BMC Urology

RESEARCH

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Transvaginal posterior levatorplasty and perineoplasty for female primary stress urinary incontinence: 12-month follow-up and technical presentation

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Abstract

Objective To investigate the feasibility of transvaginal posterior levatorplasty combined with perineoplasty (TPLP) for women with primary stress urinary incontinence and demonstrate the surgical technique with step-by-step procedures.

Methods A prospective, non-randomised study was conducted using technique of TPLP to treat female primary SUI from January 2019 to December 2021. Patient follow-up was performed at 3 and 12 months posteroperatively. A series of validated questionnaires were used to evaluate the improvement of symptom severity, sexual function and quality of life. In addition, 4-D ultrasonography was used to measure the anatomic changes of pelvic structures.

Results A total of 47 patients were enrolled in this study with a mean age of 43.6 years. Mean operative time was 78.7 min. Median estimated intraoperative blood loss was 80.2 ml. Objective cure and subjective cure rates were 87.2% and 91.5%, respectively. Compared with baseline, scores of quality of life, symptom severity and sexual function improved after surgery. Meanwhile, mobility of the urethra and bladder neck and areas of levator hiatus were decreased after surgery. Mild coitus pain was reported in 15.4% (6/39) patients at the initial several times of intercourse after resuming sexual activity.

Conclusions This study shows that transvaginal posterior levatorplasty combined with perineoplasty appears to be an effective surgical method for selected women with primary stress urinary incontinence.

Keywords Levatorplasty, Perineoplasty, Stress urinary incontinence, Woman

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Background

Stress urinary incontinence (SUI) is a widespread problem that significantly impacts the quality of life and can impair both physical and mental health in women [1]. According to studies, up to 35% of adult women experience SUI, with the highest incidence occurring between the ages of 45–59 years [2, 3].

While there are various surgical procedures available to treat SUI, most focus on the fascia and ligaments surrounding the urethra, often neglecting the importance of the levator ani muscle (LA) in maintaining urinary continence [4]. The LA plays a crucial role in supporting the bladder and urethra, providing a structural foundation that can withstand increases in intra-abdominal pressure. Studies have shown that the contraction of the LA is essential in preventing urine leakage during activities such as coughing. Barbic's research [5] demonstrated that in normally continent women, contractions of the LA precede activation of the abdominal muscles involved in the cough reflex, thereby supporting and stabilizing the bladder neck to efficiently transmit abdominal pressure to the proximal urethra. Deffieux's study [6, 7] further emphasized that in normally continent women, LA contractions precede increases in abdominal pressure due to external intercostal and abdominal muscle contractions during cough, indicating that the LA helps counteract sudden increases in abdominal pressure to prevent urine leakage. This means that prior to an increase in abdominal pressure from factors such as coughing, the contraction of the LA can elevate the pressure within the urethra. This counteracts the abrupt rise in abdominal pressure, thereby preventing urine leakage.

Throughout a woman's life, factors such as pregnancy, childbirth, aging, and menopause can contribute to the elongation, detachment, and diminished contractility of the LA. These alterations may lead to the descent of the levator plate, potentially resulting in SUI. According to reports, there are indeed significant differences in the anatomical position of the pelvic floor muscles between women with and without SUI. In contemporary practice, the International Continence Society widely acknowledges that Pelvic Floor Muscle Training (PFMT) serves as a foundational intervention for both the prevention and treatment of SUI in women [4]. The rationale of PFMT for female SUI lies in the mechanism that a forceful contraction of the pelvic floor muscles compresses the urethra, thereby elevating the urethral pressure to effectively counteract any sudden surge in intra-abdominal pressure and prevent urine leakage [8]. However, despite receiving PFMT treatment, over 50% of patients ultimately necessitate surgical intervention [4]. Therefore, we propose a hypothesis: for patients unresponsive to PFMT, could surgical intervention to anatomically restore the LA facilitate the restoration of urinary control?

In our department, we routinely perform vaginal tightening surgery using the Transvaginal Posterior Levatorplasty combined with Perineoplasty (TPLP) approach. In addition to vaginal laxity, some patients reported symptoms of SUI before surgery, which either resolved or showed significant improvement following the procedure. Motivated by these patient testimonials, we initiated a prospective investigation to assess the efficacy of this technique for women with primary SUI. The aim of this study is to give a detailed description of the surgical procedure and to demonstrate the feasibility of this surgical method by a 1-year outcome.

Materials and methods

Patiens

This is a prospective study on the use of TPLP for treatment of women with primary SUI at the Plastic Surgery Hospital at Chinese Academy of Medical Sciences and Peking Union Medical College and the Chinese PLA General Hospital. This study was conducted in accordance with the Helsinki Declaration and approved by the Ethics Committee of the hospital (No.2018-70).

Informed consent forms were obtained from all of the patients. All the patients were provided counseling on the advantages and disadvantages of the nonsurgical technique (PFMT) and surgical techniques (open abdominal or laparscopic retropubic suspension, suburethral sling procedures, bladder neck needle suspensions, anterior vaginal repair and our method), and all patients were encouraged to try PFMT, but our method was their final choice.

Patients were diagnosed with SUI were enrolled in this study. The inclusion criteria was female patients aged ≥ 18 years diagnosed with stress urinary incontinence, based on their symptoms and a positive result of a cough stress test at a bladder volume of 300 ml in a lithotomy position. There is no limitation on pregnancy and delivery times, delivery pattern or disease course. Patients were excluded if they had undergone previous surgery for SUI or pelvic organ prolapse (POP), post-void residual volume (PVR) >50 ml, POP stage >2, unhealed genitourinary infection, plans for future childbearing, pelvic malignancies and history of pelvic radiotherapy.

Patients' preoperative characteristics, including age, body mass index (BMI), menstrual history and delivery pattern, were recorded prior to surgery. In addition, each patient underwent a physical examination with a focused assessment of the vagina and perineum. 4-D ultrasonography was used to measure the urethral rotation angle (URA), retrovesical angle (RVA), bladder neck descent (BND), areas of levator hiatus, PVR, and associated POP. Baseline evaluation of symptom severity, quality of life (Qol), and sexual function was performed using a series of questionnaires, including the Chinese version of the

ICIQ-SF (International Consultation on Incontinence Questionnaire-Short Form, comprising 4 items, with a scoring range of 0 to 21), UDI-6 (Validation of Urogenital Distress Inventory 6, comprising 6 items, with a scoring range of 0 to 18), I-QOL (Urinary Incontinence Quality of Life Scale, comprising 22 items, with a scoring range of 0 to 100), and PISQ-12 (Prolapse and Incontinence Sexual Function Questionnaire 12, comprising 12 items, with a scoring range of 0 to 100), which were reported in previous studies [9].

Surgical technique

All procedures were performed in a lithotomy position, under local anesthesia, and in the outpatient setting. One of two surgeons performed each procedure (YS X and FY L).

After administration of local anesthesia (1% lidocaine), bilateral labia minora are stretched laterally using unabsorbable sutures, which are fixed on the surgical drapes to expose the introitus of the vagina (Fig. 1A). Approximately 80-100 ml tumescent solution containing 0.9% sodium chloride solution with lidocaine 0.05% and epinephrine 1:1000000 is injected submucosally into the rectovaginal septum (Fig. 1B). An arc-shaped incision is made along the hymenal ring, and the incision is performed between 3 and 9 o'clock (Fig. 1A). Starting at the hymen ring, submucosal dissection is performed using blunt and sharp surgical scissors to create a submucosal plane in the rectovaginal septum with depth approximately 6–7 cm (Fig. 1C). From the hymenal ring, about 2–3 cm of vaginal mucosa is firmly attached to the perineal body and a sharp scissors dissection is required to separate the mucosa from the underlying tissues. When the dissection reaches the LA level, the vaginal mucosa can be easily swept off from the underlying tissues with finger or gauze. After this step, bilateral limbs of the LA are exposed (Fig. 1D and E), which are separated as the result of prior vaginal delivery. Using interrupted 2−0 Vicryl sutures, the rectovaginal fascia is repaired to cover the anterior wall of the rectum (Fig. 1F). Then, bilateral limbs of the LA are approximated and plicated in a ladder manner at the middle line (Fig. 2A and B). In the process of plicating the LA, the width of the vaginal canal should be confirmed repeatedly to avoid overtightening, which may lead to vaginal stenosis or dyspareunia. Based on our experience, it is safe to tighten the vagina to a width of about 2.5 cm, which should accommodate digital examination with two fingers.

After plicating the LA, the anterior surface of the perineal body (PB) presents a V-shape gap opening towards the vaginal mucosa (Fig. 1G). Using 2−0 Vicryl sutures, the gap is closed with horizontal mattress sutures layer by layer (F. 2 A and B). This not only strengthens the distal rectovaginal septum, but also narrows the distal vaginal canal and introitus of the vagina.

After reconstruction of the PB, the edge of the posterior vaginal mucosa appears redundant relative to the narrowed vaginal introitus. The hymenal remnants of redundant mucosal edge are removed (Fig. 1H) and the incisal margin is closed using 2−0 Vicryl sutures (Fig. 1I). Next, the overlying vaginal mucosa is fixed on the underlying musculature using 4–5 deep interrupted sutures (Fig. 1J). This can close the submucosa cavity to prevent the formation of postoperative hematoma and postoperative proplase of vaginal mucosa. Subsequently, the incisions are closed using 4−0 Vicryl sutures (Fig. 1K). Finally, an Fr-16 Foley catheter is inserted into the bladder and the vaginal canal is packed with sterile gauze (Fig. 1L).

Postoperative management and followup

After the surgery, oral antibiotic prophylaxis is provided to the patients for three days and oxycodone-acetaminophen tablets are used to relieve postoperative pain. The catheter is removed 2 days after surgery and the gauze is removed 24 h postoperatively. Sexual intercourse is recommended to resume 3 months after surgery. Patients returned to clinic for follow-up at 3 and 12 months postoperatively, and annually thereafeter via e-mail or Wechat. At each follow-up appointment, vaginal examination and a cough stress test were performed. Scores of the UDI-6, ICIQ-SF, I-QOL, PISQ-12 and Patient Global Impression of Improvement (PGI-I) were recorded at 12 months to evaluate patients' improvement in symptoms severity, QoL, and sexual function. At the 3 months postoperative visit, 4-D ultrasound was used to evaluate anatomical structure changes. The objective cure was declared based on a negative cough stress test. The subjective cure was measured with the PGI-I questionnaire, and patients were considered cured if their responses were "very much improved" or "much improved" [10].

Statistical analysis

The data analysis was performed using SPSS Statistics 23.0 for Windows, and a paired-samples t-test was employed for continuous variables. Statistic significant results were defined as $p<.05$.

Results

From January 2019 to December 2021, 47 patients diagnosed primary SUI were enrolled in this study. The clinical characteristics of the patients are displayed in Table 1. The mean age was 43.6 (24–63) years, with a mean BMI of 24.6 (19.60–31.3) kg/m^2. Thirty-five (74.5%) patients had uncomplicated cases, though overactive bladder (OAB), POP (<stage 2), or both were discovered in 4 (8.5%), 5 (10.6%) and 3 (6.4%) patient respectively. In term of delivery, 40 (85.1%), 0, and 7 (14.9%) patients had

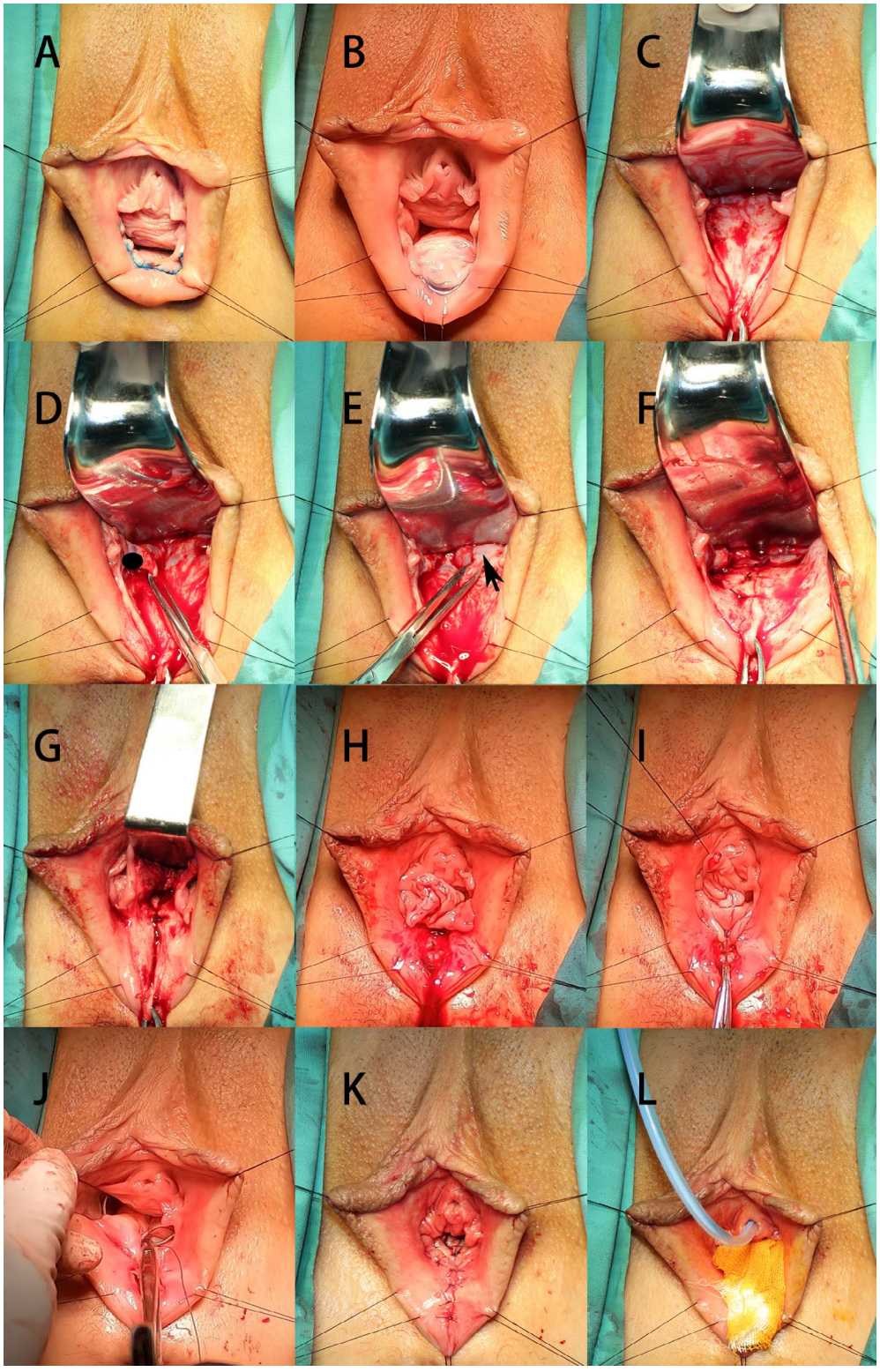

Fig. 1 Operative steps: (**A**) exposing vaginal introitus and marking the line of incision; (**B**) submucosal injection of tumescent solution into rectovaginal septum; (**C**) development of submucosal plane; (**D**, **E**) exposure of bilateral limbs of LA (circle: right, arrow: left); (**F**) repairing and plicating rectovaginal fascia to cover anterior wall of rectum; (**G**) V-shaped gap of PB after plicating LA; (**H**) removal of hymenal remnants of redundant mucosal edge; (**I**) closing redundant mucosal edge; (**J**) fixing vaginal mucosa on underlying musculature; (**K**) closing of incision; (**L**) indwelling catheter and packing gauze into vaginal cavity

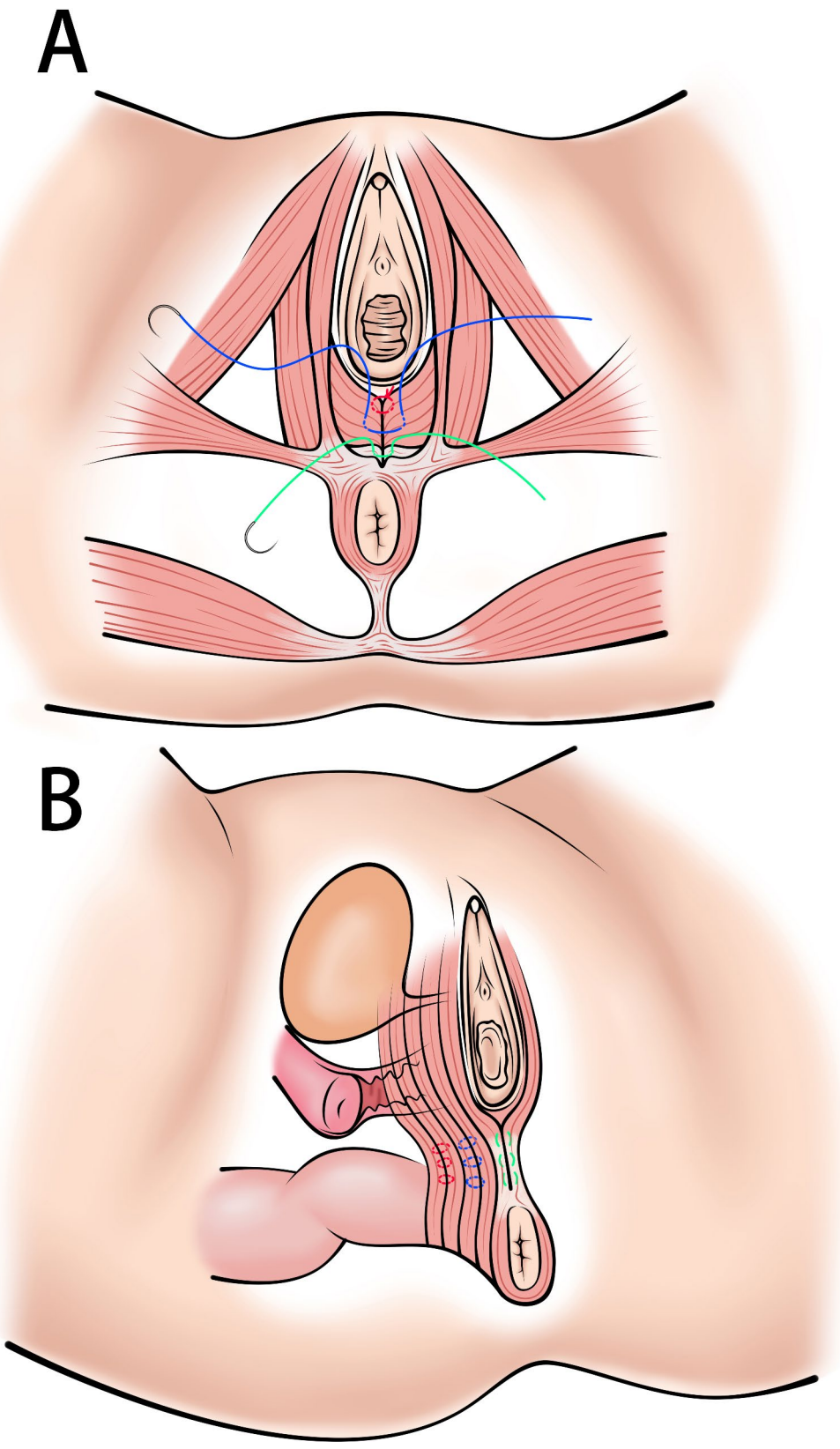

Fig. 2 Schematic diagram of levatorplasty and perineoplasty: (**A**) inferior view of the placement of sutures; (**B**) lateral view of the placement of sutures

Table 1 Clinical characteristics of the patients

Variable	Results
Patients, (*n*)	47
Mean age, yr (range)	43.6 (24–63)
Mean BMI, kg/m^2 (range)	24.6 (19.6–31.3)
Indication for Surgery, *n (%)*	
Uncomplicated SUI	35 (74.5)
Complicated SUI	
OAB	4 (8.5)
POP	5(10.6)
Both	3(6.4)
Delivery pattern, *n (%)*	
Vaginal	40 (85.1)
Caesarean	0
Both	7 (14.9)
Parity, times (range)	1.4 (1–3)
Menstrual history, *n (%)*	
Premenopause	36 (76.6)
Postmenopause	11 (23.4)
Vaginal laxity, *n (%)*	47 (100)

BMI, body mass index; OAB, over active bladder;

POP, pelvic organ prolapse; SUI, stress urinary incontinence

Table 2 Outcomes assessed by cough stress test and PGI-I

	12-month follow-up
Negative cough stress test, *n* (%)	41 (87.2)
Subjectively cured, *n* (%)	
(cured) PGI-I = 1–2	43(91.5)
(improved) PGI-I = 3	4 (8.5)
(unchanged) PGI-I = 4	0
(worsen) PGI-I > 4	0

PGI-I, patient global impression of improvement

Table 3 Outcomes assessed by UDI-6, ICIQ-SF, I-QOL and PISQ-12 scores

	Baseline	12-mo follow-up	
	mean ± SD	mean ± SD	*p* value
UDI (*n* = 47)	6.47 ± 1.09	1.74 ± 1.23	< 0.01
ICIQ-SF(*n* = 47)	12.34 ± 3.01	2.20 ± 1.56	< 0.01
I-QOL (*n* = 47)	50.05 ± 10.80	79.73 ± 8.95	< 0.01
PISQ-12 (*n* = 39)	20.31 ± 7.26	31.20 ± 4.99	< 0.01

UDI-6, urogenital distress inventory short form; ICIQ-SF, international consultation on incontinence questionnaire short form; I-QOL, incontinence quality of life questionnaire;

PISQ-12, pelvic organ prolapse/urinary incontinence sexual questionnaire short form

Table 4 Results of sonographic examinations at 3 months postoperatively

	Baseline	3-month follow-up	
	mean ± SD	mean ± SD	*p* value
URA* (degree, *n* = 47)	62.45 ± 14.70	26.66 ± 3.90	< 0.01
RVA* (degree, *n* = 47)	171.48 ± 24.74	131.72 ± 12.47	< 0.01
BND (mm, *n* = 47)	26.34 ± 6.06	15.57 ± 2.74	< 0.01
LAH* (cm^2, *n* = 47)	23.36 ± 2.45	18.69 ± 1.53	< 0.01

URA, urethral rotation angle; RVA, retrovesical angle; BND, bladder neck decent;

LAH, levator ani hiatus;

* on maximum Valsalva

prior vaginal, caesarean, or both methods of delivery, respectively, with an average parity of 1.4. The majority of patients were premenopausal (36/47, 76.6%). All patients reported symptoms of vaginal laxity which were confirmed by vaginal digital examination.

All of the procedures were successfully performed, and no injury of the rectum, urethra, or bladder was encountered during the operations. The mean operative duration was 78.7 (50–120) minutes and the median estimate blood loss was 80.2 (50–200) ml. No patient complained of dysuria after removal of the catheter. No postoperarive bledding and wound infection were discovered in all patients. Most patients experienced a certain degree of postoperative pain and sensation of rectal tenesmus, which disappeared gradually within a week.

All the patients had a minimum 12-month follow-up (average: 18.6 month). Thirty-nine (82.9%) patients resumed regular sexual intercourse 3 months after surgery, and 6 of these patients experienced mild coitus pain at the initiation of sexual activity, which disappeared with the continuation of sexual activity without medical intervention. No vaginal stenosis, rectovaginal fistula, recurrent urinary tract infection, or de novo urgency was encountered in any patients.

Tables 2 and 3 list the treatment outcomes after 12-month follow-up. Objective cure evaluated by cough stress test was 87.2% (41/47) and subjective cure measured with PGI-I was 91.5% (43/47). The remaining 4 patients reported a subjective improvement. The results of outcome assessed with UDI-6, ICIQ-SF, I-QOL and PISQ-12 were significantly improved compared with preoperative baseline. Among the 7 patients who had symptoms of OAB preoperatively, improvement of symptoms was reported postoperatively. Compared with preoperative data, decreasing of URA, RVA, BND and areas of levator hiatus under maximum Valsalva maneuver were detected on postoperative 4-D ultrasonography (Table 4). No sign of POP was identified by postoperative ultrasonography in the 8 patients with preoperative POP.

Discussion

The support system of urethra and bladder neck plays a crucial role in maintaining continence during sudden increase in intra-abodominal pressure. This system comprises all external structures that provide a layer on which the urethra and bladder neck are situated, including the LA, PB, endopelvic fascia, and the arcus tendineus fasciae pelvis [11–13]. The contraction of the LA interacts with the pelvic fascia to elevate the vaginal wall and prevent the downward movement of the urethra. As a result, the posterior urethral wall is pressed against the

anterior urethral wall, aiding in sealing the urethral cavity and preventing urinary leakage [14].

Normal function of the urethral support system necessitates normal contraction and anatomical structure of the LA. This muscle can be divided into three regions: the posterior iliococcygeal portion, the anterior pubovisceral muscle (PVM) and puborectal muscle [12]. The bundles of PVM extend medially and interlace with the contralateral muscle bundle forming the anterior sling surrounding the anterior anal region [15]. In healthy women, magnetic resonance imaging (MRI) measurements show that the muscle fibers of the PVM are positioned at an angle of 41±8.0 degrees relative to the horizontal line in the standing position [16]. The contraction of the PVM exerts two distinct mechanical forces: a closing force, characterized by a horizontal directional force that establishes a high-pressure zone within the vagina, resulting in the closure of the vaginal canal, urethral lumen, and genital hiatus (GH); and a lifting force, characterized by a vertical direction that prevents the downward displacement of pelvic organs [17]. During vaginal delivery, the tissues surrounding the vagina are significantly stretched by the baby's head, causing severe deformation of the LA. Among the three regions of the LA, the PVM experiences the highest stress and is most susceptible to stress-related injuries [18, 19]. Although most injuries are subclinical and the vast majority of women regain function and appearance similar to their prenatal state [20], these women face an increased risk of developing pelvic floor dysfunction in the future due to the degeneration of pelvic muscles and ligaments [21, 22].

PB, a wedge-shaped fibromuscular structure located in the midline of the perineum between the posterior fourchette and anus, plays a key role in maintaining the integrity of the pelvic floor. It provides attachments to muscles and fascia, which work synergistically to maintain urinary continence and the orgasmic platform [23]. Injury to the PB has been reported in 10–30% of women during vaginal delivery, resulting in the separation of the free boundaries of the LA on both sides [24]. This injury is significantly associated with pelvic floor muscle dysfunction, often manifesting as POP or urinary incontinence [25].

In recent years, ultrasonography, as a dynamic examination modality, has become an important part of urogynecological assessments. For the pelvic reconstructive surgeon, ultrasonography provides additional information regarding the characteristic anatomical alterations associated with stress incontinence [26]. Certain indicators, such as URA, BND and RVA, are considered as anatomical indicators for the preoperative and postoperative evaluation of patients with SUI. In this study, the preoperative and postoperative ultrasonographic findings are demonstrated in Table 4. Compared with the preoperative data, URA, BND and RVA were significantly reduced. The improvement of these parameters suggests enhancement of the urethral support structures and reduction of urethral hypermobility. This may elucidate the efficacy of the surgical technique described in improving or resolving female SUI.

We hypothesize that three mechanisms contributed to the enhancement of urethral support structures and the amelioration of urethral hypermobility following the procedures: Firstly, the "stiffness" of the posterior wall of the vagina was augmented after the plication of the LA and reconstruction of the PB. Four-Dimensional ultrasonography conducted 3 months postoperatively revealed that the rectovaginal septum had significantly increased in thickness compared to the preoperative state, thereby reinforcing the supportive system of the urethra (Fig. 3A and B). Secondly, following the plication of the bilateral LA, an autologous muscular "sling" was formed around the bladder neck and the proximal and middle urethra. This muscular sling acts to prevent the downward displacement of the urethra and bladder neck under conditions of sudden intra-abdominal pressure elevation (Fig. 2B). Finally, the plication of the LA may have indirectly reinforced the suspensory ligaments, which can become relaxation as a result of vaginal delivery, aging, or menopause [27]. The pelvic muscles exert tension on these ligaments; consequently, muscle strength may diminish if the ligaments are loose, compromising the ability to maintain closure of the urethral, vaginal, and anal passages [27]. Through the combined action of these three mechanisms, urethral hyperactivity was inhibited, and the urethral closing capability was improved during episodes of increased intra-abdominal pressure, thereby averting the involuntary leakage of urine.

SUI has been linked to negative impacts on sexual function in females, primarily driven by concerns over coital incontinence, odor, psychological distress, loss of self-esteem, and embarrassment [28]. In recent years, there has been a growing body of research examining the effects of anti-incontinence surgeries on patients' sexual wellbeing. Notably, most studies have observed improvements in sexual function following such procedures [29–31]. However, for those with concomitant vaginal laxity, sexual dysfunction may not be fully resolved without additional vaginal tightening measures [31]. Despite all patients in this study exhibiting combined vaginal laxity, postoperative improvements in sexual function were reported in 39 individuals who maintained regular sexual intercourse. We hypothesize that these improvements in sexual satisfaction can largely be attributed to the plication of LA and the reconstruction of PB, which work synergistically to narrow the vaginal canal and enhance its 'holding power' during sexual intercourse.

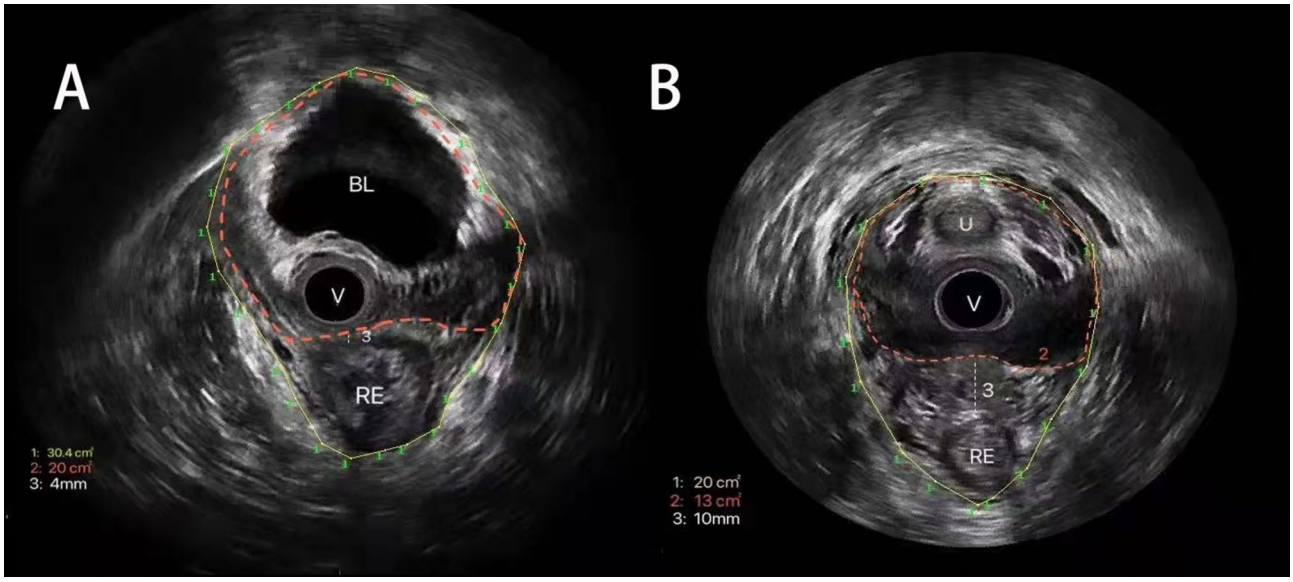

Fig. 3 Ultrasonographic findings of a 53-yr-old woman: (**A**) preoperative view at level of levator hiatus on maximum Valsalva (1. levator hiatus: 30 cm^2; 2. genital hiatus: 20 cm^2; 3. rectovaginal septum: 4 mm); (**B**) postoperative view at level of levator hiatus on maximum Valsalva (1. levator hiatus: 20 cm^2; 2. genital hiatus: 13 cm^2; 3. rectovaginal septum: 10 mm); BL = bladder; RE = rectum; U = urethra; V = vagina

This study had several limitations. First, the majority of patients were premenopause, thus the treatment outcomes in postmenopausal and elderly women could not be determined. Second, no patients with detachment of LA from the tendinous arch or LA paralysis were encountered in our study. Further research is needed to to determine whether these patients would benefit from the surgical interventions we introduced. Third, all patients enrolled had primary SUI. The effectiveness of this surgical technique in recurrent SUI requires further study. In addition, our sample size was limited and the follow-up time was only 12 months. As pelvic muscles and ligaments deteriorate with age and menopause, the treatment outcome of this surgical method requires further evaluation in a larger population with longer follow-up.

In this research, we approximated and plicated the bilateral LA and reconstructed the PB via transvaginal approach to treat the female SUI. The objective and subjective cure rates at 12 mo follow-up were at 87% and 91.3%, respectively. Although the fresults are promising, the surgical technique we reported is not the standard procedure endorsed by current urinary incontinence guidelines. Due to the limited sample size and comparatively brief follow-up duration, the evidence supporting its widespread adoption as the favored intervention for female stress urinary incontinence is insufficient. Nevertheless, in routine clinical practice, a number of patients express reluctance towards undergoing MUS surgery due to perceived risks associated with potential complications. For these individuals, the surgical approach we have discussed presents a viable alternative treatment option. This is particularly pertinent for younger patients who place a high value on sexual well-being, as our proposed method not only mitigates symptoms of urinary incontinence and improves life quality but also holds the potential to augment sexual satisfaction.

Conclusions

TPLP appears to be an effective surgical option for selected women with primary SUI, especially for sexually active women with vaginal laxity. Further validation in a broader population with longer follow-up is vital to confirm the true clinical value of this surgical techique.

Acknowledgements
Not applicable.

Author contributions
YS Xu: literature review, project developer, data analysis, first draft of manuscript; L Wei: data collection/analysis; MC Liu: data collection/analysis; ZM Jia: data collection; YL Li: data collection; FY Li: idea of the study, literature review, project development, project leader, data analysis, manuscript editing.

Funding
There is no funding for this study.

Data availability
The original data in the current study was available from the corresponding author on reasonable request.

Declarations

Ethical approval
This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institutional Review Board of the Plastic Surgery Hospital at Chinese Academy of Medical Sciences and Peking Union Medical College.

Clinical trial number
No. 2018-70/2018-12-31.

Consent to participate
Informed consent was obtained from all individual participants included in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 28 November 2023 / Accepted: 24 September 2024
Published online: 26 October 2024

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