

A Retrospective Study on the Long-Term Efficacy of an Innovative Locking-Type Reinforcement Technique for Pelvic Organ Prolapse with Stress Urinary Incontinence

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Abstract

Background: Pelvic organ prolapse (POP) and stress urinary incontinence (SUI) often yield suboptimal results with traditional point-based repairs. This study evaluates the long-term safety, anatomical efficacy, and functional outcomes of adding perineoplasty (locking-type muscular reinforcement) to anterior pelvic reconstruction with mid-urethral sling.

Methods: Retrospective analysis of 1,155 patients with stage III–IV anterior POP and SUI (2018–2025). After exclusions, 526 underwent standard anterior repair + TOT sling (Group A), and 629 received the same plus perineoplasty (Group B). Outcomes included POP-Q staging, PFDI-20/PFIQ-7, modified Oxford scale, levator hiatal area (3D ultrasound), PISQ-12, and complications, with follow-up to 5 years.

Results: Baseline characteristics were comparable. Group B had longer operative time (93.7 vs. 73.3 min) and slightly higher blood loss (41.3 vs. 33.3 mL). At 5 years, all Group B achieved POP-Q $\leq$ I, with greater improvements at posterior points versus Group A. Levator hiatal area decreased 49% in Group B (vs. 31% in Group A) at 1 month, sustained at 5 years. Pelvic floor muscle strength and patient-reported outcomes (PFDI-20/PFIQ-7) improved significantly more in Group B ($P < 0.05$). PISQ-12 scores and partner satisfaction were higher in Group B. Long-term complications were low: mesh erosion (0.79% vs. 0.95%), anatomical recurrence (0.95% vs. 3.23%), and dyspareunia (0.64% vs. 1.71% at 3 months) favored Group B.

Conclusion: The locking-type perineoplasty technique provides durable anatomical restoration, lowers recurrence, preserves sexual function, and maintains safety over 5 years, supporting its use as an advanced strategy for selected POP/SUI patients.

Trial registration: The study protocol was registered at ClinicalTrials.gov (ChiCTR2500115839) on Dec 31, 2025.

Introduction

Pelvic organ prolapse (POP) and stress urinary incontinence (SUI) represent two of the most prevalent and debilitating urogynecological conditions affecting women worldwide, with significant implications for quality of life, sexual function, and psychological well-being, particularly for middle-aged, elderly, and postpartum women[1]. Recent systematic reviews and population-based studies have demonstrated that POP affects approximately 3–6% of women symptomatically, while up to 50% of parous women demonstrate anatomical evidence of prolapse upon clinical examination [2]. The coexistence of SUI in this population is remarkably common, with studies reporting concomitant SUI in 40–60% of women presenting with anterior compartment prolapse [3]. Notably, the pathophysiological relationship between these conditions is rooted in the complex anatomical and functional interdependence of pelvic floor structures [4], which leads to a significant clinical dilemma about how to address such pelvic floor dysfunction. While traditional surgical interventions exist, they often fail to adequately address the biomechanical "foundation" of the pelvic floor, specifically the levator ani and perineal body. In conventional paradigms, the pubourethral ligament is frequently viewed as the focal "point-switch" for urinary control; however, emerging perspectives suggest that the levator ani and perineal body serve as a more robust "surface-switch" (the massive switch), representing the critical last line of defense for the external urinary control mechanism.

With improvements in living standards and advancements in medical technology, there has been a growing clinical and research focus on optimal surgical management aimed at restoring pelvic anatomy and function for these patients in recent years. Although reconstructive surgery, such as anterior pelvic compartment repair, can effectively correct prolapse, it remains controversial whether an anti-incontinence procedure should be routinely performed simultaneously [5–7]. The inherent complexity lies in the fact that repairing a significant cystocele can sometimes unmask or even exacerbate latent SUI by altering urethral geometry and pressure dynamics [8]. Conversely, performing an anti-incontinence procedure prophylactically in asymptomatic women or those with occult SUI may prevent postoperative SUI but carries the risk of introducing new complications, such as voiding dysfunction or de novo urgency [9]. In addition, several randomized controlled trials and meta-analyses have investigated this issue, yet their conclusions are inconsistent. Some studies advocate for a concomitant anti-incontinence procedure during POP surgery, demonstrating a significant reduction in the postoperative incidence of SUI without a substantial increase in complications [10, 11]. In contrast, other research suggests a more selective approach, arguing that routine incontinence surgery subjects a proportion of patients to unnecessary procedures and potential risks [12, 13]. This lack of consensus highlights the need for further well-designed studies to evaluate the trade-offs between efficacy and safety. To bridge this gap, novel approaches such as the "Locking-type" reconstruction have been proposed. This comprehensive strategy integrates anterior pelvic repair, transobturator tension-free vaginal tape (TOT), and perineal body plasty, aiming to reinforce pelvic support through anatomical and axial recalibration while optimizing sexual functional outcomes.

Therefore, to address the ongoing need for comprehensive evaluation of combined surgical approaches for concurrent POP and SUI, the present study aims to systematically evaluate the efficacy of anterior pelvic reconstruction combined with anti-incontinence procedures and perineoplasty, specifically utilizing the "Locking-type" reconstruction concept, in achieving anatomical and functional success. We seek to comprehensively assess safety profiles and complication rates associated with these combined procedures in patients diagnosed with POP and SUI. Our findings are intended to provide evidence-based guidance for surgeons in optimizing treatment strategies for this challenging patient population, ultimately improving surgical success rates and long-term quality of life while minimizing risks in patients with both POP and SUI.

Methods

Patients

A total of 1155 patients presenting with pelvic organ prolapse (POP) concomitant with stress urinary incontinence (SUI), who were hospitalized between January 2018 and February 2025, were enrolled and analyzed. All patients had a primary diagnosis of Stage III-IV anterior vaginal wall prolapse according to the Pelvic Organ Prolapse Quantification (POP-Q) system [14]. The inclusion criteria were as follows: patients diagnosed with Stage III or IV POP, either as an initial treatment or as a recurrence following previous POP surgery; presence of concomitant SUI; age greater than 40 years; and a willingness to undergo surgical intervention and comply with follow-up assessments. Exclusion criteria included: patients opting for conservative pelvic floor management, those refusing surgery, individuals with severe surgical contraindications, patients desiring future fertility, and those with malignant lesions of the reproductive system. Relevant perioperative parameters were recorded for all included patients. All patients were enrolled in a follow-

up program for the documentation of complications. The study protocol was approved by the Institutional Review Board of Shanghai Fifth People's Hospital, Fudan University (approval No. 2024 – 257) and registered at ClinicalTrials.gov (ChiCTR2500115839); all participants provided written informed consent.

Surgical Procedures

A total of 526 patients underwent anterior pelvic floor reconstruction combined with mid-urethral sling procedure (Surgical Group A); another 629 patients received anterior pelvic floor reconstruction with mid-urethral sling procedure and perineoplasty (Surgical Group B). The combined surgical procedure involved anterior pelvic floor reconstruction, a mid-urethral sling procedure for SUI, and perineoplasty was shown in a diagram (Fig. 1); a decision-making algorithm for combined surgical approach is shown in Fig. 2. Under satisfactory anesthesia, the patient was placed in the lithotomy position, and the surgical field was routinely disinfected and draped.

Anterior Compartment Repair

A midline incision was made on the anterior vaginal wall from the bladder neck to the apex of the anterior fornix. Sharp and blunt dissection was used to separate the vaginal epithelium from the underlying pubocervical fascia, extending laterally to the white line (arcus tendineus fasciae pelvis). In accordance with the "Locking-type" reconstruction concept, particular attention was paid to identifying any defects or attenuation in the pubocervical fascia. Instead of simple plication, the fascia was reinforced using a folding technique where the lateral edges of the fascia were brought together in the midline using interrupted absorbable sutures (e.g., 2 – 0 or 3 – 0 polyglactin). This step not only closed the cystocele defect but also created a robust anterior support layer that serves as the anterior component of the "lock," stabilizing the bladder base and proximal urethra. Excess vaginal epithelium was trimmed, and the incision was closed with a running suture.

Mid-Urethral Sling Placement

Following the anterior repair, the transobturator tension-free vaginal tape (TOT) procedure was performed for patients with confirmed SUI or occult SUI. Two small incisions were made in the groin creases bilaterally. Using a dedicated TOT introducer, the mesh tape was passed through the obturator foramen from the inside out (or outside in, depending on the specific device used), ensuring the path remained close to the ischiopubic ramus to avoid neurovascular injury. The tape was positioned at the mid-urethra without tension. Crucially, reflecting the personalized design principles, the tension was adjusted dynamically while performing a cough stress test with the bladder filled with approximately 200–300 mL of saline. The goal was to achieve continence without causing obstruction, ensuring the tape complemented the reconstructed anterior wall rather than creating an artificial kink. The protective sheaths were removed, and the groin incisions were closed with subcuticular sutures.

Perineal Body Reconstruction and "Locking" Mechanism

This phase represents the core innovation of the integrated procedure, aiming to restore the "surface-switch" function of the pelvic floor. A triangular incision was made on the posterior fourchette to excise redundant

hymenal remnants and scar tissue. Dissection was carried out deeply to expose the underlying muscular structures, specifically identifying the bulbospongiosus muscles laterally and the superficial and deep transverse perineal muscles. The critical step involved the identification and mobilization of the levator ani muscles (puborectalis portion). Unlike traditional perineorrhaphy which often focuses merely on skin and superficial muscle approximation, this technique emphasizes the re-approximation of the levator ani fascia and muscle bellies in the midline. Using heavy absorbable sutures (e.g., 0 or 2 – 0 polyglactin), the bilateral levator ani muscles were plicated from the apex of the dissection down to the perineal body. This plication was performed with sufficient tension to narrow the genital hiatus to approximately 2–3 fingerbreadths but avoiding excessive tightness that could lead to dyspareunia. The "locking" effect was achieved by interdigitating the repaired anterior pubocervical fascia, the mid-urethral sling, and the newly reconstructed posterior levator plate. The perineal body was rebuilt as a solid, central tendon where these forces converge. This reconstruction effectively recalibrates the vaginal axis, restoring it to a more horizontal orientation relative to the pelvic inlet, which is essential for optimal pressure transmission during increases in intra-abdominal pressure. Furthermore, by reinforcing the distal third of the vagina and the introitus, this step significantly enhances the vaginal grasping force (grip strength), addressing the biomechanical deficit often overlooked in standard repairs. The vaginal epithelium was then trimmed appropriately to match the new caliber of the vaginal canal and closed with a running absorbable suture.

Follow-up and Evaluation

All patients were followed up by trained professionals primarily via outpatient visits, supplemented by telephone interviews. Scheduled follow-up time points were at 1 month, 3 months, 6 months, 1 year, 3 years, and 5 years postoperatively.

Objective Evaluation

The degree of prolapse was systematically assessed using the Pelvic Organ Prolapse Quantification (POP-Q) system preoperatively and at each follow-up interval. Anatomical cure was defined as the absence of recurrent prolapse, with recurrence objectively characterized as any POP-Q point reaching Stage II or greater in conjunction with corresponding symptoms, observed beyond 6 weeks postoperatively. Complementing these clinical metrics, levator ani muscle hiatus area was quantified via three-dimensional translabial ultrasound to evaluate structural integrity and hiatal distensibility. Concurrently, pelvic floor muscle strength was graded using the Modified Oxford Scale to assess functional recovery. Collectively, these parameters provided a comprehensive multimodal assessment of both anatomical restoration and physiological function.

Subjective Evaluation

Patients were asked to complete validated questionnaires independently at each interval. These included the Pelvic Floor Distress Inventory-Short Form 20 (PFDI-20) to assess bothersome symptoms, the Pelvic Floor Impact Questionnaire-7 (PFIQ-7) to evaluate the impact on quality of life, and for sexually active patients, the Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire (PISQ-12) to assess sexual function. Higher scores on the PFDI-20 and PFIQ-7 indicate greater symptom distress and poorer quality of life, whereas a higher PISQ-12 score indicates better sexual function [15, 16].

Complication Monitoring

Short-term and long-term postoperative complications were recorded, including voiding dysfunction, surgical site infection, overactive bladder (OAB), new-onset urinary incontinence, mesh exposure or erosion, pain, prolapse recurrence, and dyspareunia.

Statistical Analysis

Statistical analyses were performed using SPSS software (Version 26.0). Continuous data were tested for normality of distribution. Data conforming to a normal distribution are presented as mean $\pm$ standard deviation (mean $\pm$ SD) and were compared using paired t-tests. Non-normally distributed measurement data are expressed as median (interquartile range). Categorical data are presented as numbers (percentages) and were compared using the Pearson chi-square test or non-parametric tests as appropriate. A two-tailed P-value of less than 0.05 was considered statistically significant.

Results

Patient Demographics and Perioperative Outcomes

This study included a total of 1,155 patients who underwent combined pelvic floor surgery. The mean age, parity, and body mass index (BMI) in Surgical Group A were 63.12 ± 9.64 years, 2.06 ± 0.83 , and 25.32 ± 3.51 kg/m², respectively. In Surgical Group B, the mean age was 61.70 ± 13.20 years, mean parity was 2.23 ± 1.34 , and mean BMI was 24.54 ± 2.14 kg/m². All surgeries were successfully completed without conversion to alternative surgical approaches. No statistically significant differences were observed in baseline preoperative characteristics between the two groups.

Intraoperative and postoperative parameters are expressed as mean $\pm$ standard deviation. In Group A, the mean operative time was 73.29 ± 15.82 min, and the estimated blood loss was 33.32 ± 21.49 mL. The mean postoperative hospital stay was 2.75 ± 1.70 days, and the mean duration of indwelling urethral catheterization was 1.44 ± 0.61 days. In Group B, the mean operative time was 93.72 ± 18.45 min, and the estimated blood loss was 41.32 ± 23.55 mL. The mean postoperative hospital stay was 2.89 ± 1.56 days, and the mean duration of indwelling catheterization was 1.53 ± 0.45 days. Of note, no intraoperative injuries to adjacent visceral organs (bladder, urethra, rectum) or major neurovascular structures were recorded. There were no statistically significant differences between the two groups in mean hospital stay or duration of catheterization. Compared with Group A, Group B had significantly longer operative time and greater estimated blood loss, which is attributable to the additional perineoplasty required in Group B, inevitably resulting in extra operative time and bleeding.

Efficacy Outcomes

Analysis by Anatomical Outcomes

Preoperative POP-Q staging results showed that the surgical Group B exhibited significant improvement in postoperative anatomical assessment, with all patients achieving POP-Q stage I or lower at all follow-up time

points. Quantitative analysis of the POP-Q index points (Aa, Ba, C, Ap, Bp, Gh, Pb, TVL) demonstrated statistically significant improvements at the 5-year follow-up compared to preoperative values (all $P < 0.05$, Table 1), indicating favorable and durable anatomical restoration in Group B, whereas in Group A, the recovery at points Ap, Bp, and Pb was not significant compared to preoperative status. Furthermore, postoperative evaluations revealed marked improvements in pelvic floor morphology and muscle strength (Table 2). In Group B, the levator ani hiatus area was significantly reduced from a preoperative value of $30.94 \pm 8.39 \text{ cm}^2$ to $15.63 \pm 4.23 \text{ cm}^2$ at 1 month postoperatively (a reduction of approximately 49%, compared to 31% in Group A). Although a slight gradual increase was observed over time, the area remained substantially reduced at the 5-year follow-up ($19.46 \pm 6.92 \text{ cm}^2$), confirming the sustained effectiveness of anatomical restoration. Type I muscle strength in Group B increased from a baseline value of $22.29 \pm 3.78 \text{ } \mu\text{V}$ to a postoperative peak of $28.18 \pm 6.31 \text{ } \mu\text{V}$ at 1 month, stabilizing at $25.62 \pm 8.84 \text{ } \mu\text{V}$ at year 5. Type II muscle strength similarly increased from $23.89 \pm 3.59 \text{ } \mu\text{V}$ to a peak of $33.39 \pm 6.68 \text{ } \mu\text{V}$, maintaining an improved level of $27.29 \pm 6.35 \text{ } \mu\text{V}$ at the 5-year follow-up. Collectively, these results confirm that the surgical approach effectively reduces the distensibility of the levator ani hiatus and enhances the strength of both slow-twitch and fast-twitch muscle fibers, with functional benefits persisting up to five years postoperatively. Overall, compared with Surgical Group A, Group B, with the addition of perineoplasty, demonstrated a significant effect on anatomical restoration of the posterior vaginal wall and increase in perineal body thickness, as well as marked improvements in levator ani hiatus area and pelvic floor muscle strength.

Table 1
Comparison of POP-Q point scores of the patients from two groups before the operation and at 3 months, 6 months and 1 year after the operation

Group	POP-Q(cm)	Pre-surgery	3 months post-surgery	6 months post-surgery	1 year post-surgery	3 years post-surgery	5 years post-surgery
A	Aa	1.45 ± 0.39	-2.56 ± 0.65	-2.56 ± 0.45	-2.63 ± 0.34	-2.22 ± 0.47	-2.25 ± 0.32
	Ba	0.49 ± 0.38	-2.34 ± 0.38	-2.67 ± 0.52	-2.52 ± 0.52	-2.44 ± 0.62	-2.27 ± 0.45
	C	-2.29 ± 0.39	-7.58 ± 1.45	-6.22 ± 1.56	-6.99 ± 0.46	-6.56 ± 0.56	-5.98 ± 0.34
	Ap	-1.06 ± 0.45	-1.67 ± 0.85	-1.34 ± 0.38	-1.23 ± 0.83	-1.26 ± 0.65	-1.20 ± 0.62
	Bp	-1.99 ± 0.30	-2.26 ± 0.78	-2.19 ± 0.83	-2.11 ± 0.70	-2.13 ± 0.41	-2.12 ± 0.71
	Gh	5.47 ± 1.53	4.56 ± 0.87	4.45 ± 0.56	4.45 ± 0.23	4.45 ± 0.77	4.41 ± 0.48
	Pb	2.35 ± 0.51	2.56 ± 0.52	2.34 ± 0.63	2.43 ± 0.49	2.40 ± 0.55	2.31 ± 0.24
	TVL	6.73 ± 1.43	8.45 ± 1.45	8.37 ± 0.78	8.34 ± 0.56	8.56 ± 0.43	8.44 ± 0.80
B	Aa	1.26 ± 0.41	-2.86 ± 0.33	-2.75 ± 0.72	-2.68 ± 0.47	-2.33 ± 0.26	-2.20 ± 0.39
	Ba	0.44 ± 0.25	-2.64 ± 0.45	-2.59 ± 0.26	-2.48 ± 0.67	-2.32 ± 0.34	-2.21 ± 0.61
	C	-2.15 ± 0.63	-7.05 ± 1.22	-6.87 ± 1.05	-6.69 ± 0.83	-6.12 ± 0.12	-5.81 ± 0.46
	Ap	-1.21 ± 0.49	-2.63 ± 0.45	-2.56 ± 0.75	-2.52 ± 0.67	-2.34 ± 0.56	-2.23 ± 0.87
	Bp	-1.83 ± 0.56	-2.74 ± 0.61	-2.55 ± 0.36	-2.57 ± 0.31	-2.23 ± 0.45	-2.34 ± 0.62
	Gh	5.81 ± 1.08	4.19 ± 0.83	4.31 ± 0.91	4.39 ± 0.56	4.65 ± 0.43	4.56 ± 0.75
	Pb	2.23 ± 0.69	3.56 ± 0.54	3.63 ± 0.48	3.60 ± 0.45	3.44 ± 0.78	3.31 ± 0.84
	TVL	6.29 ± 1.21	8.56 ± 1.13	8.73 ± 0.94	8.66 ± 0.89	8.43 ± 0.76	8.23 ± 0.42

Table 2

Longitudinal Changes in Area of the levator ani muscle hiatus and pelvic floor muscle strength of the patients from two groups

Group	Parameter	Preoperative	1 Month	3 Months	1 Year	3 Years	5 Years
A	Area of the levator ani muscle hiatus (cm ²)	29.24 ± 6.20*	20.23 ± 5.54	21.32 ± 4.53	21.76 ± 6.74	22.71 ± 4.52	23.54 ± 7.10
	Pelvic floor muscle strength, Type I (μV)	23.79 ± 6.34*	27.63 ± 7.12	25.43 ± 4.56	26.31 ± 5.30	24.15 ± 3.23	25.41 ± 5.11
	Pelvic floor muscle strength, Type II (μV)	25.21 ± 4.23*	30.12 ± 3.19	28.20 ± 5.13	26.67 ± 4.01	25.30 ± 6.65	24.11 ± 7.40
B	Area of the levator ani muscle hiatus (cm ²)	30.94 ± 8.39*	15.63 ± 4.23	17.84 ± 5.36	18.62 ± 7.28	19.22 ± 5.56	19.46 ± 6.92
	Pelvic floor muscle strength, Type I (μV)	22.29 ± 3.78*	28.18 ± 6.31	26.33 ± 3.69	25.65 ± 4.51	26.12 ± 6.33	25.62 ± 8.84
	Pelvic floor muscle strength, Type II (μV)	23.89 ± 3.59*	33.39 ± 6.68	30.75 ± 5.92	28.08 ± 4.87	29.68 ± 7.29	27.29 ± 6.35

* $P < 0.05$

Analysis by Patient-Reported Outcomes

All enrolled patients successfully completed the comprehensive 1-year follow-up assessment, ensuring a robust dataset for evaluating subjective clinical outcomes. Comparative analysis of validated quality-of-life instruments revealed statistically significant improvements across all domains. Specifically, scores on the PFDI-20, which quantifies symptom burden related to pelvic organ prolapse, urinary, and colorectal dysfunction, demonstrated a profound reduction from preoperative baselines ($P < 0.05$). This decline indicates a substantial alleviation of physical discomfort and psychological distress associated with pelvic floor disorders. Concurrently, the PFIQ-7 scores, which assess the impact of these symptoms on daily activities, social functioning, and emotional well-being, also decreased significantly ($P < 0.05$, Table 3). The marked divergence between preoperative and postoperative metrics underscores not only the anatomical efficacy of the intervention but also its transformative effect on health-related quality of life. These findings suggest that the surgical restoration of pelvic anatomy directly correlates with a meaningful recovery of functional status, enabling patients to resume normal daily routines with significantly reduced symptom interference and enhanced overall life satisfaction.

Table 3

Comparison of PEDI-20/PFIQ-7 scores of the patients from two groups before the operation and at 3 months, 6 months and 1 year after the operation

Group	Questionnaire	Preoperative	1 Month	3 Months	1 Year	3 Years	5 Years
A	PFDI-20	128.26 ± 29.98	59.29 ± 18.03	51.11 ± 18.92	40.05 ± 8.21	34.01 ± 7.20	30.21 ± 8.30
	PFIQ-7	120.21 ± 39.11	55.22 ± 22.35	42.34 ± 15.64	34.63 ± 9.22	30.33 ± 9.55	28.13 ± 8.08
B	PFDI-20	132.26 ± 27.41	58.16 ± 15.35	30.27 ± 10.66	14.5 ± 6.47	15.36 ± 5.64	17.54 ± 8.21
	PFIQ-7	122.84 ± 35.20	43.68 ± 19.43	22.59 ± 13.16	17.6 ± 8.38	19.32 ± 7.39	18.56 ± 5.92

Analysis by Sexual Function

In a subgroup of 184 sexually active patients in Surgical Group A (accounting for 35.0% of the eligible study cohort) and 206 patients in Surgical Group B (accounting for 32.8% of the eligible study cohort), sexual function was rigorously assessed using the validated Pelvic Organ PISQ-12 questionnaire. Comprehensive analysis demonstrated a statistically significant trend toward improvement in sexual health indicators following surgical intervention. Specifically, compared with preoperative baseline values, PISQ-12 scores were significantly elevated at the 3-month and 1-year postoperative follow-ups, with the therapeutic effect persisting through the 5-year follow-up, reaching statistical significance ($P < 0.05$; Table 4). Moreover, Surgical Group B showed better partner sexual satisfaction than Surgical Group A. This quantifiable improvement not only reflects the alleviation of prolapse-related somatic symptoms (e.g., dyspareunia), but also exerts profound positive effects on psychosocial sexual health, including increased libido, enhanced sexual arousal, and overall improved satisfaction. The sustained increase in scores throughout the one-year follow-up period suggests that the anatomical restoration achieved through surgery can be effectively translated into durable functional benefits, thereby significantly improving the quality of sexual life and intimate relationships for the majority of sexually active subjects in this cohort.

Table 4

Comparison of PISQ-12 score of the patients before the operation and at 6 months and 1 year after the operation

Questionnaire	Preoperative	1 Month	3 Months	1 Year	3 Years
PISQ-12	12.26 ± 3.85	30.92 ± 8.73	35.18 ± 7.68	35.18 ± 7.68	35.18 ± 7.68
Sexual satisfaction (%)	27.3	82.2	86.5	78.6	75.1

Safety and Complications

The incidence of postoperative complications is detailed in Table 5. Among the short-term complications (within 1 month postoperatively) in the two groups, the most common were pain (7.22% vs. 5.25%) and symptoms of overactive bladder (3.99% vs. 3.50%). Other early complications included postoperative urinary retention (3.04% vs. 2.23%), surgical site infection (2.28% vs. 1.59%), and de novo urinary incontinence (3.80% vs. 1.11%). Regarding long-term complications in Surgical Group A, dyspareunia was reported in 9 patients

(1.71%) at 3 months and in 8 patients (1.52%) at 1 year. Mesh-related complications (exposure or erosion) and anatomical recurrence of prolapse (defined as POP-Q stage $\geq$ II with associated symptoms) were the primary long-term concerns. The incidence of mesh exposure/erosion was 0.76% (n = 4) at the 6-month follow-up and 0.95% (n = 5) at the 1-year follow-up. The prolapse recurrence rate at 5 years postoperatively was 3.23% (n = 17). In Surgical Group B, dyspareunia was reported in 4 patients (0.64%) at 3 months and in 3 patients (0.48%) at 6 months. The incidence of mesh exposure/erosion was 0.32% (n = 2) at the 6-month follow-up and 0.79% (n = 5) at the 5-year follow-up. The prolapse recurrence rate at 5 years postoperatively was 0.95% (n = 6).

Table 5
The incidence of short-term and long-term postoperative complications in patients [n(%)]

Complications	1 month preoperative	3 months preoperative	6 months preoperative	1 year preoperative	3 years preoperative	Pre-surgery
Difficulty in urination	14(2.23%)	3(0.48%)	0	0	0	0
Postoperative infection	10(1.59%)	4(0.64%)	0	0	0	0
Overactive bladder	22(3.50%)	13(2.07%)	8(1.27%)	3(0.48%)	6(0.95%)	9(1.43%)
New-onset urinary incontinence	7(1.11%)	3(0.48%)	2(0.32%)	0	2(0.32%)	4(0.64%)
Exposure or erosion of vaginal mesh	0	0	2(0.32%)	3(0.48%)	2(0.32%)	5(0.79%)
pain	33(5.25%)	15(2.38%)	7(1.11%)	2(0.77%)	1(0.16%)	0
recidivation	0	0	2(0.32%)	3(0.48%)	3(0.48%)	6(0.95%)
dyspareunia	0	4(0.64%)	3(0.48%)	4(0.64%)	0	0

Discussion

This study demonstrates that the innovative locking-type reinforcement technique, combining anterior pelvic floor reconstruction, mid-urethral sling placement, and perineoplasty, is safe and feasible for treating advanced POP and concomitant SUI. The procedure is associated with excellent and sustained anatomical outcomes, evidenced by all POP-Q indices in Surgical Group B showed significant improvement at 5 years postoperatively, with all patients achieving stage I or lower, indicating durable restoration of the supportive structures and a marked advantage over Surgical Group A. Functionally, compared with patients in Surgical Group A, patients in Surgical Group B presented significant improvements in symptom burden (reduced PFDI-20 and PFIQ-7 scores) and sexual function (enhanced PISQ-12 scores), indicating a higher quality of life post-surgery [17, 18]. Regarding safety, the low intraoperative risks, minimal blood loss, and long-term complications, specifically a mesh exposure/erosion rate of 0.79% and a dyspareunia rate of $\leq$ 0.64%, in two groups align with the safety profile of minimally invasive reconstructions [19–22].

From an anatomical perspective, the POP-Q score indicators of all patients in Surgical Group B significantly improved 5 years after the surgery, and all patients achieved stage I or lower, suggesting persistent recover of the supporting structure, and a significant advantage over Surgical Group A. Of note, the anatomical durability observed in this study, characterized by a 0.95% recurrence rate at 5 years in Group B, stands in stark contrast to the often-reported higher recurrence rates associated with native tissue repairs in the existing literature [23, 24]. While native tissue repairs rely on the inherent strength of the patient's fascia, which may be deficient in cases of advanced POP, our results suggest that the comprehensive biomechanical restoration based on the innovative locking-type reinforcement technique achieved by addressing multiple compartments simultaneously provides superior long-term support. This finding also aligns with previous reports highlighting the safety of minimally invasive pelvic floor reconstructions when performed by experienced surgeons [19, 20], yet it extends these findings by demonstrating exceptional durability rarely seen in long-term follow-up studies.

Furthermore, the low complication rates of innovative locking-type reinforcement technique reported here challenge the prevailing skepticism surrounding mesh-augmented procedures. Critics often cite landmark studies, such as the FDA safety communications and various randomized controlled trials, which emphasize the risks of mesh erosion and chronic pain [25, 26]. However, our observed mesh exposure rate of 0.79% is significantly lower than those typically reported in historical series involving synthetic mesh [21]. This discrepancy suggests that the specific surgical methodology, particularly the "shingle-style" imbrication and the inclusion of perineoplasty which enhances tissue coverage, may effectively mitigate the risks traditionally associated with synthetic materials [22, 27]. By preserving the vascular plexus and avoiding radical mucosal excision, this technique appears to resolve the historical trade-off between anatomical success (often higher with mesh) and complication rates (often higher with mesh), placing it in a unique position within the current surgical landscape.

The clinical significance of this study lies in its potential to update the standard of care for women presenting with complex pelvic floor dysfunction. Traditionally, clinicians have faced a dilemma: opting for conservative native tissue repairs risks higher recurrence rates, while mesh-augmented procedures risk patient dissatisfaction due to complications. The "Locking-type" technique described here offers a middle path by integrating the structural integrity of mesh with the biological compatibility of native tissue preservation. The mechanism of action, specifically the restoration of the "self-locking angle" and the "massive switch" involving the levator ani and perineal body, provides a biomechanical explanation for the low recurrence rates [21, 23]. This suggests that surgeons should move beyond simple anatomical repositioning (point-to-point suspension) and instead focus on reconstructing the functional units of the pelvic floor to achieve stable, long-term outcomes.

For clinicians, these findings imply that a combined, comprehensive approach is not only safe but may be preferable to staged or isolated procedures. By recalibrating the vaginal axis based on the angle of male penile erection and selectively reducing vaginal diameter to enhance "grip strength," this procedure directly improves the quality of sexual life. Critically, the overlapping "shingle-style" suturing technique preserves the underlying vascular plexus by avoiding vaginal mucosal resection, thereby preventing the ischemic fibrosis and vaginal shortening commonly associated with partial excision of the posterior vaginal wall. The intact vaginal mucosa is preserved intraoperatively and induced to protrude into the vaginal lumen, forming thicker longitudinal mucosal ridges. This preserves the rich sensory innervation of the genital organs, providing effective stimulation to the penis [28]. Given that the sensory nerves of the penis are distributed ventrally, the

pronounced stimulation of these vaginal mucosal ridges results in markedly enhanced sensitivity for the partner, thereby synchronously improving tactile stimulation for the male partner postoperatively. Moreover, the preservation and even enhancement of sexual function (PISQ-12 scores) are critical factors in patient-centered care. Unlike standard posterior colporrhaphy, which often results in vaginal shortening and dyspareunia [18, 29], this Locking-Type technique's focus on "biological thickening" and maintaining vaginal length ensures that the treatment does not compromise the patient's intimate relationships. Therefore, when counseling patients, clinicians can now present this combined approach as a viable option that offers both structural durability and functional preservation, potentially alleviating the fear of mesh-related complications that often deters patients from seeking necessary reconstructive surgery.

Future research should validate these findings in populations with higher BMI, as the current cohort had a mean BMI of 24.5 kg/m, which is lower than the averages of Western cohort [30]. Additionally, while the results are promising, the lack of urodynamic confirmation for "de-novo" incontinence suggests a need for more rigorous diagnostic validation in future studies. Comparative studies against standard techniques in a multi-center setting would further establish the generalizability of these results.

A key strength of this study is the granular 5-year follow-up data with a high retention rate of 92%, providing robust real-world evidence on the durability of the repair. The study also demonstrates a remarkably low rate of mesh-related complications. However, the study is limited by its single-center design and the lack of a comparator arm, such as a native tissue repair group. Additionally, the findings may not be generalizable to obese populations (BMI ≥ 30 kg/m) due to the lower BMI profile of the cohort.

Conclusions

The innovative locking-type reinforcement technique is a safe and effective treatment for advanced POP and stress incontinence. It achieves durable anatomical correction through biomechanical restoration and provides significant improvements in quality of life with a low risk of complications. By balancing structural strength with tissue vitality, this approach represents a viable comprehensive option for appropriately selected patients.

Abbreviations

POP
Pelvic organ prolapse
SUI)
stress urinary incontinence
TOT
transobturator tension
POP-Q
Pelvic Organ Prolapse Quantification
PFDI-20
Pelvic Floor Distress Inventory-Short Form 20
PFIQ-7
Pelvic Floor Impact Questionnaire-7
PISQ-12

Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire

OAB

overactive bladder

BMI

body mass index.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its later amendments. The study protocol was approved by the Institutional Review Board of Shanghai Fifth People's Hospital, Fudan University (approval No. 2024-257); all participants provided written informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Administrative, technical, or material support: Yangyun Wang

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Figures

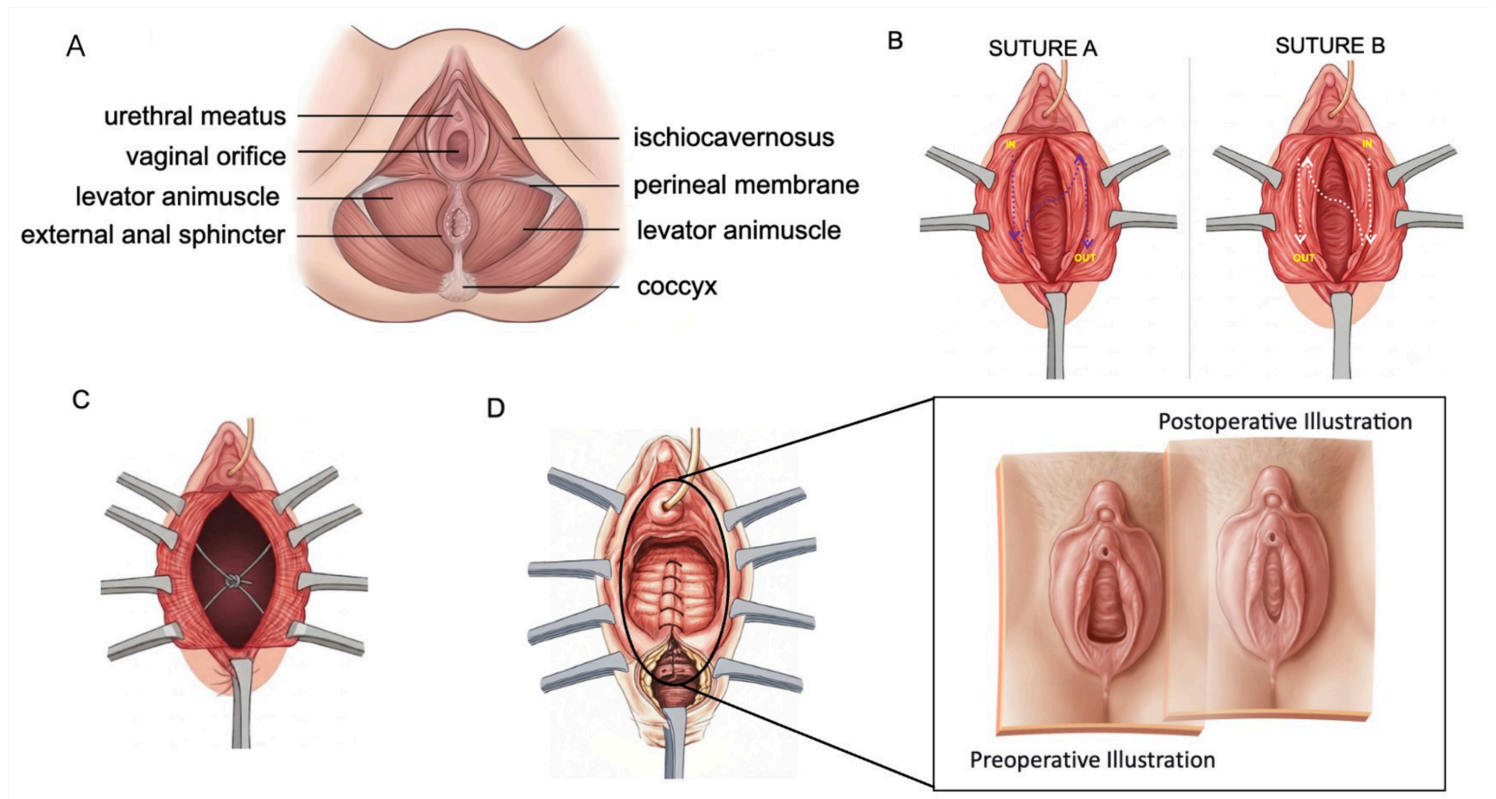


Figure 1

A Diagram of Innovative Locking-Type Reinforcement Technique for Pelvic Floor Support. (A) The baseline topographic anatomy of the pelvic floor musculature. (B) The initial surgical step, comprising a longitudinal incision of the posterior vaginal wall followed by blunt dissection within the rectovaginal space to adequately expose the levator ani muscle and its overlying fascia. (C) The pivotal second step, wherein an internal, self-locking suture technique is employed to approximate the deep layer of the levator ani muscle and fascia in a tension-controlled manner. (D) The final step, which involves closure of the posterior vaginal wall using a specifically designed suture configuration, designated as the "Pyramid Suture" technique. This step not only completes the anatomical reconstruction but also yields significant functional and morphological improvements: preoperatively, patients typically present with a widened genital hiatus and a descended perineal body; postoperatively, the genital hiatus is effectively narrowed, and the perineal body is elevated to a more anatomically normal position, thereby restoring perineal support and enhancing pelvic floor integrity.

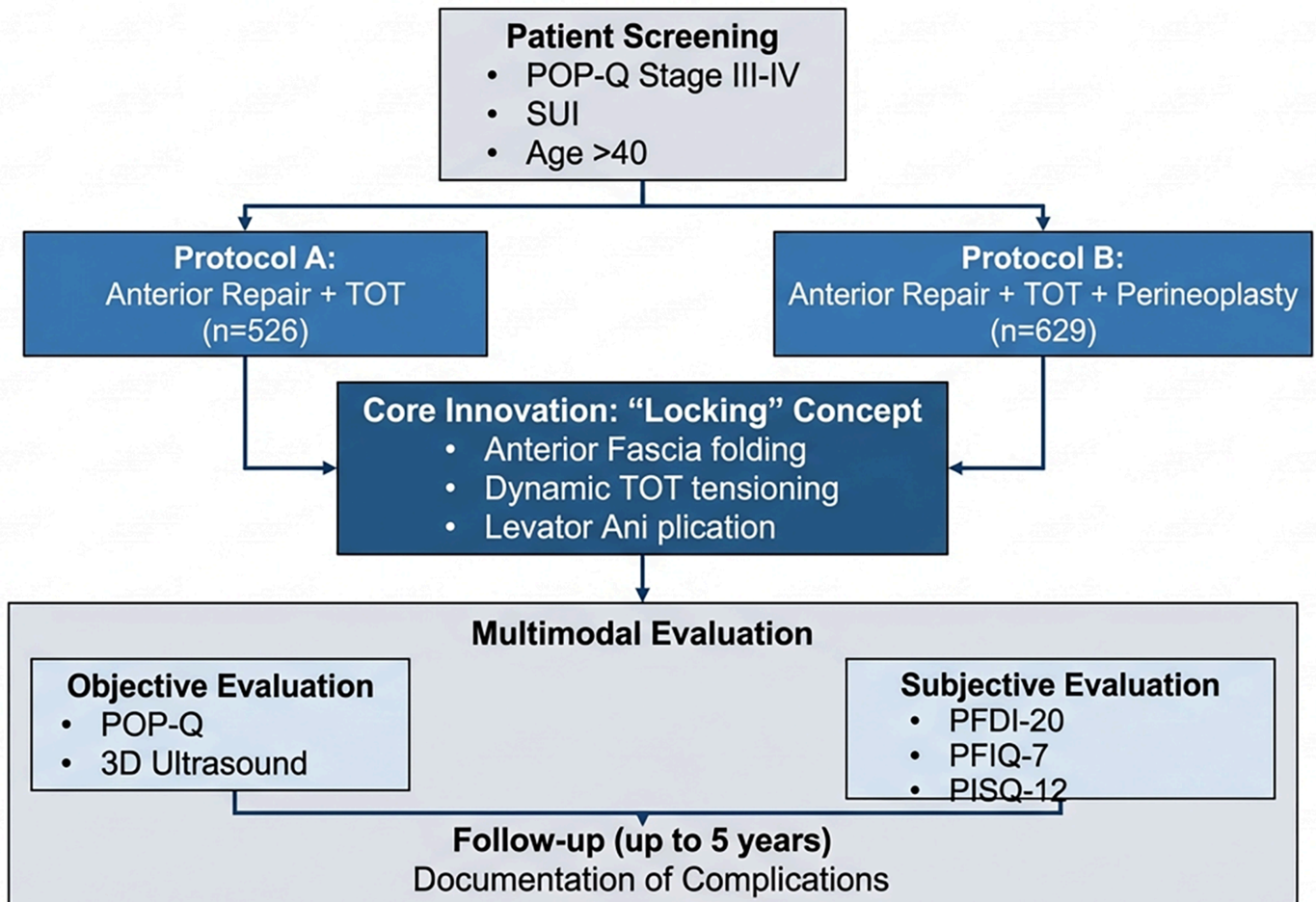


Figure 2

Surgical Decision-making algorithm for POP with SUI.