

All-Inside Arthroscopic Posterior Cruciate Ligament (PCL) Reconstruction with Internal Brace Augmentation: Review on Residual Laxity at 3- and 6-Months Post Reconstruction via Posterior Drawer Test (PDT) Assessment and Lateral Radiograph Gravity Stress View

—A Case Series of 6 Patients in Orthopaedic Department, Hospital Raja Perempuan Zainab II Kelantan

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Abstract

Background: Recurrent posterior laxity remains a significant concern following posterior cruciate ligament (PCL) reconstruction. The all-inside arthroscopic technique with internal brace augmentation is emerging as a minimally invasive option with potential benefits in graft protection and early mobilization. **Objective:** This case series evaluates the residual posterior laxity at 3 and 6 months postoperatively in six patients who underwent all-inside PCL reconstruction with internal brace augmentation. The assessment was based on the Posterior Drawer Test (PDT) and lateral gravity stress view radiographs. By critically analysing recent literature and clinical findings, this paper seeks to contribute to improved diagnosis and management strategies for PCL reconstruction failures. **Methods:** Six patients (4 males, 2 females) with isolated or combined PCL injuries underwent arthroscopic all-inside PCL reconstruction with internal brace augmentation. Clinical evaluation using the PDT and radiological assessment via lateral gravity stress view were performed at 3 and 6 months. Residual posterior tibial translation >5 mm or increasing PDT grade was considered indicative of persistent laxity. **Results:** At 3 months, four patients had Grade 0 - 1 PDT and posterior translation ranging from 3.57 mm to 5.57 mm. At 6 months, five patients maintained or improved stability. One patient showed progression from Grade 1 to Grade 2 PDT and an increase in radiographic posterior translation from 5.57 mm to 6.96 mm, suggesting pos-

sible graft elongation or failure. **Conclusion:** All-inside PCL reconstruction with internal bracing demonstrated satisfactory short-term stability in most cases. However, residual laxity may still occur, emphasizing the importance of serial clinical and radiographic evaluation. Further studies are needed to validate long-term outcomes and refine surgical indications.

Keywords

PCL, Posterior Cruciate Ligament, All-Inside Reconstruction, Internal Brace Augmentation, Residual Laxity, Posterior Drawer Test, Gravity Stress View, HRPZ

1. Introduction

Posterior cruciate ligament (PCL) injuries, while less common than anterior cruciate ligament (ACL) injuries, can significantly compromise knee stability and may lead to degenerative changes if not appropriately treated [1]. In patients with high-grade injuries or persistent symptoms, surgical reconstruction is often indicated. The all-inside arthroscopic reconstruction technique has recently become more popular due to its minimally invasive nature, which helps preserve bone stock, limits soft tissue disruption, and allows for precise graft tensioning.

However, even with technical improvements, achieving consistent postoperative knee stability remains a challenge [2]. Residual laxity, if not addressed, can impair function and may predispose the graft to eventual failure. To enhance construct durability during the early healing phase, internal brace augmentation has been introduced as a supportive measure to protect the graft under physiological loads [3].

Accurate postoperative assessment is vital to evaluating surgical success. Clinically, the Posterior Drawer Test (PDT) is widely used, while radiographically, the lateral gravity stress view offers an objective approach to quantify posterior tibial translation. Nonetheless, there is limited literature evaluating the correlation between these assessment tools in patients who have undergone all-inside PCL reconstruction with internal bracing.

This case series aims to evaluate residual posterior knee laxity in patients who underwent all-inside arthroscopic PCL reconstruction with internal brace augmentation in the Orthopaedic Department, Hospital Raja Perempuan Zainab II Kelantan, assessed through PDT and lateral gravity stress radiographs at 3 and 6 months postoperatively. The study provides insight into early postoperative stability and highlights the utility of combining clinical and radiographic assessments in guiding postoperative management.

Functionally, PCL injuries can result in altered knee kinematics, reduced quadriceps efficiency, and early onset of patellofemoral osteoarthritis, especially in chronic untreated cases [1] [4].

This study was conducted at Hospital Raja Perempuan Zainab II, a major tertiary center in Kelantan, Malaysia, where high rates of motor-vehicle-related knee

injuries are seen due to the region's urbanization and traffic density, making it a pertinent setting for such a case series.

2. Literature Review

1) Recurrent Laxity Following PCL Reconstruction

Recurrent posterior knee laxity is a known complication after PCL reconstruction, with reported rates ranging from 10% to 30% depending on variables such as surgical technique, graft type, and postoperative care protocols. Factors contributing to suboptimal outcomes include insufficient graft tensioning, misaligned tunnel placement, biological integration failure, and poor fixation strategies [5]. Previous studies underscore the importance of replicating the native PCL's biomechanical profile to minimize the likelihood of persistent posterior tibial translation.

2) All-Inside Technique in PCL Reconstruction

The all-inside arthroscopic approach has gained increasing interest due to its less invasive nature and the potential for quicker rehabilitation. This technique relies on retrograde socket formation, which minimizes disruption to bone and surrounding tissues. Nevertheless, concerns remain about initial fixation stability and the possibility of graft elongation over time, both of which may contribute to persistent laxity [6]. Outcomes compared to traditional reconstruction methods have been inconsistent, highlighting the need for more robust, long-term comparative studies.

3) Internal brace augmentation for PCL reconstruction

Recent reviews have highlighted the growing interest in internal brace augmentation (IBA) for PCL reconstruction, particularly its role in enhancing graft stability and reducing elongation under cyclic loading. A scoping review by Root *et al.* emphasized the biomechanical rationale and early clinical promise of suture tape augmentation, though it called for more long-term data to support widespread use [7].

Additionally, a narrative review by Lu *et al.* summarized the expanding role of internal bracing techniques across various knee ligament injuries, emphasizing their biomechanical benefits and clinical applicability in both primary and revision settings [8].

Our findings align with prior biomechanical studies, such as those by Trasolini *et al.*, who demonstrated that internal brace augmentation significantly reduces posterior tibial translation under cyclic loading [9]. Furthermore, clinical studies by Zhao *et al.* report sustained improvements in knee stability and function up to two years postoperatively with internal brace reinforcement [2].

However, other biomechanical studies have reported mixed outcomes with internal brace augmentation. For instance, Elbegawy *et al.* (2022) noted that while IBA may enhance initial graft stability, it did not consistently prevent postoperative laxity at short-term follow-up [10]. This discrepancy highlights the variability in outcomes and underscores the importance of contextual factors such as surgical technique and patient compliance.

4) Posterior Drawer Test in Clinical Practice

Studies have demonstrated that the PDT possesses high diagnostic accuracy. For instance, Rubinstein *et al.* reported a sensitivity of 90% and a specificity of 99% in detecting PCL tears using the PDT. The overall clinical examination accuracy for detecting PCL injuries was 96%, with higher accuracy observed in grade II and III posterior laxity compared to grade I. The posterior drawer test, which included palpation of the tibia-femur step-off, was identified as the most sensitive and specific clinical test in their study [11].

However, the test's reliability can be influenced by examiner variability and subjective interpretation. Efforts have been made to develop instrumented testing techniques to reduce these inconsistencies and enhance diagnostic accuracy.

4) Lateral Gravity Stress View as a Radiographic Tool

The lateral gravity stress view has emerged as a dependable imaging modality for assessing posterior tibial translation in a standardized and non-invasive manner [12]. Unlike kneeling stress radiographs, this technique capitalizes on gravitational force in a lateral decubitus position to elicit measurable posterior displacement. Studies have demonstrated its strong correlation with both intraoperative findings and clinical grading, making it a useful adjunct to physical examination in postoperative evaluation [13].

3. Methodology

Study Design and Population

This retrospective case series was conducted at the Orthopaedic Department of Hospital Raja Perempuan Zainab II, Kelantan. It included six patients who underwent all-inside arthroscopic posterior cruciate ligament (PCL) reconstruction augmented with internal bracing between August 2023 and June 2024. Ethical approval was obtained from the institutional review board (NMRR ID-24-00132-BSM).

Inclusion Criteria

- Patients aged 18 years and older;
- Underwent all-inside arthroscopic PCL reconstruction with internal brace augmentation;
- Availability of clinical and radiographic follow-up data at 3 and 6 months post-operatively;
- Completion of both clinical examination and radiological imaging for residual posterior laxity.

Exclusion Criteria

- Patients with a Beighton score of 5 or higher, indicating generalized ligamentous laxity;
- Revision PCL reconstruction cases;
- Incomplete follow-up data for either clinical or radiographic assessment.

Surgical Technique

- The all-inside PCL reconstruction technique utilizes a transcruciate or trans-septal approach, allowing direct arthroscopic visualization of the posterior cruciate ligament (PCL);

- A posteromedial (PM) portal is created at the soft spot located between the semimembranosus tendon and the medial head of the gastrocnemius muscle, using the Gillquist maneuver to enter the posteromedial knee compartment. Portal placement is guided intraarticularly by a needle, positioned high and away from the medial femoral condyle;
- Optionally, a posterolateral (PL) portal can be established between the biceps femoris and lateral collateral ligament (LCL). A switching stick is passed from the PM portal into the posterior notch and exits at the lateral aspect of the knee. The stick is held in position while a trocar is introduced into the PL portal, followed by the insertion of the arthroscope;
- The PCL can now be directly visualized via the PL portal for tibial tunnel preparation;
- The tibial tunnel point is marked at PCL footprint 15 mm distal to the posterior condyle of tibia plateau, superior to the popliteus muscle;
- A PCL tibial guide jig set at 55 - 65° is inserted via the anteromedial (AM) portal, with its bullet placed near the tibial crest. Under fluoroscopic guidance (II), both AP and lateral views are used to confirm the placement of the k wire—a tip of the exit wire should align with the center of the tibial plateau or just medial to the lateral tibial spine (AP view). Then the guidewire is placed approximately 7 mm from the posterior tibial cortex. The K-wire tip should exit 6 - 7 mm proximal to the “champagne drop-off” posterior slope of the tibia;
- A guidewire is then drilled, followed by protective curettage. Tunnel dilation is performed using a 3.5 mm manual dilator, and retrograde reaming is completed according to graft diameter (typically 35 mm depth for graft socket length);
- A Litenol wire is passed retrograde from the tibial cortex into the posterior notch, retrieved via the PM portal, then delivered through the intercondylar notch and exited via the AM portal. Both ends are clamped externally;
- Femoral tunnel preparation is visualized from the AM portal. The femoral footprint is identified on the medial femoral condyle at the 11 o'clock position. A guidewire is drilled through to the far cortex, and femoral tunnel depth is calculated and the femoral socket reamed accordingly;
- A passing suture is introduced into the femoral tunnel and retrieved via the AM portal along with the Litenol wire;
- The PCL allograft diameter sized 10 mm and length 90 mm augmented with 2 mm suture tape are loaded into the Litenol wire and advance from the AM portal through the notch and into the tibial tunnel. Tension is applied until the infinity adjustable loop button exits and is visualized externally at tibia tunnel.
- The femoral end sutures are passed through the AM portal and drawn medially until the XO button flips securely on the femoral cortex;
- Tension is applied to the graft sutures at the tibia side to ensure the graft is taut;
- Final fixation is performed with the knee positioned at 90° flexion while applying an anterior drawer force.

Postoperative Rehabilitation Protocol

Patients followed a structured rehabilitation regimen:

- **Immediately post-operation:** Immobilization in a posteriorly supported cylinder backslab in knee extension. After wound inspection at day 3, the backslab was replaced with a full cylinder cast for two weeks;
- **Weeks 0 - 2:** Initiation of static quadriceps exercises, ankle pumps, straight leg raises, and hip abduction/adduction; no weight bearing permitted on operated leg, ambulation with crutches;
- **Weeks 3 - 4:** Transition to a PCL-specific brace; passive range of motion exercises (0° - 60° in prone), patellar mobilization, and cryotherapy or ice compression were introduced;
- **Weeks 5 - 6:** Gradual increase of passive range of motion up to 90° , progressing to full flexion by week 12;
- **After week 6:** Partial weight bearing was initiated, advancing to full weight bearing by week 12;
- **After 3 months:** PCL brace was advised to continue till 6 months. PCL brace was off during the range of motion exercise to achieve full knee flexion;
- **Return to sports:** Permitted after 9 - 12 months depending on functional recovery.

All patients were supervised by the same physiotherapist throughout the post-operative period to ensure consistency in rehabilitation.

Assessment of Residual Laxity

Clinical Evaluation—Posterior Drawer Test (PDT):

Posterior knee stability was assessed using the PDT at both 3 and 6 months postoperatively. The test was graded as follows:

- **Grade 0:** No posterior translation.
- **Grade 1:** 0 - 5 mm.
- **Grade 2:** 6 - 10 mm.
- **Grade 3:** >10 mm.

Radiographic Evaluation—Lateral Gravity Stress View:

Posterior tibial translation was quantified using the lateral gravity stress radiograph, analyzed via the Picture Archiving and Communication System (PACS). A difference greater than 5 mm at 3 and 6 months was considered indicative of significant residual laxity. Measurements were based on parallel lines drawn through the posterior cortex of the tibial shaft intersecting the posterior margins of the femoral condyle and tibial plateau.

To ensure objectivity, two fellowship-trained sports orthopaedic surgeons independently assessed both the clinical and radiographic parameters.

Inter-rater reliability for PDT grading between the two surgeons was calculated using Cohen's κ and showed substantial agreement ($\kappa = 0.76$), supporting the reliability of the clinical assessments.

4. Data Analysis

Patient demographics, injury mechanism, associated injuries, PDT grades, and radiographic measurements were compiled and analysed descriptively.

5. Results

A total of six patients (four males and two females) with a mean age of 28.7 years underwent arthroscopic all-inside PCL reconstruction with internal brace augmentation (Table 1). The majority of cases (five out of six) were secondary to motor vehicle accidents, while one injury occurred during work-related activities. The mean interval from injury to surgical intervention was 17.3 months. Given the small sample size, this study should be regarded as exploratory. Findings are intended to guide hypotheses for future investigations rather than draw definitive conclusions. Percentages (e.g., “33.3% of patients”) should be interpreted cautiously due to the limited sample.

Table 1. Demographic data of the patients.

Patient No.	Sex	Age	Race	Mechanism of Injury	Diagnosis	Time from Injury to Surgery	Surgery Performed
1	Male	22	Malay	Motor Vehicle Injury	1) Right Posterior Cruciate Ligament complete tear 2) Right Posterior Lateral Corner injury 3) Anterior horn right meniscus tear	18 months	1) Arthroscopic right knee all inside Posterior Cruciate Ligament reconstruction with allograft 2) modified Larson procedure using allograft 3) arthroscopic right lateral meniscus repair
2	Male	36	Malay	Fall at workplace	1) Left Posterior Cruciate Ligament complete tear 2) Left Posterior Lateral Corner injury	15 months	1) Arthroscopic left knee all inside Posterior Cruciate Ligament reconstruction with allograft 2) Modified Larson procedure using allograft
3	Female	23	Malay	Motor Vehicle Injury	1) Left Posterior Cruciate Ligament complete tear 2) Left Posterior Lateral Corner injury 3) Left medial and lateral meniscus injury	22 months	1) Arthroscopic left knee all inside Posterior Cruciate Ligament reconstruction with allograft 2) Modified Larson procedure using allograft 3) Arthroscopic left lateral and medial meniscus repair
4	Female	22	Malay	Motor Vehicle Injury	1) Left Anterior and Posterior Cruciate Ligament complete tear 2) Left Posterior Lateral Corner injury 3) Chondral injury of medial femoral condyle, medial and lateral tibial plateau	12 months	1) Arthroscopic left knee all inside Posterior Cruciate Ligament and Anterior Cruciate Ligament reconstruction with allograft 2) Modified Larson procedure using allograft 3) Chondroplasty procedure
5	Male	38	Malay	Motor Vehicle Injury	1) Right Posterior Cruciate Ligament complete tear 2) Right Posterior Lateral Corner injury 3) Chondral injury of lateral femoral condyle, medial tibia plateau, medial patella facet	7 months	1) Arthroscopic right knee all inside Posterior Cruciate Ligament reconstruction with allograft 2) Modified Larson procedure using allograft 3) Chondroplasty procedure
6	Male	31	Malay	Motor Vehicle Injury	1) Right Anterior and Posterior Cruciate Ligament complete tear 2) Right Posterior Lateral Corner injury 3) Right lateral meniscus tear	30 months	1) Arthroscopic right knee all inside Posterior Cruciate Ligament and Anterior Cruciate Ligament reconstruction with allograft 2) Modified Larson procedure using allograft 3) Right lateral meniscus repair

Clinical and Radiographic Outcomes:

- At the 3-month follow-up:

Posterior Drawer Test (PDT) (Table 2):

- Grade 0: 2 patients.
- Grade 1: 4 patients.

Posterior Tibial Translation (PTT) via Lateral Gravity Stress View (Figure 1):

- Ranged from 3.57 mm to 5.60 mm.

At the 6-month follow-up:

PDT Findings:

- Grade 0: 2 patients.
- Grade 1: 2 patients.
- Grade 2: 2 patients.

PTT Measurements:

- Two patients demonstrated an increase in posterior translation, measuring 6.96 mm and 6.85 mm, respectively.

Detailed Patient Outcomes:

Table 2. Distribution of PDT grades at 3 and 6 months postoperatively.

Patient	PDT at 3 Months	PDT at 6 months	Gravity Stress View at 3 Months	Gravity Stress View at 6 Months
1	Grade 1	Grade 1	5.16 mm	5.51 mm
2	Grade 1	Grade 1	5.10 mm	5.45 mm
3	Grade 0	Grade 0	3.57 mm	4.22 mm
4	Grade 1	Grade 2	5.57 mm	6.96 mm
5	Grade 0	Grade 0	4.10 mm	4.23 mm
6	Grade 1	Grade 2	5.60 mm	6.85 mm

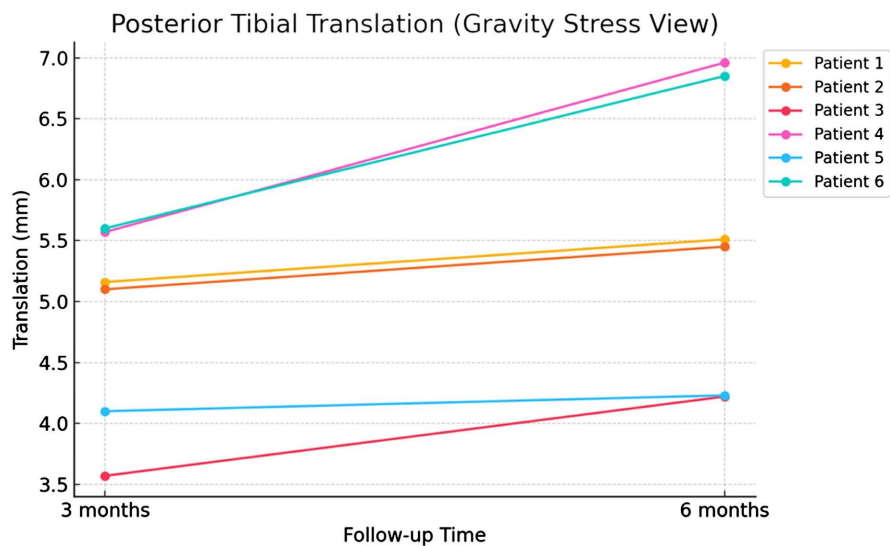


Figure 1. Posterior tibial translation (mm) was measured via lateral gravity stress radiographs at 3 and 6 months.

Most patients exhibited stable or improved outcomes between 3 and 6 months. Notably, Patient 4 and Patient 6 showed increases in posterior tibial translation and PDT grades, suggesting early graft insufficiency or potential non-compliance. Conversely, Patient 3 maintained excellent outcomes with minimal translation (3.57 - 4.22 mm).

6. Discussion

Recurrent laxity following all-inside PCL reconstruction poses a significant clinical dilemma. Although the technique offers advantages such as reduced invasiveness and preservation of native anatomy, the recurrence of posterior translation may indicate biomechanical insufficiencies. In particular, insufficient initial graft tension, tunnel misalignment, or suboptimal fixation can compromise graft function. Graft creep and stress relaxation over time may further contribute to laxity.

The posterior drawer test, while useful for quick bedside evaluation, presents limitations in consistency due to its subjective nature and examiner dependency. Despite these limitations, it remains valuable when interpreted in conjunction with radiologic findings. Clinicians must be trained in proper grading and comparison with the contralateral knee to improve diagnostic accuracy.

The lateral gravity stress view radiograph has emerged as a robust and objective assessment tool. Its non-invasive nature, ease of performance, and reproducibility make it especially useful in postoperative evaluations. It allows for quantification of posterior tibial translation, helping differentiate between normal postoperative laxity and true reconstruction failure.

Combining both modalities provides a more comprehensive assessment strategy. Serial measurements using lateral gravity stress views can track graft behaviour over time, while the posterior drawer test offers immediate clinical correlation. Future studies should aim to establish normative values for postoperative translation in all-inside PCL reconstructions and determine thresholds for revision consideration.

Furthermore, standardized protocols in surgical technique, graft fixation, and rehabilitation may reduce the variability in outcomes. Comparative studies between traditional and all-inside methods with long-term follow-up are necessary to validate the durability and effectiveness of the all-inside approach.

The 6-month follow-up was selected to capture early postoperative outcomes and detect early graft failures, which are critical in guiding rehabilitation protocols. Nonetheless, extended follow-up is planned to assess longer-term graft behaviour and patient-reported functional outcomes.

This case series demonstrates that all-inside PCL reconstruction with internal bracing generally provides satisfactory short-term outcomes. However, two patients (33.3%) exhibited recurrent posterior laxity at 6 months.

This case series reviewed residual laxity following all-inside arthroscopic posterior cruciate ligament (PCL) reconstruction with internal bracing augmentation, with a focus on clinical and radiological assessments at 3 and 6 months post-

operatively. The findings suggest that the all-inside technique generally provides acceptable short-term posterior stability, though a subset of patients may exhibit progressive laxity.

The majority of patients in this study maintained or improved posterior stability by the 6-month follow-up. Specifically, five of six patients (83.3%) showed stable or improved results based on the Posterior Drawer Test (PDT) and gravity stress radiographs. This aligns with existing literature, which supports the biomechanical strength and favourable outcomes of all-inside PCL reconstruction using suspensory fixation devices.

However, two patients demonstrated deterioration in both clinical and radiographic parameters between the 3- and 6-month evaluations. Patients 4 and 6, who developed increased laxity, shared factors such as multi-ligament injuries and longer preoperative intervals. These cases may reflect the influence of delayed surgical timing, complex injury patterns, or surgeon experience during the early learning curve of the all-inside PCL technique.

This progression also could be attributed to other factors, including inadequate graft incorporation, early graft stretching, or non-compliance with rehabilitation protocols.

Radiographic evaluation using the lateral gravity stress view served as a useful adjunct to clinical assessment. The mean increase in posterior tibial translation between the 3- and 6-month intervals was modest, suggesting that in most cases, the graft continued to provide adequate restraint.

Despite internal brace augmentation, careful follow-up remains essential.

The modest increase in posterior translation observed in most cases may be within the expected physiological range during ligament remodelling. However, the presence of progressive instability in select patients highlights the importance of early identification and potential intervention. Future studies should aim to define normative thresholds for acceptable postoperative laxity specific to all-inside PCL reconstruction.

Additionally, variations in surgical technique, graft fixation methods, and rehabilitation adherence likely influence postoperative outcomes. The optional use of posterolateral portals and individualized rehabilitation adjustments could introduce heterogeneity in outcomes. While these variations reflect real-world practice, they may confound interpretation and underscore the need for protocol standardization in future studies. Standardization of these parameters may help reduce variability and improve long-term success. Comparative studies evaluating traditional versus all-inside reconstruction approaches with longer follow-up periods are necessary to further delineate the durability of this technique.

Limitations include a small sample size and short-term follow-up. Larger studies are needed.

7. Conclusions

Residual posterior laxity remains a relevant concern following all-inside PCL re-

construction, even with the addition of internal brace augmentation [3]. Although this minimally invasive technique offers advantages such as bone preservation and controlled graft tensioning, questions remain regarding long-term graft stability and the effectiveness of current fixation strategies.

This case series demonstrated that most patients achieved satisfactory posterior knee stability by the 6-month postoperative mark. Five out of six patients showed either maintained or improved outcomes based on both clinical (PDT) and radiographic (gravity stress view) assessments. However, the occurrence of increased laxity in two patients underscores the need for careful follow-up, especially in the early rehabilitation phase.

The Posterior Drawer Test remains a practical clinical tool for evaluating knee stability, but its diagnostic reliability improves when complemented by objective radiographic techniques such as the lateral gravity stress view. Together, these modalities offer a more holistic approach to postoperative assessment and decision-making.

To enhance surgical outcomes, future research should focus on standardizing operative techniques, identifying critical thresholds for intervention, and correlating imaging findings with functional and patient-reported outcomes. Larger-scale studies with extended follow-up will be essential in establishing the long-term viability of the all-inside technique with internal bracing.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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