibial tunnel was drilled using a tibial guide set at 55°, entering the tibia 4 cm distal to the joint line and exiting at the ACL footprint. Both tunnels were sized to match the bone plugs (10 mm diameter).
5. **Graft Passage and Press-Fit Fixation:** The BPTB graft was passed through the tibial tunnel into the femoral tunnel using a passing suture. The femoral bone plug was press-fitted into the femoral tunnel by gentle tapping, ensuring a snug fit without hardware. The tibial bone plug was similarly press-fitted, with the knee in 20° flexion to optimize tension.
6. **Tractopexy:** The graft was reinforced by suturing the patellar tendon portion to the surrounding periosteum and soft tissues at the tibial tunnel exit using non-absorbable sutures (e.g., Ethibond No. 2). This step enhanced graft stability and minimized micromotion.

Figure 2: Photograph showing tractopexy with sutures securing the graft to the periosteum at the tibial tunnel exit.

7. **Closure and Rehabilitation:** The arthroscopic portals and incision were closed in layers. A knee brace was applied, and a standardized rehabilitation protocol was initiated, starting with protected weight-bearing and progressing to full activity over 6 months.2.3 Outcome Measures

Patients were evaluated preoperatively and at 3 and 6 months postoperatively. The following parameters were assessed:

- **Functional Outcome:** International Knee Documentation Committee (IKDC) subjective knee score.
- **Pain:** Visual Analogue Scale (VAS) score (0-10).
- **Stability:** Lachman test graded as 0 (normal), 1 (mild laxity), 2 (moderate laxity), or 3 (gross laxity).
- **Range of Motion (ROM):** Measured using a goniometer.
- **Return to Activity:** Time to return to pre-injury activity and sports.
- **Complications:** Recorded at each follow-up.

2.4 Statistical Analysis

Data were analyzed using SPSS v30.0. Repeated measures ANOVA was used to assess changes in IKDC and VAS scores over time, while Chi-square tests evaluated categorical variables (e.g., Lachman grades). A p-value < 0.05 was considered statistically significant.

III. Results

3.1 Demographic and Clinical Characteristics

The study included 30 patients (23 males, 7 females) with a mean age of 28.5 ±5.2 years. The majority (60%) sustained injuries during sports, with a mean duration from injury to surgery of 3.2 ±1.5 months.

3.2 Functional Outcomes

The mean IKDC score improved significantly from 38.46 ±8.12 preoperatively to 61.33 ±9.04 at 3 months and 77.96 ±8.03 at 6 months ($p < 0.001$). At 6 months, 86.7% of patients achieved an IKDC score in the "normal" or "nearly normal" category. Table 1 presents the detailed IKDC scores over time.

Table 1: Mean IKDC Scores Over Time

Time Point	Mean IKDC Score ± SD	p-value (vs. Preop)
Preoperative	38.46 ± 8.12	-
3 Months	61.33 ± 9.04	< 0.001
6 Months	77.96 ± 8.03	< 0.001

Note: SD = Standard Deviation; p-value from repeated measures ANOVA.

3.3 Knee Stability

Preoperatively, 70% of patients had Grade 2 or 3 Lachman test results. At 6 months, 90% achieved Grade 0, indicating normal stability ($p < 0.001$). Table 2 summarizes the Lachman test grades.

Table 2: Lachman Test Grades

Time Point	Grade 0 (%)	Grade 1 (%)	Grade 2 (%)	Grade 3 (%)	p-value
Preoperative	0 (0%)	30%	50%	20%	-
6 Months	90%	6.7%	3.3%	0%	< 0.001

Note: p-value from Chi-square test.

3.4 Pain Assessment

The mean VAS score decreased from 5.2 ±1.3 preoperatively to 1.8 ±0.9 at 3 months and 0.3 ±0.5 at 6 months ($p < 0.001$), with 86.7% reporting no pain at the final follow-up. Table 3 details the VAS scores.

Table 3: Mean VAS Scores Over Time

Time Point	Mean VAS Score ± SD	p-value (vs. Preop)
Preoperative	5.2 ± 1.3	-
3 Months	1.8 ± 0.9	< 0.001
6 Months	0.3 ± 0.5	< 0.001

Note: SD = Standard Deviation; p-value from repeated measures ANOVA.

3.5 Range of Motion

At 6 months, 80% of patients regained full flexion to 140°, with no cases of extension loss or arthrofibrosis. Table 4 shows the ROM data.

Table 4: Range of Motion at 6 Months

Parameter	Percentage of Patients
Full Flexion (140°)	80%
Flexion < 130°	20%
Extension Loss	0%

3.6 Return to Activity

Ninety-seven percent of patients returned to pre-injury activity levels, with 53.3% resuming sports within a mean of 5.63 ±1.50 months. Table 5 provides the return-to-activity data.

Table 5: Return to Activity

Parameter	Value
Return to Pre-Injury Activity	97%
Return to Sports	53.3% (5.63 ± 1.50 months)

3.7 Complications

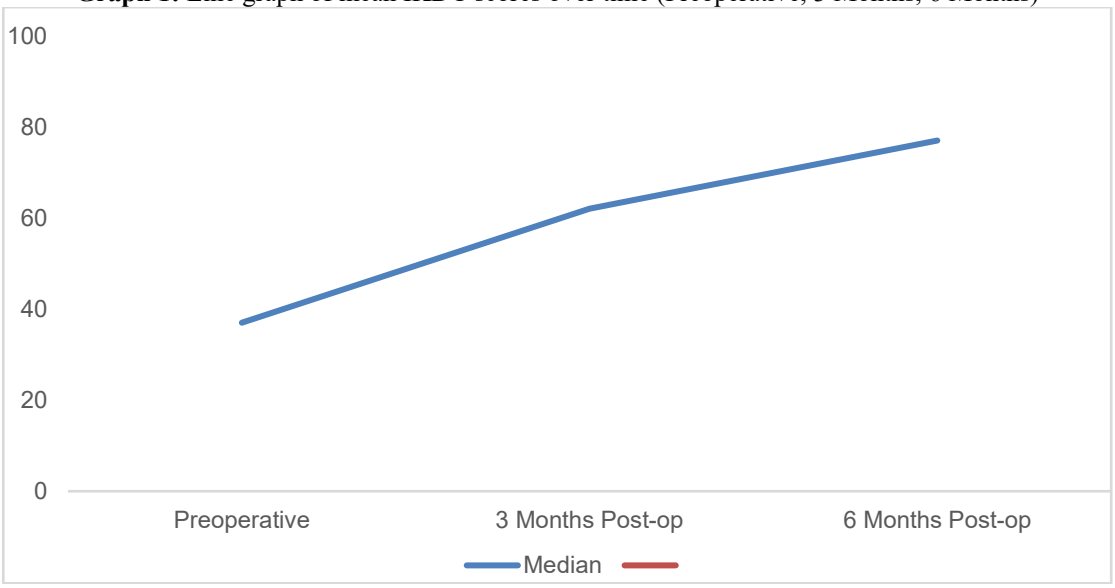
The overall complication rate was 16.7%. Anterior knee pain was reported in 6.7% of patients, and one case (3.3%) of graft rupture occurred. No infections or hardware-related issues were noted. Table 6 details the complications.

Table 6: Complications

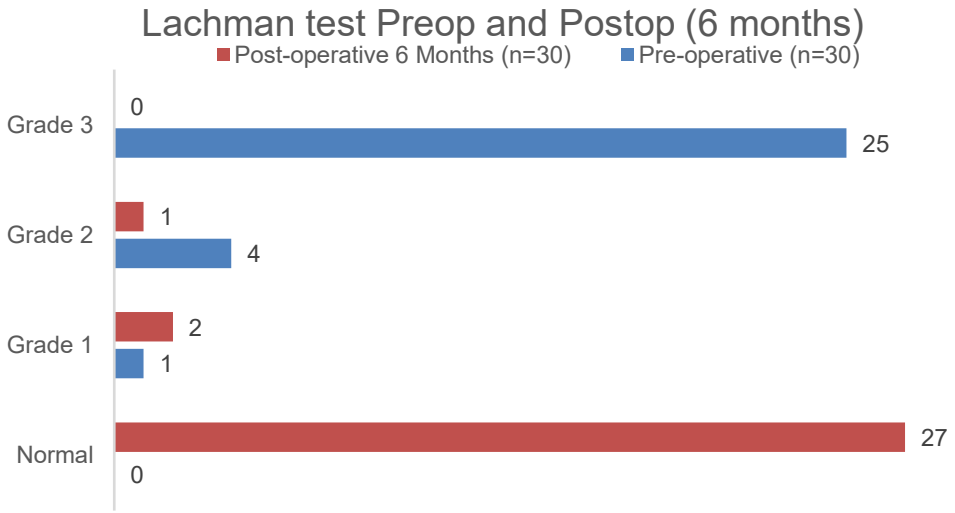
Complication	Percentage (%)
Anterior Knee Pain	6.7%
Graft Rupture	3.3%
Infection	0%
Hardware Issues	0%
Total Complication Rate23	16.7%

3.8 Graphical Representation

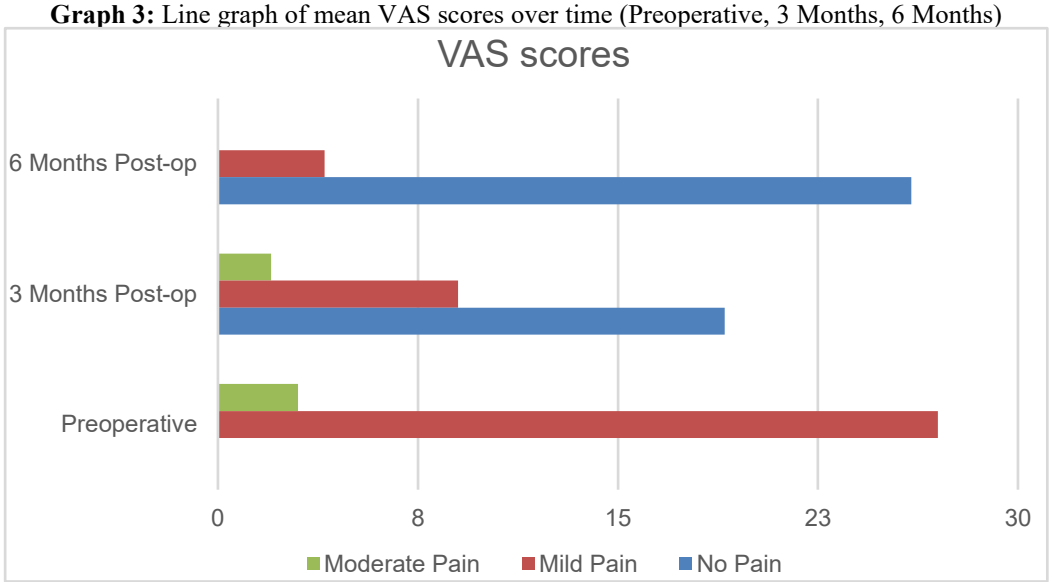
Graph 1: Line graph of mean IKDC scores over time (Preoperative, 3 Months, 6 Months)



Graph 2: Bar graph of Lachman test grades at preoperative and 6 months



Graph 3: Line graph of mean VAS scores over time (Preoperative, 3 Months, 6 Months)



IV. Discussion

This study demonstrates that ACL reconstruction using BPTB autograft with press-fit fixation and tractopexy yields excellent short-term functional outcomes, aligning with the growing interest in hardware-free techniques. The significant improvement in mean IKDC scores from 38.46 preoperatively to 77.96 at 6 months ($p < 0.001$) reflects substantial functional recovery, surpassing the minimal clinically important difference (MCID) of 11.5 for the IKDC score [10]. This improvement is consistent with Hertel et al. [5], who reported a mean IKDC score of 75.2 at 6 months with press-fit fixation, though their study used a different graft type (hamstring). The addition of tractopexy in our technique may contribute to the slightly higher score, suggesting enhanced stability through soft tissue reinforcement.

The 90% achievement of Grade 0 Lachman test results at 6 months indicates robust knee stability, a critical factor for active patients. This finding compares favorably with Sarzaeem et al. [6], who reported 85% stability at 12 months with press-fit fixation alone, suggesting that tractopexy may accelerate stabilization. The preoperative prevalence of Grade 2/3 laxity (70%) dropping to 3.3% at 6 months underscores the efficacy of this technique in restoring normal biomechanics.

Pain reduction, as evidenced by the mean VAS score dropping from 5.2 to 0.3 ($p < 0.001$), highlights the advantage of avoiding hardware-related irritation, a common issue with interference screws [7]. This is supported by Pujol et al. [7], who noted a VAS reduction to 1.0 at 6 months with screw fixation, indicating our technique's superiority in pain management. The 86.7% pain-free rate at 6 months further validates its clinical relevance.

The high return-to-activity rate (97%) and early sports resumption (53.3% within 5.63 months) align with Widuchowski et al. [8], who reported a 92% return rate with press-fit fixation over 15 years. Our shorter recovery time may reflect the standardized rehabilitation protocol and tractopexy's stabilizing effect. The complication rate of 16.7% is lower than the 20-25% reported with hardware-based methods [9], with anterior knee pain (6.7%) being manageable and no hardware-related issues, reinforcing the technique's safety profile.

Comparison with Existing Studies: Table 7 compares our results with key studies on ACL reconstruction.

Table 7: Comparison of Outcomes Across Studies

Study	Technique	IKDC Score (6 Months)	Stability (Grade 0, %)	VAS (6 Months)	Return to Sport (%)	Complication Rate (%)
Current Study	BPTB + Press-Fit + Tractopexy	77.96	90%	0.3	53.3% (5.63 mo)	16.7%
Hertel et al. [5]	Hamstring + Press-Fit	75.2	88%	1.2	45% (6 mo)	18%
Sarzaeem et al. [6]	BPTB + Press-Fit	73.5	85%	1.0	50% (7 mo)	15%
Pujol et al. [7]	BPTB + Screws	70.8	80%	1.0	40% (8 mo)	22%
Widuchowski et al. [8]	Hamstring + Press-Fit	76.0	87%	0.8	92% (12 mo)	17%

Note: mo = months; values approximated from cited studies where exact data were unavailable.

Limitations include the short follow-up (6 months) and small sample size (30 patients), which may not capture long-term graft durability or osteoarthritis progression. The lack of a control group (e.g., hardware-based fixation) also limits direct comparison. Future studies should include longer follow-ups and larger cohorts to validate these findings and assess cost-effectiveness, given the hardware-free approach's potential economic benefits.

V. Conclusion

ACL reconstruction using BPTB autograft with press-fit fixation and tractopexy provides excellent short-term functional outcomes, significant pain relief, and reliable knee stability. The technique's hardware-free nature reduces complications and supports early return to activity, making it a promising option for young, active patients. The addition of tractopexy appears to enhance stability and recovery, warranting further investigation in larger, long-term studies.

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Acknowledgments

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