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Association Between Lesion-Directed Positioning Management and Early Functional Recovery Following PRP-Augmented Meniscal Repair: A Retrospective Cohort Study

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Research Article

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Abstract

Background

Platelet-rich plasma (PRP) serves as a biological augment for meniscal repair; however, evidence regarding strategies to optimize the local retention and distribution of PRP at the repair site in the postoperative period remains scarce. Postoperative positioning protocols administered by nursing personnel may modulate the gravitational distribution of PRP at the repair site and consequently influence early functional recovery, yet this hypothesis has not been investigated. This study aimed to evaluate the association between nurse-led, lesion site–directed positioning and early patient-reported outcomes following PRP-augmented arthroscopic meniscal repair.

Methods

This single-center retrospective cohort study included 53 consecutive patients who underwent arthroscopic meniscal repair supplemented with intra-articular PRP injection at the conclusion of surgery between April 2024 and January 2025. Patients were stratified into a directed positioning group (n = 23) or a conventional positioning group (n = 30) based on whether a lesion site–directed positioning protocol was implemented postoperatively. Primary outcomes included the International Knee Documentation Committee (IKDC) subjective score, Lysholm score, Tegner activity level score, and Numeric Rating Scale (NRS) pain score assessed at 1, 3, and 12 months postoperatively. Postoperative complications and reoperations were also documented. This study was reported in accordance with the STROBE guidelines.

Results

Baseline demographic characteristics, meniscal tear morphology and location, and preoperative patient-reported outcome measures were comparable between groups. The directed positioning group exhibited significantly superior IKDC and Lysholm scores at 1 and 3 months postoperatively compared with the conventional positioning group (both $P < 0.05$). At 3 months, the directed positioning group also demonstrated a significantly higher Tegner activity level score and a significantly lower NRS pain score (both $P < 0.05$). By 12 months postoperatively, no statistically significant between-group differences were detected in any of the outcome measures (all $P > 0.05$). No cases of surgical site infection, deep vein thrombosis, or arthrofibrosis necessitating arthroscopic lysis of adhesions were recorded in either group, and no patient underwent reoperation.

Conclusions

In patients undergoing PRP-augmented arthroscopic meniscal repair, nurse-led lesion site–directed positioning was associated with improved patient-reported functional outcomes during the first 3

postoperative months and reduced pain at 3 months. Given its low cost, ease of implementation, and feasibility of independent execution by nursing staff, this positioning strategy warrants integration into orthopedic nursing practice; nevertheless, its clinical efficacy necessitates confirmation through well-designed prospective trials.

Background

The meniscus serves critical biomechanical functions including load transmission, shock absorption, joint stabilization, and chondroprotection. Meniscal injuries are prevalent among athletes and physically active individuals, potentially resulting in pain, functional impairment, and secondary osteoarthritic degeneration [1]. Owing to the marked regional variation in meniscal vascularity—particularly the limited healing capacity of the avascular inner zone—a non-negligible risk of repair failure and subsequent reoperation persists even after arthroscopic suture repair [2]. Platelet-rich plasma (PRP), which harbors a concentrated array of platelet-derived growth factors and bioactive mediators, has been increasingly employed as a biological augment for musculoskeletal injuries [3]. In recent years, PRP has been incorporated into meniscal repair protocols; however, the available clinical evidence remains conflicting: certain studies suggest potential benefits in terms of pain relief, functional improvement, or reduced failure rates, whereas others have failed to demonstrate a definitive advantage [4]. Substantial heterogeneity in PRP preparation protocols, cellular composition, dosage, delivery method, injection timing, patient selection criteria, and concomitant surgical procedures may collectively confound study outcomes [5–7].

Prior investigations have predominantly centered on PRP utilization, preparation protocols, and injection dosage and frequency, while the post-injection local distribution of PRP and the influence of postoperative management factors have received comparatively limited attention [8, 9]. Once liquid PRP is introduced into the joint cavity or the repair site, its local distribution is likely governed by multiple factors, including residual intra-articular effusion, gravitational positioning, joint kinematics, and tissue contact dynamics [10]. Accordingly, adopting a targeted postoperative position tailored to the specific site of meniscal injury may theoretically optimize the contact interface between PRP and the repair zone. Nevertheless, direct imaging-based or clinical evidence confirming that such "lesion site–directed positioning management" can enhance postoperative outcomes following meniscal repair remains absent.

Using a retrospective cohort design, this study compared early clinical outcomes between patients who underwent identical PRP-augmented meniscal repair followed by either lesion site–directed positioning or conventional postoperative positioning. The primary focus was on longitudinal changes in knee function, activity level, and pain at serial postoperative time points, with secondary exploration of the association between positioning strategies and the incidence of complications and reoperations.

From a nursing practice perspective, postoperative positioning management constitutes a non-pharmacological intervention that falls within the autonomous scope of nursing care. This study aimed

to investigate the impact of nurse-led, lesion site–directed positioning management on early functional recovery following PRP-augmented meniscal repair, thereby generating evidence to inform evidence-based orthopedic nursing practice.

Methods

Study design and participants

This single-center retrospective cohort study enrolled consecutive patients who underwent arthroscopic meniscal repair supplemented with intraoperative PRP injection at the Department of Sports Medicine, Fujian Medical University Union Hospital, between April 2024 and January 2025. Data extracted included age, sex, body mass index (BMI), meniscal tear type and location, number of PRP injections administered, and preoperative scores on the IKDC subjective form, Lysholm knee scoring scale, Tegner activity level scale, and NRS pain scale. This report was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Additional file 1).

Inclusion criteria were as follows: (1) age between 18 and 60 years; (2) meniscal injury diagnosed on the basis of clinical examination and magnetic resonance imaging (MRI), confirmed arthroscopically, and treated with meniscal repair; (3) PRP injection administered at the conclusion of surgery; (4) minimum postoperative follow-up of 12 months; and (5) complete documentation of postoperative positioning protocol and primary outcome data retrievable from medical records. Exclusion criteria were as follows: (1) knee osteoarthritis classified as Kellgren–Lawrence grade ≥ 3; (2) concurrent knee joint infection, neoplasm, or severe vascular or neurological pathology; (3) history of prior surgical intervention on the ipsilateral knee; and (4) concomitant anterior cruciate ligament (ACL) reconstruction.The flow diagram illustrating patient screening and inclusion criteria is presented in Fig. 1.

The study protocol was approved by the Institutional Ethics Committee of Fujian Medical University Union Hospital (Approval No.: 2026KY668). The requirement for individual informed consent was waived owing to the retrospective nature of the study.

Surgical procedure and PRP injection

All patients underwent arthroscopic meniscal repair performed by the same surgical team. A single PRP injection was administered at the conclusion of surgery, and no repeat PRP injection was performed within the subsequent 12-month period. Fifteen milliliters of peripheral venous blood was aspirated from each patient and processed using a Type I centrifuge (Production No. K20240701; Beijing Huizhong International Medical Device Co., Ltd., Beijing, China) combined with a PRP preparation kit (Model ABS-10010; Catalog Nos. ABS-10014 and ABS-10014-E; Arthrex, Inc., Naples, FL, USA) to yield approximately 5–6 mL of PRP. Upon completion of the repair, residual intra-articular irrigation fluid was aspirated as thoroughly as possible under direct arthroscopic visualization, after which the prepared PRP was injected directly into the meniscal repair site.

Postoperative positioning protocol

Directed positioning group. Postoperatively, the primary assigned nurse implemented and supervised a site-specific positioning protocol tailored to the location of the meniscal lesion, as detailed below: For posterior horn tears: supine position with the knee maintained at 15°–30° of flexion(Fig. 2); for medial meniscal body tears: contralateral lateral decubitus position(Fig. 3); for lateral meniscal body tears: ipsilateral lateral decubitus position with the affected knee in full passive extension(Fig. 4). The positioning protocol was initiated by nursing staff immediately upon recovery from anesthesia; the prescribed position was maintained continuously for 18 hours, after which patients were permitted to assume a position of their own choosing. During the first three postoperative days, the targeted position was maintained for a minimum of 18 hours per day. The directed positioning protocol was administered by a dedicated nursing team that had completed a standardized training program prior to study initiation. Nursing staff monitored protocol adherence at hourly intervals during the first 24 hours postoperatively and at 2-hour intervals from 24 to 72 hours postoperatively.

Conventional positioning group. No lesion site–directed positioning was implemented; the assigned nurse positioned patients according to standard postoperative nursing protocols (e.g., elevation of the affected extremity, unrestricted recumbent positioning), without any additional site-specific positioning intervention.

Postoperative rehabilitation protocol

Both groups followed identical foundational principles of postoperative analgesia, edema management, and rehabilitation. Ankle pump exercises were initiated in all patients immediately upon recovery from anesthesia. The tear type–specific rehabilitation protocols are detailed below.

For longitudinal tears (including bucket-handle tears): early postoperative rehabilitation emphasized multi-angle quadriceps isometric contractions, straight leg raises, and resistance band terminal knee extension, supplemented by neuromuscular electrical stimulation (NMES) and blood flow restriction (BFR) training to attenuate muscle atrophy; hamstring exercises were restricted to proximal hip hinge and bridging movements designed to minimize shear loading [11]. Rehabilitation was stratified by tear length: tears < 3 cm permitted progressive full weight-bearing as tolerated without prolonged bracing, with early range of motion (ROM) of 0°–125°; tears ≥ 3 cm required hinged brace immobilization for 8 weeks with partial weight-bearing maintained and flexion restricted to ≤ 125°; strengthening exercises were designed to avoid anterior tibial shear during terminal extension (0°–40°) and posterior tibial shear during deep flexion (> 30°) [12].

For horizontal tears: given the inherently limited resistance to flexion and shear forces at the repair site, a conservative rehabilitation protocol was implemented [12]. Toe-touch partial weight-bearing was progressed beginning at 4 weeks postoperatively; knee flexion was restricted to ≤ 60° during the first 4 weeks and gradually advanced to 90° between weeks 4 and 8; early strengthening exercises were

designed to minimize intra-articular shear stress—quadriceps training was limited to shear-free isometric contractions and straight leg raises, with early large-arc resisted knee extension avoided; resisted hamstring knee flexion was deferred, and only proximal hip-driven bridging and hip hinge exercises were permitted [13].

For radial tears: given the complete disruption of circumferential load-bearing fibers, weight-bearing progression was deliberately conservative. Toe-touch protective weight-bearing was maintained for 4–6 weeks, with all forms of full weight-bearing and axial impact loading strictly prohibited; knee flexion was limited to ≤ 60° during the first 4 weeks and progressively advanced to 90° between weeks 4 and 8; early strengthening was restricted to fixed-angle quadriceps isometric contractions and straight leg raises, avoiding anterior shear during terminal extension (40°–0°) and posterior shear during flexion beyond 30°; resisted hamstring leg curls were contraindicated, with only proximal stabilization exercises retained; BFR and NMES were employed to preserve muscle cross-sectional area and prevent disuse atrophy; open and closed kinetic chain strengthening was cautiously progressed only after adequate passive ROM and weight-bearing tolerance were restored [14].

For meniscal root tears: root tears result in complete loss of circumferential hoop stress transmission and represent the most rehabilitation-restrictive tear pattern. Weight-bearing was restricted to strict protective offloading with toe-touch contact only for 4–6 weeks; knee flexion was limited to ≤ 60° during the first 4 weeks, with deep flexion beyond 90° strictly prohibited; early strengthening prioritized NMES to maintain quadriceps activation and mitigate atrophy, with only shear-free isometric contractions permitted; for medial posterior root tears, resisted hamstring training was specifically deferred; low-load strengthening was gradually introduced after preliminary biological stabilization of the repair at approximately 8 weeks postoperatively [15].

For combined (complex) tears: toe-touch progressive partial weight-bearing was implemented for 4–6 weeks, with early full weight-bearing and impact loading prohibited; knee flexion was restricted to ≤ 60° within the first 4 weeks, and a hinged brace was applied during weeks 6–8 with ROM gradually advanced to 90°; early strengthening consisted of zero-shear quadriceps isometric exercises, straight leg raises, and proximal hamstring stabilization, supplemented by electrical stimulation and BFR training to preserve muscle function; all resisted exercises generating anterior or posterior tibial shear forces were contraindicated [12, 13].

For ramp lesions: early progressive weight-bearing was permitted as tolerated by the patient; pain-free active ROM from 0° to 90° was encouraged early; early strengthening could incorporate shear-free closed kinetic chain exercises, with NMES and BFR routinely applied to both quadriceps and hamstrings to accelerate strength recovery; no specific exercise contraindications applied [16].

Outcome measures

Knee function and activity level. The International Knee Documentation Committee (IKDC) subjective knee evaluation form, Lysholm knee scoring scale, and Tegner activity level scale were assessed preoperatively and at 1, 3, and 12 months postoperatively.

Pain

Pain intensity was quantified using the Numeric Rating Scale (NRS), administered preoperatively and at 1, 3, and 12 months postoperatively.

Complications and reoperations.

Recorded complications included postoperative surgical site infection, deep vein thrombosis, arthrofibrosis necessitating repeat arthroscopic lysis of adhesions, and any meniscus-related reoperation.

Statistical analysis

All statistical analyses were performed using SPSS software (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation or median (interquartile range) based on their distributional properties; between-group comparisons were conducted using the independent-samples t-test or Mann–Whitney U test, as appropriate. Categorical variables were reported as frequencies (n) and percentages (%), and compared using the Pearson chi-squared test or Fisher's exact test, depending on expected cell frequencies. All statistical tests were two-tailed, with a significance threshold set at $P < 0.05$.

Results

Baseline characteristics

A total of 53 consecutive patients who underwent arthroscopic meniscal repair with intraoperative PRP injection were ultimately included in the analysis, of whom 23 were assigned to the directed positioning group and 30 to the conventional positioning group. Baseline demographic and clinical characteristics, including age, sex, BMI, meniscal tear type and location, number of PRP injections, and preoperative IKDC, Lysholm, Tegner, and NRS scores, were comparable between the two groups (Table 1). Given the non-randomized retrospective design of this study, the absence of statistically significant baseline differences does not preclude the possibility of residual confounding; therefore, clinically meaningful potential confounders should be considered in the interpretation of subsequent analyses.

Table 1
Baseline characteristics of patients

Characteristics	Injury-site-guided position group (n = 23)	Routine position group (n = 30)	*P*-value
Age (years)	33.8 ± 10.4	33.6 ± 10.5	0.906
Male, n (%)	12(52.2%)	13 (43.3%)	0.523
BMI(kg/m²)	23.1 ± 2.0	23.2 ± 1.9	0.814
Meniscal tear type, n (%)			0.935
Longitudinal tear	8 (34.8%)	11 (36.7%)	
Horizontal tear	8 (34.8%)	9 (30.0%)	
Radial tear	4 (17.4%)	4 (13.3%)	
Oblique tear	1 (4.3%)	3 (10.0%)	
Complex tear	2 (8.7%)	3(10.0%)	
Location of meniscal injury, n (%)			0.949
Posterior horn	14 (60.9%)	18 (60.0%)	
Body	9 (39.1%)	12 (40.0%)	
Pre-operative NRS pain score	3.7 ± 2.2	3.5 ± 1.8	0.255

Postoperative knee function and activity level

In unadjusted between-group comparisons, the directed positioning group demonstrated significantly superior IKDC and Lysholm scores at 1 and 3 months postoperatively relative to the conventional positioning group (both $P < 0.05$). At 3 months, the directed positioning group also exhibited a significantly higher Tegner activity level score ($P < 0.001$), whereas no statistically significant between-group differences were observed at 1 or 12 months. By 12 months postoperatively, between-group differences in IKDC and Lysholm scores were no longer statistically significant (Table 2).

Table 2
Comparison of postoperative knee joint function and activity level scores (x ± s, points)

Functional outcomes	Injury-site-guided position group (n = 23)	Routine position group (n = 30)	*P-value*
IKDC score			
Preoperative	57.7(44.8–69.9)	57.1(41.4–69.6)	0.987
1-month post-operatively	78.6(72.6–84.6)	65.6(60.1–73.7)	0.002
3-month post-operatively	92.5(88.5–97.0)	82.8(78.6–90.9)	0.001
12-month post-operatively	96.0(95.0–98.0)	95.5(90.8–97.7)	0.12
Lysholm score			
Preoperative	62.0(46.0–79.0)	65(50.0–78.0)	0.792
1-month post-operatively	80.0(73.0–88.0)	70.0(63.0–77.0)	0.002
3-month post-operatively	94(90.0-100.0)	86.0(80.0–94.0)	0.001
12-month post-operatively	98.0(95.0-100.0)	96.0(89.0-100.0)	0.089
Preoperative			
Tegner activity level score	4.0(4.0–5.0)	4.0(4.0–5.0)	0.781
1-month post-operatively	1.0(1.0–2.0)	1.0(0.0–1.0)	0.031
3-month post-operatively	2.0(2.0–3.0)	1.0(1.0–2.0)	0.002
12-month post-operatively	4.0(3.0–5.0)	3.0(3.0–4.0)	0.01

Pain

At 3 months postoperatively, the directed positioning group reported significantly lower NRS pain scores compared with the conventional positioning group (P = 0.010); no statistically significant between-group differences in NRS pain scores were detected at 1 or 12 months (Table 3).

Table 3
Comparison of Postoperative NRS Pain Scores (x ± s,points)

NRS	Injury-site-guided position group (n = 23)	Routine position group (n = 30)	*P*--value
1-month post-operatively	2.0 ± 1.1	2.1 ± 1.1	0.56
3-month post-operatively	0.4 ± 0.7	1.1 ± 1.1	0.01
12-month post-operatively	0.3 ± 0.7	0.4 ± 0.9	0.551

Reoperations and complications

No cases of surgical site infection, deep vein thrombosis, or arthrofibrosis necessitating arthroscopic lysis of adhesions were documented in either group throughout the follow-up period. No patient underwent reoperation during the study period.

Discussion

The principal finding of this study is that, among patients undergoing PRP-augmented arthroscopic meniscal repair, lesion site–directed positioning was associated with superior patient-reported functional outcomes during the first 3 postoperative months and reduced pain at 3 months; by 12 months, functional, activity level, and pain scores had converged between groups. No serious postoperative complications were observed in either group; however, given the limited sample size and the low event rate, no definitive safety conclusions can be drawn. These findings suggest that postoperative positioning management may influence the early recovery trajectory, although the current evidence should be regarded as exploratory.

The clinical utility of PRP as a biological augment for meniscal repair remains a subject of ongoing debate. A systematic review by Liang et al. suggested that PRP may improve certain pain and functional outcomes while reducing the risk of treatment failure [17]; conversely, Yang et al. failed to demonstrate definitive additional functional benefits with multiple postoperative intra-articular PRP injections, and other meta-analyses have similarly highlighted substantial inter-study heterogeneity [18]. These discordant findings indicate that the clinical efficacy of PRP is likely contingent not merely on its administration per se, but also on a constellation of factors including preparation methodology, cellular composition, delivery route, injection timing, repair technique, rehabilitation strategy, and patient-specific characteristics [19, 20]. Accordingly, the present study explored postoperative positioning as a modifiable postoperative management variable, representing a clinically feasible avenue of investigation.

The theoretical rationale underlying this study is that, following injection of liquid PRP into the repair site, gravitational forces and limb positioning may modulate the short-term local distribution of PRP and its contact interface with the meniscal repair zone [21]. However, this study did not employ imaging-based

tracer techniques or biomarker assays to directly demonstrate that directed positioning enhances PRP concentration at the target site, prolongs local retention, or alters growth factor exposure kinetics. Consequently, the present data support only an association between positioning management and early clinical outcomes; a causal mechanism mediated through local PRP enrichment cannot be established. It is particularly noteworthy that the release of the majority of platelet-derived factors from PRP occurs predominantly during the early phase [22]; therefore, symptom differences observed at several months postoperatively are more plausibly attributed to the cumulative effects of early biological stimulation, tissue repair cascades, and rehabilitation behaviors, rather than to sustained intra-articular PRP release over months. From a nursing practice perspective, the directed positioning protocol described herein offers several distinct advantages: first, it is low-cost, requiring no additional equipment or consumables; second, it is readily implementable, as nurses can acquire competency after brief standardized training; third, it is non-invasive and does not impose additional risk or discomfort on patients. Accordingly, even at this preliminary stage of evidence, the protocol may be considered a low-risk, potentially beneficial intervention worthy of broader implementation.

Temporally, the advantage of the directed positioning group was confined primarily to the first 3 postoperative months, with between-group differences attenuating by 12 months. This temporal pattern is more consistent with an interpretation of accelerated early recovery rather than sustained improvement in long-term outcomes. Early postoperative IKDC, Lysholm, and Tegner scores are influenced not only by biological meniscal healing but also substantially by weight-bearing restrictions, brace utilization, pain management, range of motion recovery, and rehabilitation adherence [23]. Future studies should therefore rigorously standardize rehabilitation protocols and document adherence, report effect sizes with 95% confidence intervals for between-group differences, and interpret statistical findings in the context of the minimal clinically important difference (MCID) or patient acceptable symptom state (PASS), rather than relying exclusively on P-values to judge treatment efficacy.

The mechanism underlying the NRS score difference observed at 3 months postoperatively cannot be definitively elucidated from the present data. One plausible explanation is that early differences in the local biological milieu and rehabilitation trajectory gradually manifest as divergences in pain and activity levels over weeks to months [24]; alternatively, residual confounding from unmeasured rehabilitation behaviors, injury characteristics, or procedural details may account for the observed difference. The convergence of scores by 12 months suggests that, even if positioning management exerts a genuine effect, it is more likely to influence the velocity of recovery rather than the ultimate functional ceiling. Furthermore, as neither second-look arthroscopy nor PRP tracing was performed, it is not possible to infer from patient-reported outcomes alone that PRP exhibited prolonged retention at the injury site or that directed positioning accelerated the biological healing process.

This study is subject to several limitations. First, the retrospective, non-randomized allocation may introduce selection bias and confounding by indication, and the sample size is modest; although certain baseline variables were similarly distributed between groups, the possibility of unmeasured confounding cannot be excluded. Second, critical PRP preparation parameters—including platelet concentration,

leukocyte content, and activation method—were not adequately characterized or reported. Third, early functional outcomes are highly contingent upon the rehabilitation protocol, which should be comprehensively reported and confirmed to be equivalent between groups. Fourth, this study did not provide objective assessment of medium- to long-term structural healing (e.g., second-look arthroscopy or advanced imaging), nor did it directly quantify intra-articular PRP distribution; consequently, the proposed mechanistic hypothesis cannot be substantively validated. Fifth, longitudinal outcomes should ideally be analyzed using statistical models appropriate for repeated measures (e.g., linear mixed-effects models), with interpretation anchored to effect sizes, 95% confidence intervals, and established clinical importance thresholds. Prospective, multicenter studies incorporating imaging-based PRP tracing are warranted to further validate the present findings. Sixth, this study did not systematically evaluate patient adherence to the positioning intervention, inter-nurse consistency in protocol delivery, or patient acceptability and satisfaction with the positioning regimen; these parameters should be incorporated as predefined endpoints in future prospective trials.

Conclusions

In this retrospective cohort, nurse-led, lesion site–directed positioning was associated with superior patient-reported knee function during the first 3 postoperative months and reduced pain at 3 months following PRP-augmented arthroscopic meniscal repair. As a low-cost, readily implementable postoperative nursing intervention that falls within the autonomous scope of nursing practice, this positioning strategy holds promise for broader clinical adoption. Given the retrospective design and modest sample size of the present study, well-designed prospective trials incorporating standardized nursing care pathways are warranted to confirm its clinical efficacy and elucidate the underlying mechanism of action.

Abbreviations

ACL
Anterior cruciate ligament
BFR
Blood flow restriction
BMI
Body mass index
IKDC
International Knee Documentation Committee
MCID
Minimal clinically important difference
MRI
Magnetic resonance imaging
NMES
Neuromuscular electrical stimulation

NRS
Numeric Rating Scale
PASS
Patient acceptable symptom state
PRP
Platelet-rich plasma
ROM
Range of motion
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Ethics Committee of Fujian Medical University Union Hospital (Approval No.: 2026KY668). The requirement for individual informed consent was waived by the Ethics Committee owing to the retrospective nature of the study and the use of de-identified data. All procedures were performed in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Xinxin Cheng: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft. Shixin Nie: Data curation, Investigation, Formal analysis. Biwen Lu: Data curation, Investigation, Validation. Hua Zhang: Conceptualization, Supervision, Project administration, Writing – review & editing. All authors read and approved the final manuscript.

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Figures

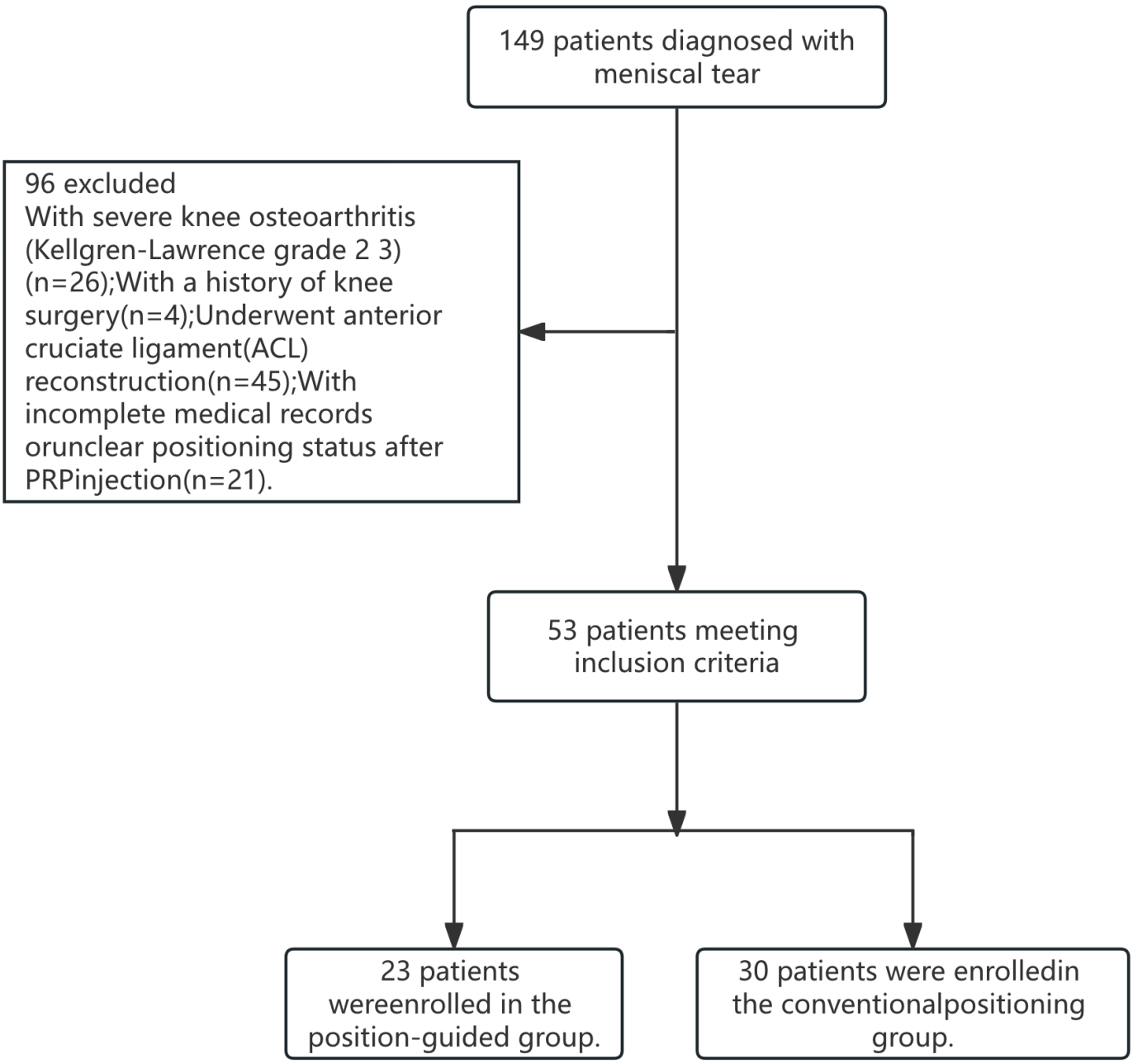


Figure 1

Flowchart of participant selection

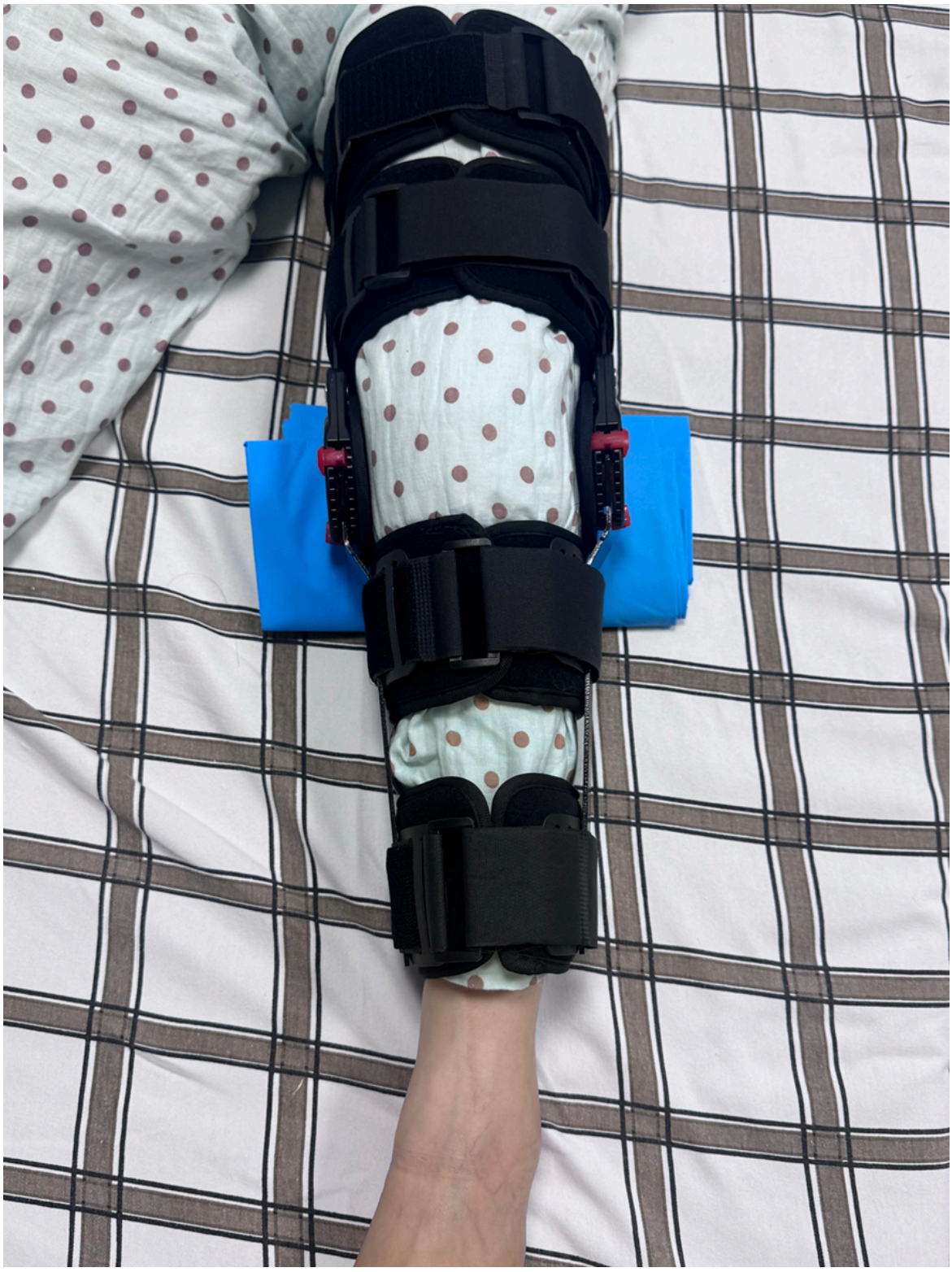


Figure 2

For posterior horn meniscal tears: Supine position with knee flexion of 15°–30°.



Figure 3

Medial meniscus body tear: Contralateral decubitus position.

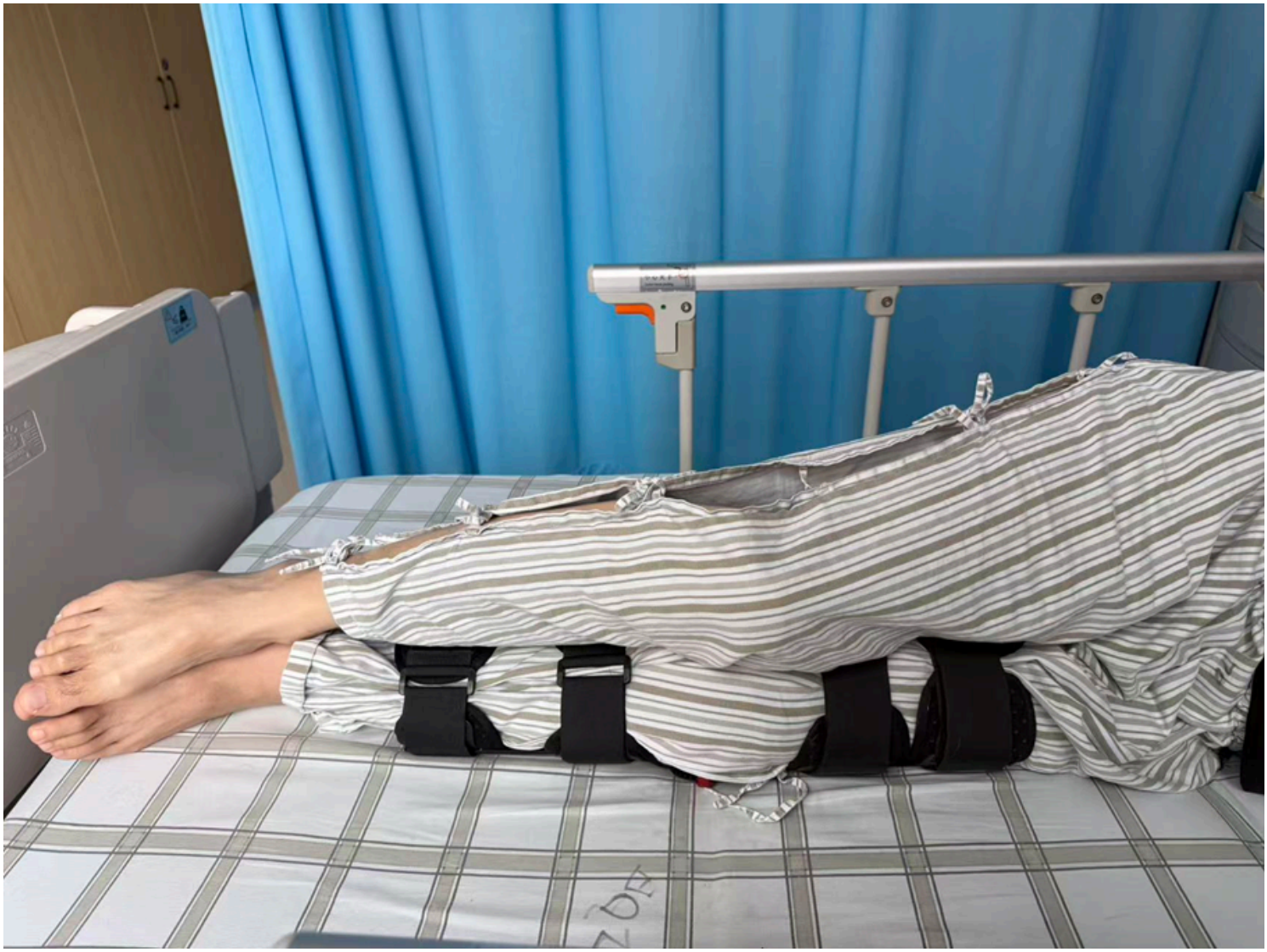


Figure 4

Lateral meniscus body tear: Lateral decubitus position with the affected knee in natural extension.