Orthopaedic Surgery
SURGICAL TECHNOLOGY INTERNATIONAL 46
doi: 10.36922/sti.0402

Clinical and Functional Outcomes of Trans-Septal Remnant-Preserving versus Conventional Posterior Cruciate Ligament Reconstruction in Competitive Athletes

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Abstract

Background: Posterior cruciate ligament (PCL) reconstruction techniques have evolved to include remnant-preserving approaches, yet comparative evidence in competitive athletes remains limited.

Objective: This study aims to compare the clinical and functional outcomes of trans-septal remnant-preserving PCL reconstruction with conventional methods in competitive athletes.

Methods: This prospective comparative study enrolled 37 competitive athletes (Tegner score >5) who underwent PCL reconstruction between January 2019 and January 2023. Patients were randomized to trans-septal remnant-preserving (n = 17) or conventional (n = 20) PCL reconstruction group. All procedures were performed by a single surgeon. Primary outcomes included pain assessment using visual analog scales, range of motion, and instability. Secondary outcomes included the Lysholm score, the Tegner activity scale, and the International Knee Documentation Committee (IKDC) score, and return-to-sport duration. Evaluations were conducted at 3, 6, 12, and 18 months postoperatively.

doi: 10.36922/sti.0402

Results: Baseline demographics were comparable between groups. The remnant-preserving group demonstrated significantly superior Lysholm and IKDC scores at six months with 83.12 ± 6.25 vs. 75.54 ± 7.54 ($p < 0.001$) and 80.0 ± 9.1 vs. 67.9 ± 11.3 ($p < 0.05$), respectively. Return-to-sport duration was shorter in the remnant-perserving group, with a 1.6-month earlier return than the conventional group (9.8 ± 2.4 vs. 11.4 ± 3.1 months; $p = 0.12$). However, by 12 and 18 months, functional scores converged with no significant differences in range of motion, Lysholm scores, IKDC scores, or Tegner activity levels.

Conclusion: While the remnant-preserving group demonstrated significantly better functional scores during the early follow-up intervals, these advantages converged by 12–18 months without apparent clinical significance. However, the potential for enhanced outcomes remains evident, as evidenced by the shorter return-to-sport duration in the remnant-preserving group.

***Keywords*:** Posterior cruciate ligament reconstruction, Remnant preservation, Athletes, Posterior cruciate ligament, Return-to-sport duration, Trans-septal portal

INTRODUCTION

Posterior cruciate ligament (PCL) reconstruction techniques have evolved significantly, with increasing emphasis on remnant preservation strategies to optimize graft integration and proprioceptive function.[1-3] The trans-septal remnant-preserving PCL reconstruction technique represents an innovation that integrates anatomic tunnel placement with preservation of viable PCL fibers and synovial tissue.[1,2] This approach enables direct visualization of both femoral and tibial footprints, allowing more accurate graft positioning and maintaining native tissue continuity.[1,2,4] The preserved remnants contribute to graft revascularisation, mechanoreceptor retention, and reduced tunnel widening, translating to faster recovery and improved postoperative knee stability in high-demand populations such as athletes.[5-8] This biological advantage is particularly pertinent for athletes who require symmetric lower limb function for cutting, pivoting, and decelerating maneuvers that depend critically on intact neuromuscular feedback, where remnant preservation may facilitate optimal graft integration and reinnervation.[3,5,9-11] Additionally, maintaining remnant fibers has been associated with increased synovial coverage and reduced inflammatory response, potentially minimizing fibrosis and postoperative stiffness.[1,7,12]

Conversely, conventional PCL reconstruction techniques rely on complete debridement of native PCL tissue to facilitate footprint and tunnel visibility as well as graft passage.[13] It remains a standardized and cost-effective surgical approach that provides reliable restoration of knee stability and functional outcome,[14,15] achieving consistently favorable clinical results while avoiding the technical complexity and steep learning curve associated with the remnant-preserving procedure.[16] Conventional technique offers simpler visualization of tunnel geometry, shorter operative time, and fewer iatrogenic chondral injuries than transseptal remnantpreserving techniques, while achieving comparable or better posterior stability with fewer hardware and soft tissue conflicts.[15,17] Biomechanically, standardized graft tensioning and tunnel placement in conventional methods reduce stress risers from remnant tissue manipulation and avoid cyclical graft abrasion in the intercondylar notch.[16] Although technically straightforward and reproducible, conventional singlebundle PCL reconstruction may diminish proprioceptive input and intrinsic healing potential reported with remnant preservation.[14] A systematic review on conventional PCL reconstruction methods by Vandenrijt *et al*.[18] reported non-inferior International Knee Documentation Committee (IKDC)/Lysholm scores with similar or lower residual posterior tibial translation, if adhered to strict rehabilitation protocols with milestones streamlined appropriately based on recovery without remnant-related synovitis or cyclops-like impingement. As competitive athletes place high biomechanical demands on reconstructed ligaments, a comparative assessment of remnant preservation and complete debridement approaches is fundamental in establishing the optimal surgical method and protocol that ensures both biomechanical stability and superior functional results.[5,6,9]

Despite technical refinements in conventional arthroscopic PCL reconstruction, clinical outcomes in athletic populations remain variable regarding restoration of knee stability and return-to-sport duration.[19,20] Persistent posterior sag, residual laxity, and incomplete proprioceptive recovery have been documented even after anatomic single-bundle reconstructions.[21,22] The challenge lies not merely in achieving mechanical fixation but in ensuring biological recovery that resembles the native ligament's viscoelastic and sensory properties.[3,23] In high-performing athletes, even minor proprioception or strength

doi: 10.36922/sti.0402

deficits can translate to performance limitations or reinjury.[9,19,24] Competitive athletes necessitate expeditious, comprehensive, and durable restoration of knee function.[9,17,19]

The need for this study stems from the escalating demands among sports medicine practitioners for techniques that optimize athletic performance and longevity.[9,19] Athletes represent a unique subgroup where return-to-sport duration, proprioceptive efficiency, and ligament strength are critical determinants of surgical success.[10,19,24] Although trans-septal remnant-preserving PCL reconstruction has shown encouraging preliminary results in general populations, evidence specifically targeting competitive athletes remains limited.[1,9,25,26] Recent studies highlighted a lack of comparative research on trans-septal remnant-preserving versus conventional approaches in athletes, which concurrently incorporates clinical parameters and functional outcomes within a systematic framework.[1,17,21] Hence, to resolve this uncertainty, the present study tests the hypothesis that transseptal, remnant-preserving PCL reconstruction yields superior clinical and functional outcomes compared with conventional reconstruction in competitive athletes, characterized by reduced posterior laxity, enhanced proprioceptive performance, expedited achievement of rehabilitation milestones, and an earlier return to pre-injury levels of sport participation.

METHODS

Study design and patient selection

This prospective comparative study was conducted in the Department of Orthopaedics, Yenepoya Medical College and Hospital, Mangalore, between January 2019 and January 2023. Ethical approval was obtained from the Institutional Ethics Committee, and informed consent was secured from all participants before enrolment. The study included (i) patients aged 18–40, who were engaged in regular systematic physical training (more than one hour a day and more than three days a week), (ii) patients who participated in official competitions of any sport organized at the district, state, national, or international level until the time of injurt as competitive athletes,[27] (iii) patients with clinically and radiologically (magnetic resonance imaging) confirmed isolated PCL rupture requiring reconstruction, and (iv) patients who were willing to adhere to the postoperative rehabilitation protocol and clinical follow-up. Exclusion criteria comprised associated ligament injuries requiring intervention, multiligamentous knee injuries, prior ligament surgeries altering knee anatomy, presence of osteoarthritis, degenerative or systemic knee disorders, associated fractures, tendon injuries, non-athletic status, or inability to comply with follow-up.

A total of 41 eligible patients were enrolled, and four were excluded during the study period for various reasons (**Figure 1**), leaving 37 patients who completed the full follow-up evaluation. Patients were randomized using a computer-generated number to undergo either trans-septal remnant-preserving PCL reconstruction (RP; n = 17) or conventional PCL reconstruction (CN; n = 20). All procedures were performed by a single orthopedic sports surgeon.

Randomization

A computer-generated sequence of random numbers (1–100) was used to randomize patients into two groups. An independent junior resident, blinded to the study protocol, assigned the randomization numbers to the respective treatment groups. Patients assigned odd numbers underwent trans-septal portal remnant-preserving PCL reconstruction, while those assigned even numbers received conventional PCL reconstruction.

Blinding

Blinding was maintained at two levels: patients were unaware of their group allocation, and the data collector (junior resident) remained blinded to treatment assignment throughout the collection of clinical parameters, radiological findings, and outcome metrics (Lysholm and IKDC scores).

Surgical techniques

All procedures were performed under spinal anesthesia, with the patient in a supine position and the affected knee flexed to 90° and freely hanging off the edge of the operating table. A pneumatic tourniquet was applied to the proximal thigh. Standard anterolateral and anteromedial portals were created, and diagnostic arthroscopy was performed using conventional techniques.

Trans-septal portal remnant-preserving group

In the RP group, the trans-septal approach was created by sequentially establishing posteromedial and posterolateral portals using a Wissinger rod under direct visualization. The portal was secured by introducing an 8 mm cannula driven all the way through the medial compartment, piercing the septum[4] (**Figure 2**). The posterolateral portal was used as a viewing portal, and the posteromedial trans-septal portal was used as a working portal (which could be interchanged as needed), as depicted in **Figure 3**. PCL remnant was identified and preserved, freed from adhesions and posterior capsule (**Figure 4A**), to better visualize the footprint for drilling the tibial tunnel. The tibial tunnel was established using a dedicated PCL jig, with the tunnel orifice positioned at the lateral tibial condyle just inferior to Gerdy's tubercle and directed toward the anatomic PCL footprint (**Figure 5**). This lateral trajectory from tibia offered several technical advantages: (i) optimization of tunnel trajectory resulting in reduced tunnel and thereby graft length; (ii) maximized graft fixation area by allowing proportionally greater screw accommodation length within the tunnel relative to the free tendon length; and (iii) placement of the tunnel orifice in a deeper location with inherent muscular coverage, thereby reducing soft tissue irritation and enhancing tunnel healing.

Conventional posterior cruciate ligament reconstruction group

Following diagnostic arthroscopy, a standard posteromedial portal was established, with visualization maintained via the anterolateral portal to facilitate precise identification and debridement of the PCL remnant up to its tibial footprint. Subsequently, the posterior capsule was released from its tibial attachment approximately 20 mm distal to the articular surface. The central point of the posterior tibial articular surface was then meticulously identified and marked to guide subsequent tunnel placement in the tibia.[4]

Tunnel preparation and graft passage

In both groups, the tibial tunnel was made using a PCL-specific alignment jig, with dimensions tailored to the harvested graft diameter. Femoral tunnels were constructed using standard anatomic techniques at the 1 o'clock or 11

doi: 10.36922/sti.0402

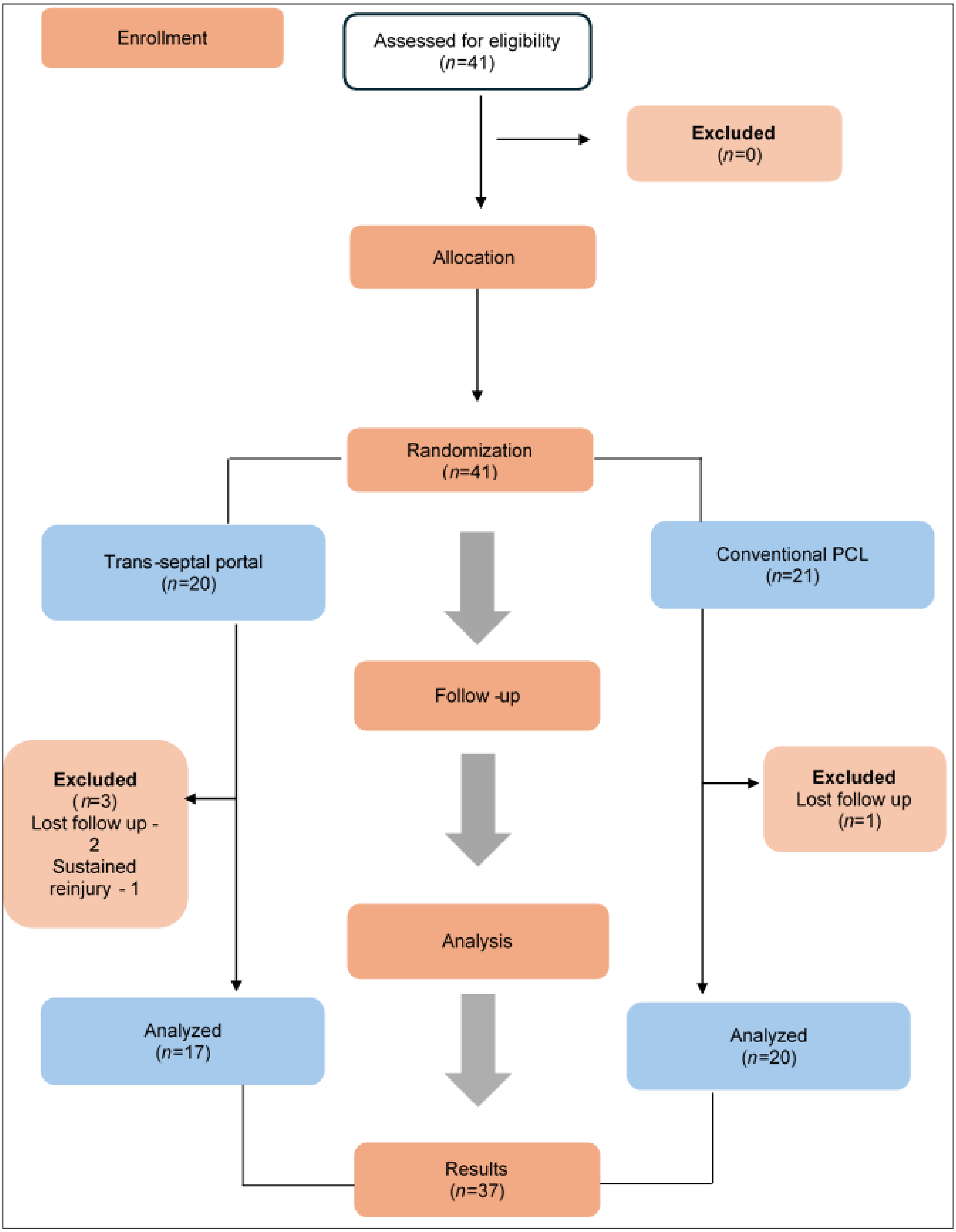

Figure 1. CONSORT flow diagram showing the flow of patient recruitment throughout the study
Abbreviations: CONSORT: Consolidated Standards of Reporting Trials; PCL: Posterior cruciate ligament.

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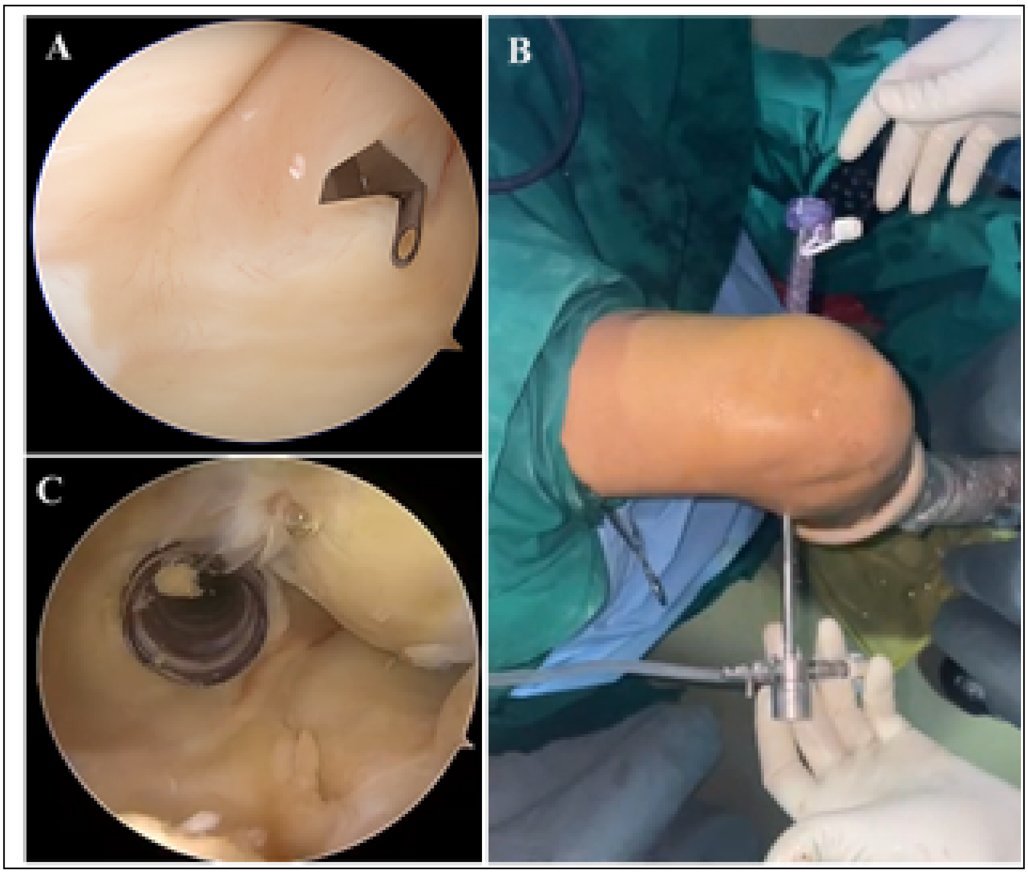

Figure 2. Intraoperative clinical images of the knee illustrating the posteromedial and trans-septal portal creation. (A) Arthroscopic image of the posteromedial compartment of the knee showing portal incision with needle guidance. (B) Intra-operative clinical image of securing a cannula through the posteromedial portal into the septum. (C) Arthroscopic image of the trans-septal portal with cannula *in situ*.

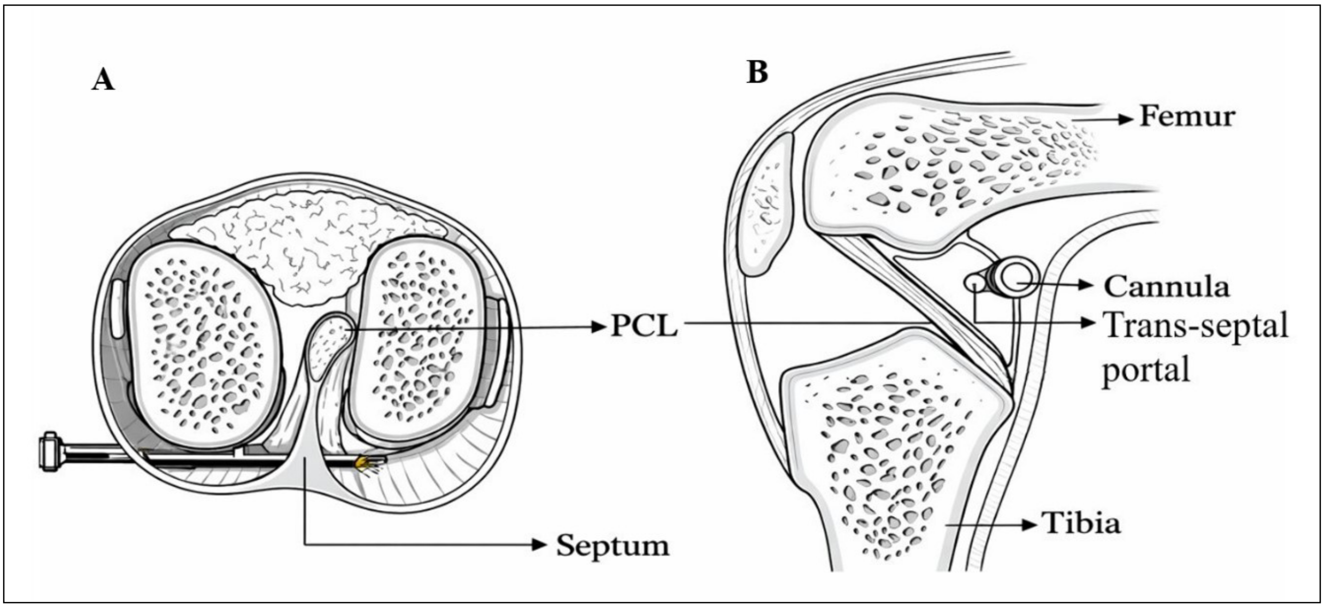

Figure 3. Illustrated diagram of the knee showing axial and sagittal views demonstrating the posterior septum and the trans-septal portal with (A) arthroscope and (B) cannula through the septum.
Abbreviation: PCL: Posterior cruciate ligament.

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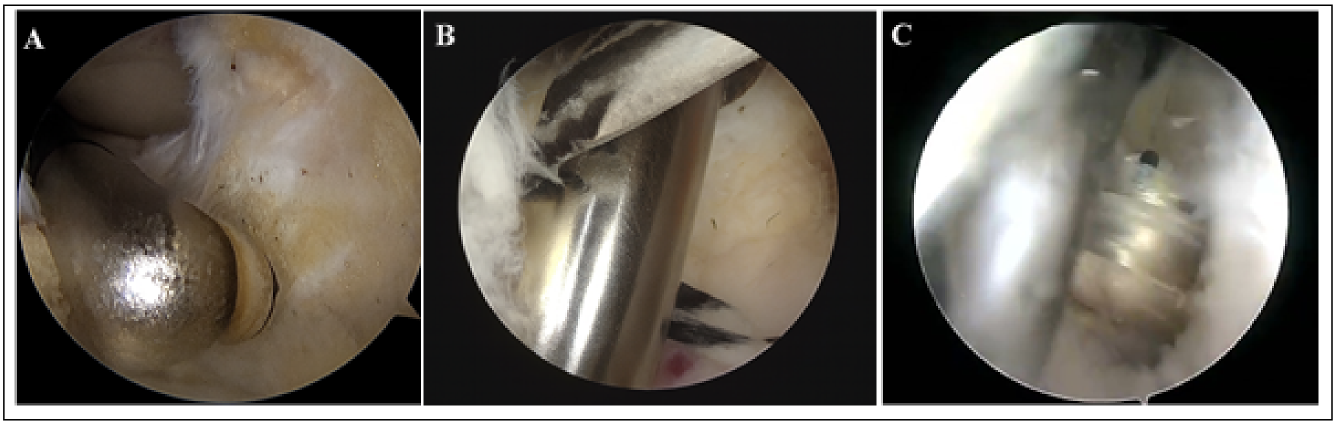

Figure 4. Intraoperative arthroscopic view of the posterolateral compartment with (A) radio frequency probe separating the capsule from the posterior cruciate ligament attachment. (B) Arthroscopic image showing the use of the Wissinger rod as a pulley in negotiating the "killer turn," showing the wire. (C) The passage of graft protected by the Wissinger rod.

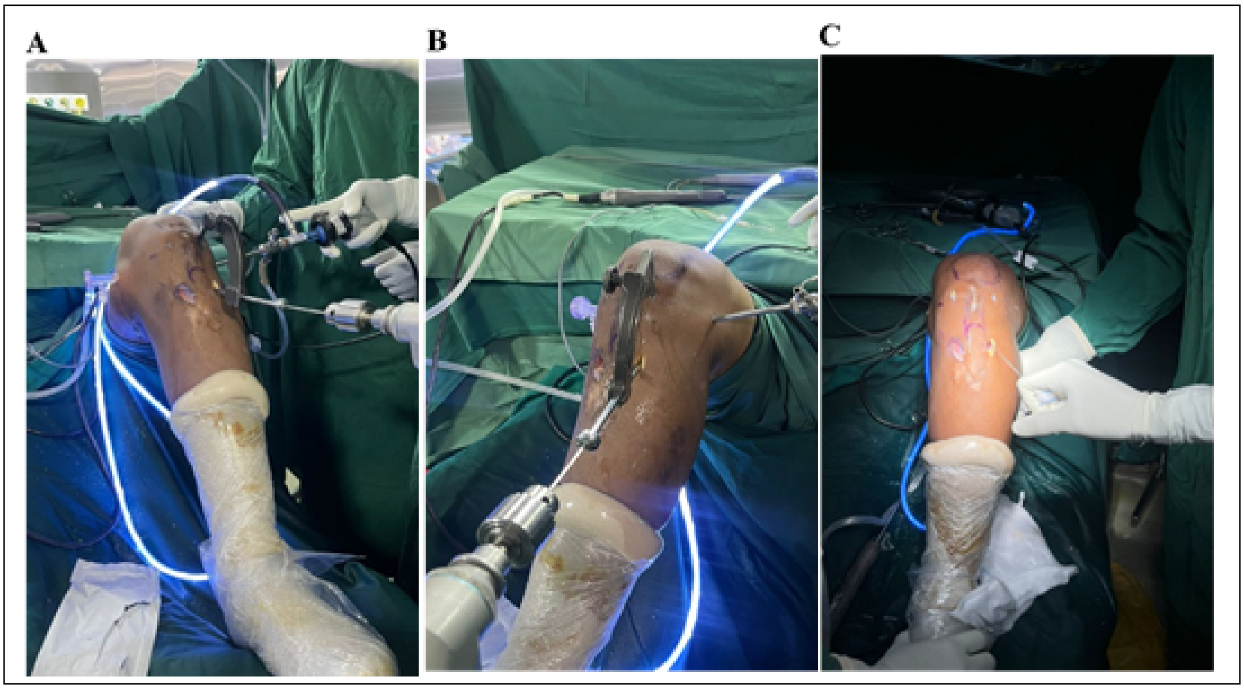

Figure 5. Intra-operative clinical image of posterior cruciate ligament reconstruction demonstrating the tibial tunneling from the (A & B) lateral tibial condyle, and (C) the passage of graft from the lateral side.

o'clock position in the medial condyle of the right and left knees, respectively, as viewed from the anterolateral portal. After thorough debridement of the tunnel entrances, the graft was introduced and shuttled in a standardized fashion, negotiating the killer turn using the Wissinger rod (**Figure 4B** and **4C**) and through both the tibial and femoral tunnels. Following tensioning and slack removal, the graft was secured using suspensory fixation (Endobutton) on the femoral side and a polyether–ether–ketone interference screw of appropriate size on the tibial side, with the knee positioned at 30° of flexion. Wounds were closed in layers, and a knee mobilizer with posterior calf support was applied.[9]

Postoperative rehabilitation protocol

In both groups, the rehabilitation protocol was carried out in six phases. In the first four weeks, the graft was protected by locking the brace in full extension with calf support, and weight bearing was allowed as tolerated using crutches, avoiding weight training and twisting exercises. Phase 2 (weeks 4–6) targeted a 0–110° range of motion (ROM), quadriceps strengthening, and gait normalization, avoiding painful activities and uncontrolled stair descent. Phase 3 (weeks 7–12) focused on >115° ROM, strength training (graded and static resistance), and light activities, restricting running and sports. Phase 4 (weeks 12–16) emphasized advanced strength and proprioceptive training, avoiding high-impact sports. Phase 5 (weeks 16–24) included plyometric and agility training involving pain-free running and achievement of a hop test score >75% (of the contralateral side), with sports activity allowed only after clearance. Phase 6 (week 24) continued agility and plyometric exercises to achieve full sports readiness, with a hop test score

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>85% relative to the contralateral side, avoiding pain and apprehension. Based on individual patient recovery trajectories and milestone achievement, the protocol was modified as required.

Outcome parameters

Primary outcome measures included pain assessment using the numerical visual analog scale at rest (VAS-R) and during activity (VAS-A), clinical evaluation of ROM, and instability testing through special tests. Secondary outcomes comprised functional evaluation using patient-reported outcome measures (PROMs), including the Lysholm score, Tegner scale, IKDC score, return-to-sport duration, and a successful return to preinjury sports, as determined by our return-to-play questionnaire (Supplementary File). Outcomes were measured at 3, 6, 12, and 18 months postoperatively and compared between groups to assess recovery progression and functional improvement.

Statistical methods

Statistical analysis was performed using the Statistical Package for Social Sciences version 29 software. Categorical data are presented as frequencies and percentages; the chi-square test or Fisher's exact test was used as the test of significance. Continuous data are presented as mean and standard deviation. An unpaired t-test was used to compare group means. A p-value <0.05 was considered statistically significant. The independent-samples t-test or the Mann–Whitney U test was used to compare quantitative variables.

RESULTS

The study enrolled 37 competitive athletes, including 17 patients in the RP group and 20 patients in the CN group. Baseline demographic profiles were comparable between the two groups, with no significant differences observed in sex distribution (trans-septal: 12 male, 5 female; conventional: 16 males, 4 females) or mean age (trans-septal: 26.64 ± 1.89 years; conventional: 28.55 ± 0.85 years) as shown in **Table 1**. Preoperative assessment of baseline characteristics revealed no significant difference in VAS-R between groups, while VAS-A was significantly higher in the CN group (4.84 ± 0.78) compared to the RP group (3.13 ± 1.32, $p < 0.001$). Preoperative ROM was lower in the CN group (45.26° ± 6.68°) than in the RP group (55.44° ± 12.27°), though the difference was not statistically significant. Physical activity levels assessed by the Tegner activity scale (RP: 7.20 ± 1.05; CN: 7.11 ± 1.07) and functional scores, including Lysholm and IKDC scores (**Table 2**), were similar between groups, indicating no significant baseline functional differences before surgery.

At three months postoperatively, the RP group demonstrated lower pain at rest (VAS-R: 0.8 ± 0.7) yet higher pain during activity (VAS-A: 2.75 ± 0.5) compared to the CN group (VAS-R: 0.2 ± 0.9, VAS-A: 3.5 ± 0.3), differences that were not statistically significant. Moreover, there were no significant differences between the RP and CN groups at 6, 12, and 18 months, as shown in **Figure 6.**

Range of motion outcomes demonstrated differing recovery trajectories between groups across follow-up intervals. At three months postoperatively, the CN group achieved a mean ROM of 95.62° ± 11.5°, while the RP group recorded a mean ROM of 88.34° ± 12.5° ($p = 0.076$), indicating a clinically relevant yet statistically nonsignificant difference. At six months, the CN group showed a mean ROM of 112.48° ± 6.72°, compared with 110.15° ± 7.08° in the RP group ($p = 0.348$), reflecting comparable improvement with no statistically significant difference. By 12 months postoperatively, the CN group reached a mean ROM of 126.92° ± 5.31°, while the RP group attained 124.37° ± 6.09° ($p = 0.297$), again showing marginal but nonsignificant variation. At 18 months, both groups achieved excellent, comparable functional outcomes, with mean ROM values of 134.21° ± 4.58° for the conventional group and 133.47° ± 4.91° for the transseptal group ($p = 0.642$), indicating complete functional equivalence at final follow-up, as shown in **Figure 6**.

Lysholm scores showed no significant differences at three months (RP: 63.18 ± 8.62 vs. CN: 68.53 ± 10.71; $p = 0.1013$). The RP group demonstrated superior statistically significant scores at six months (RP: 83.12 ± 6.25 vs. CN: 75.54 ± 7.54; $p < 0.001$). Additionally, the RP group exhibited scores comparable to those of the CN group at 12 and 18 months, as shown in **Table 2**.

International Knee Documentation Committee scores showed no significant differences at three months (RP: 58.09 ± 7.86 vs. CN: 54.32 ± 6.55; $p = 0.1269$), despite the RP group demonstrating a clinically higher score. However, at six months, the RP group achieved a higher functional score of 80.0 ± 9.1, which was statistically higher than that of the CN group (67.9 ± 11.3; $p < 0.05$). At 12 and 18 months, there was a similar range of scores between the RP and CN groups (**Table 2**).

Postoperative Tegner activity scale scores were similar between the cohorts, with both groups achieving near-baseline activity restoration (RP: 6.3 ± 1.5; CN: 5.9 ± 1.05). The mean return-to-sport duration was 1.6 months shorter in the RP group than in the CN group (9.8 ± 2.4 months vs. 11.4 ± 3.1 months, respectively). However, this difference did not attain statistical significance, as shown in **Table 2** ($p = 0.12$). Similarly,

Table 1. Demographic characteristics of the study participants

Characteristics	Trans-septal group (RP)	Conventional group (CN)
Sample size (*n*)	17	20
Male, *n* (%)	12 (70.6%)	16 (80%)
Female, *n* (%)	5 (29.4%)	4 (20%)
Mean age (years), mean ± standard deviation	26.64 ± 1.89	28.55 ± 0.85
Tegner activity scale (Preoperative)	7.20 ± 1.05	7.11 ± 1.07

doi: 10.36922/sti.0402

Table 2. Patient-related outcome scores at different intervals during the study

Group	Lysholm score					International Knee Documentation Committee score (IKDC)					Return-to-sport duration (months)	Patient satisfaction score
	preop	3 months	6 months	12 months	18 months	Preop	3 months	6 months	12 months	18 months		
Trans-septal group	55.61 ± 16.09	63.18 ± 8.62	83.12 ± 6.25	87.32 ± 4.12	87.6 ± 5.6	43.96 ± 6.32	58.09 ± 7.86	80.0 ± 9.1	91.2 ± 6.2	92.7 ± 3.21	9.8 ± 2.4	3.45 ± 1.15
Conventional group	53.27 ± 13.78	68.53 ± 10.71	75.54 ± 7.54	85.79 ± 3.81	85.8 ± 6.11	45.52 ± 7.2	54.32 ± 6.55	67.9 ± 11.3	88.5 ± 7.8	90.4 ± 6.81	11.4 ± 3.1	3.24 ± 1.35
p-value	0.50	0.1013	<0.001	0.140	0.080	0.32	0.1269	<0.05	<0.010	0.07	0.12	0.6088

Note: Data presented as mean ± standard deviation.

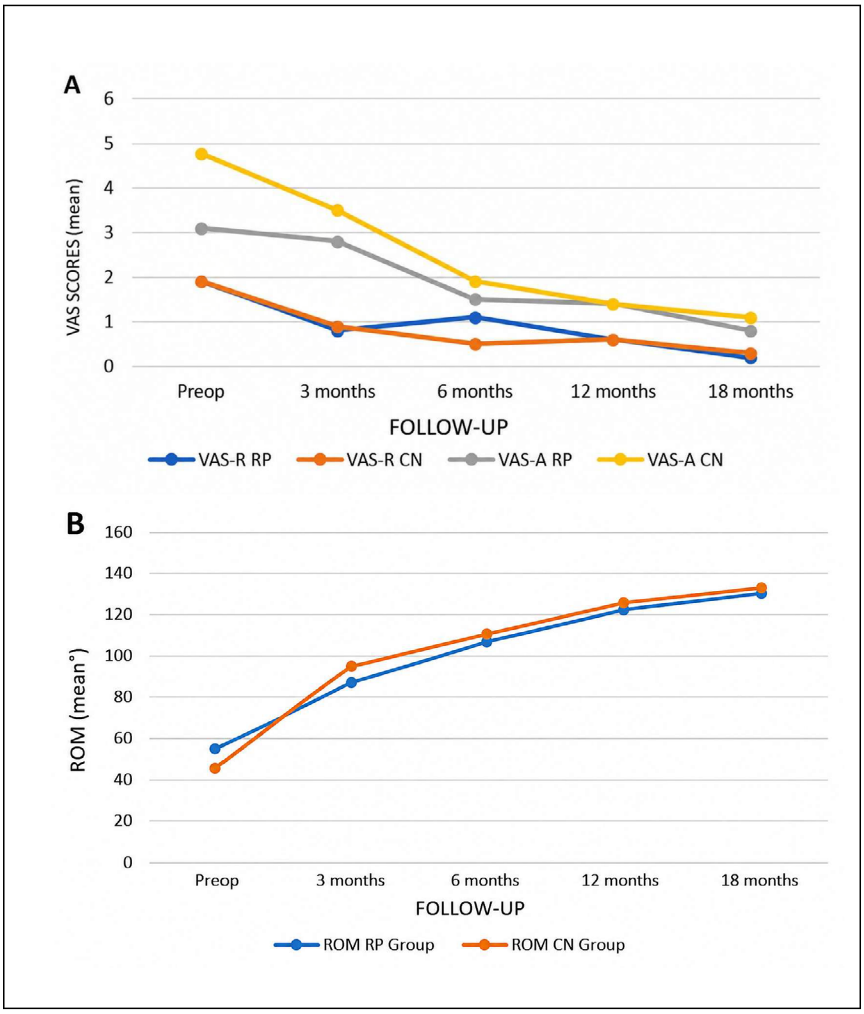

Figure 6. Line graphs depicting the temporal progression of pain scores and range of motion measurements from preoperative baseline through various postoperative follow-up periods. (A) Pre- and postoperative visual analog scale (VAS) scores. (B) Pre- and postoperative range of motion (ROM) measurements. Abbreviations: CN: Conventional posterior cruciate ligament technique; RP: Remnant-preserving posterior cruciate ligament reconstruction; SD: Standard deviation; VAS-A: Visual analog scale during activity; VAS-R: Visual analog scale at rest.

the mean patient satisfaction scores were comparable between the two groups (3.45 ± 1.15 vs. 3.24 ± 1.35; $p = 0.6088$), with no statistically significant difference. Postoperative complications were observed in two patients (11.8%) in the RP group, manifesting as stiffness in both cases, compared to one patient (5.0%) in the CN group who developed persistent instability requiring revision.

DISCUSSION

Both groups in our study achieved nearly identical functional outcomes at 18-month follow-up, despite comparable baseline characteristics. Notably, the RP group demonstrated a statistically significant difference in functional recovery at six months, with a mean Lysholm score 7.58 points higher (approximately 10% higher) than the CN group and a 1.6 months earlier return-to-sport duration. However, in addition to these advantages, both groups achieved equivalent functional and Tegner activity scores at 12 and 18 months postoperatively, indicating convergence in long-term outcomes. Similar outcomes were reported by Gong *et al*.[28] in their comparative analysis between remnant-preserving and conventional PCL reconstruction techniques among 36 patients with no statistically significant inter-group differences in IKDC scores (83.2 vs. 87.6), Lysholm scores (90.5 vs. 93.1), or Tegner activity scale (5.0 vs. 5.2) at the final follow-up (20.6 vs. 18.3 months). Yet,

doi: 10.36922/sti.0402

the remnant-preserving group demonstrated statistically superior posterior knee stability, achieving a greater reduction in KT-2000 side-to-side difference (7.8 mm to 1.8 mm vs. 8.9 mm to 3.7 mm) at final follow-up.[28]

In a comparative study of conventional and remnant-preserving PCL reconstruction techniques combined with posterolateral corner reconstruction involving 53 patients, Kim *et al*.[21] reported similar mean Lysholm scores (84.1 vs. 82.6) and objective IKDC grades (83.3% vs. 73.9%) at final follow-up (95 months vs. 76 months). Nevertheless, the analysis of the "IKDC subscale for sports activities" revealed statistically higher scores in the remnant-preserving group (26.1 vs. 22.4), with a statistically significant difference demonstrated in the Tegner activity scale (3.5 vs. 4.3) at final follow-up. Despite showing a similar return-to-sport rate (21.7% vs. 26.7%), the remnant-preserving group revealed a higher rate of near return to activity (73.3% vs. 43.5%), suggesting a potential that may confer a distinct advantage in achieving a higher rate of return-to-sport activity.[21]

Although only a few studies have undertaken direct comparative assessments, as highlighted previously, the majority of the existing literature consists of technical reports describing isolated outcomes rather than direct comparisons. A recent systematic review by D'Ambrosi *et al*.[15] pooled data from 643 patients across 13 studies (with various approaches and graft types), demonstrating clinically significant improvements in functional outcomes at follow-up >24 months, with mean postoperative IKDC scores improving from 51.2 to 80.2, and Lysholm scores improving from 59.8 to 86.3. Radiographic analysis showed significant improvements in posterior tibial translation, decreasing from 11.5 mm preoperatively to 3.3 mm postoperatively across studies, resulting in 90.8% return-to-sport activity rates with minimal complications.[15] Similarly, Lee *et al*.,[5] in their outcome analysis of remnant-preserving PCL reconstruction in 52 patients with Tegner activity >5 at a follow-up of 29.5 months, reported statistically significant improvement in all functional and subjective assessments postoperatively with a mean time to return to full sports activity of 9.7 months. Additionally, 73.1% and 86.5% of patients returned to their previous sports activities at 9 and 24 months, respectively. The sports experience questionnaire indicated that 48% and 69.2% of the patients were participating with unlimited effort and performance with no pain at 9 and 24 months.[9]

The parity in outcomes between the two groups in our study may be attributed to several factors, which include early recognition of the injury and consequent timely reconstruction, facilitated by the study population comprising athletes. Furthermore, early return to sport in both of our cohorts relative to the common average in the literature (12 months by Kew *et al*.[19]) may be due to the athlete population, whose strong motivation to regain athletic function may have enhanced adherence with standardized rehabilitation protocols, coupled with the operative consistency achieved through execution of both procedures by a single senior surgeon with considerable technical expertise. While the trans-septal portal technique offers distinct operative advantages, including enhanced visualization of the tibial attachment site, facilitation of anatomically accurate tunnel placement, and preservation of proprioceptive function through remnant conservation, conventional techniques, when performed diligently with standardization and adherence to surgical protocols, can achieve comparable functional outcomes. Moreover, the selection of the approach should be judicious, based on the surgeon's expertise, specific intraoperative findings, and individual patient factors, without compromising ultimate functional recovery.

The limitations of our study include a relatively small sample size, which may reduce statistical power and the precision of the outcome. Nevertheless, the study population represents a well-defined and carefully characterized clinical cohort, and the consistency of the observed trends across outcomes suggests that the findings are still informative and hypothesis-generating. Additionally, the single-center design may limit the generalizability of the findings. Despite these limitations, precise measurements and comprehensive outcome analyses strengthen the reliability of our results. Future multicenter randomized trials with larger cohorts, extended follow-up, and biomechanical evaluations could establish the efficacy and external validity of the trans-septal portal remnant-preserving PCL reconstruction technique compared with conventional methods.

CONCLUSION

The remnant-preserving method using the trans-septal portal technique demonstrated significantly superior early functional improvements and accelerated return-to-sport timelines; these advantages diminished by 12–18 months postoperatively, yielding equivalent long-term outcomes to conventional reconstruction. Although these advantages were not sustained long-term, the potential for earlier functional recovery may offer meaningful benefits for patients prioritizing rapid return to athletic activity.

AUTHORS' DISCLOSURE

We acknowledge our mentors, supporting staff, and librarian for their valuable time and support in publishing this manuscript. The corresponding author truly and with the best of knowledge affirms that this manuscript or any of its authors were not funded by any sponsors or corporations. Ethical approval was obtained from the Institutional Ethics Committee (YEC-1/2019/212); and written informed consent was obtained from all participants prior to enrolment, including consent for participation in the study and for publication of the data.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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doi: 10.36922/sti.0402