



Research article

De novo urinary incontinence and lower urinary tract symptoms after colpocleisis: A single-center prospective study

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ABSTRACT

Background: Colpocleisis is one of traditional surgical procedures for elderly and frail women with advanced pelvic organ prolapse. The occurrence of de novo urinary incontinence following colpocleisis was considered to impair the postoperative quality of life. The incidence of de novo urinary incontinence after colpocleisis has been reported to be ranging from 6.6 % to 27 %. There was an absence of prospective large-sample study to investigate the accurate incidence of de novo urinary incontinence following colpocleisis and the impact on the quality of life till now.

Purpose: s The primary objective was to report the incidence of de novo urinary incontinence after colpocleisis. The second objectives were to evaluate the long-term quality of life in patients with de novo urinary incontinence, and to conduct detailed pre- and post-operative evaluations of lower urinary tract symptoms.

Methods: This prospective study included 253 patients with symptomatic pelvic organ prolapse who underwent colpocleisis between 2009 and 2021. De novo urinary incontinence was defined as the occurrence of urinary incontinence 3 months postoperatively. All patients were required to complete the Urinary Distress Inventory questionnaire and the Urinary Impact Questionnaire for the evaluation of patients' quality of life, and the Patient Global Impression of Improvement questionnaire for the evaluation of patients' satisfaction.

Results: 245 patients (245/253, 96.8 %) completed the 3-month follow-up, and were included in the final analysis. The incidence of de novo urinary incontinence was 5.4 % (10/185). There was no significant difference in the Urinary Distress Inventory –6 scores (22.50 vs. 10.30, $P = 0.276$) or the subjective satisfaction rate (100 % vs. 98.9 %, $P = 0.250$) between the patients with or without de novo urinary incontinence at the long-term follow-up. The incidence of voiding difficulty was significantly reduced after colpocleisis (27.8 % vs. 0.0 %, $P < 0.001$). The patients' quality of life indicated by Urinary Distress Inventory-6 and Urinary Impact Questionnaire-7 scores were significantly improved postoperatively (26.27 vs. 13.39, and 19.13 vs. 6.05, $P < 0.05$).

Conclusion: The incidence of de novo urinary incontinence after colpocleisis was very low. Patients' quality of life, and low urinary tract symptoms were significantly improved after colpocleisis.

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1. Introduction

Pelvic organ prolapse (POP) is a common gynecological condition that affects the patients' quality of life. A multicenter cross-sectional study in China found that symptomatic POP occurred in 9.6 % of all adult women [1]. Since the population is aging, POP will affect an increasing proportion of women over the next several decades [2]. The lifetime risk of any primary surgery for POP was 12.6 % by the age of 80 years [3]. A meta-analysis suggested the recurrence risk of POP surgery was 37.7 % [4]. Another population-based cohort research revealed that the risk of POP reoperation was 29.2 % [5]. Colpocleisis is a traditional and highly effective surgical procedure that is suitable for elderly women with advanced POP who no longer desire coital function.

Most patients with advanced or symptomatic POP experience concomitant urinary incontinence (UI) and lower urinary tract symptoms (LUTS) [6]. Nevertheless, some women with advanced POP do not complain of stress urinary incontinence (SUI) despite the loss of vaginal and urethral support, which can be the result of anatomic urethral kinking, a common manifestation of advanced prolapse [7]. When the prolapse is reduced by pessaries or surgical repair, UI may develop in those with no history of UI, which is named de novo UI and is recognized as an issue affecting quality of life after surgery. The incidence of de novo UI after colpocleisis varies from 9.7 % to 27 % [8,9]. The search for risk factors for de novo UI has been inconclusive, and the accuracy of predictors for de novo UI has not been tested in a well-conducted clinical trial. Therefore, preoperative counseling is essential for POP patients and decision on prophylactic midurethral sling at the time of colpocleisis is challenging. In addition, the long-term impact of de novo UI after colpocleisis on quality of life is still unclear. Although colpocleisis was demonstrated to significantly relieve bladder distress in patients with advanced POP, the detailed changes in urinary symptoms following obliterative surgery were not described.

The purpose of this prospective study was to determine the incidence of de novo UI after colpocleisis and the potential risk factors predisposing to de novo UI and to evaluate the long-term quality of life of patients with de novo UI. Second, we comprehensively evaluated the LUTS of POP patients before and after colpocleisis.

2. Materials and methods

This prospective study was conducted in a single obstetrics and gynecology department at Peking Union Medical College Hospital and approved by the hospital's ethics committee. From January 2009 to December 2021, 253 patients with symptomatic POP who underwent colpocleisis were consecutively enrolled in this study. The inclusion criteria were symptomatic utero-vaginal prolapse or vaginal vault prolapse and no desire for future vaginal intercourse. The exclusion criteria were as follows: previous anti-incontinence surgery, contraindications to transvaginal surgery, such as acute vaginal infection, extremely narrow vagina, or not tolerant surgical treatment due to severe comorbidities, and insufficient or incomplete pre- or postoperative data.

The baseline characteristics included a standard medical and urogynecological history, standardized Pelvic Organ Prolapse Quantification System (POP-Q) measurements, pelvic and urinary tract ultrasound examinations, urinalysis, 1-h pad test, and uroflowmetry. Patients were instructed to arrive at the office with a comfortably full bladder. Patients were asked to void into a flowmeter when they felt urge to void to generate a time-flow curve on a urodynamic recorder. Mean and maximum flow rate, voiding time, flow duration, voiding volume, and postvoid residual (PVR) were measured [10]. If the 1-h pad test was negative (<2 g), then the test was performed with prolapse reduction, which is also named OSUI (occult stress urinary incontinence) test. If the 1-h pad test was positive (≥ 2 g), urodynamic examination was subsequently performed to determine the type of urinary incontinence. The 1-h pad test and urodynamic examination were performed after urinary tract infection was ruled out. The participants were asked to complete the Chinese version of the Pelvic Floor Distress Inventory—Short Form 20 (PFDI-20) questionnaire consisting of the Urinary Distress Inventory-6 (UDI-6) scale, the Chinese version of the Pelvic Floor Impact Questionnaire Short Form (PFIQ-7) consisting of the Urinary Impact Questionnaire-7 (UIQ-7) before and after surgery, and the Patient Global Impression of Improvement (PGI-I) questionnaire postoperatively.

All surgical procedures were performed by experienced gynecologists. Before surgery, preoperative medical consultations were conducted in all patients, and necessary medical interventions were performed to optimize the surgical outcomes. Total or partial (LeFort) colpocleisis was performed either alone or in combination with other procedures, such as hysterectomy, anti-incontinence surgery and perineorrhaphy. Bedside ultrasound examination was performed to test the volume of PVR after removal of the catheter. Transient postoperative urinary retention (UR) was defined as a PVR volume >100 ml.

Patients were followed up for 3 months, 1 year, and 3 years postoperatively and then as needed thereafter. Considering that patients who underwent colpocleisis were elderly and had multiple medical comorbidities, follow-up was conducted in the outpatient clinic or by phone. The primary outcome was the presence of de novo UI at the 3-month follow-up. The objective evaluation included a 1-h pad test and urodynamic examination if the outpatients complained of new-onset urinary leakage. In the subjective evaluation, urinary leakage was defined according to the Ingelman-Sundberg classification; grade I—urinary incontinence when coughing or sneezing, grade II—urinary incontinence when running or picking up objects from the floor and grade III—incontinence when walking or climbing stairs [11]. The secondary outcomes were the UDI-6, UIQ-7, PGI-I scores and the LUTS and at long-term follow-up. The UDI-6 scale includes six items. The patients were asked whether they experienced each symptom, and if so, how much the symptom bothered them. Scores on the UDI-6 range from 0 to 100, with higher scores indicating greater symptom distress [12,13]. The UIQ-7 scale has 7 items and is used to assess the impact of POP on the quality of life in affected women, with higher scores indicating greater life impact [14]. The differences and 95 % confidence interval were calculated to evaluate the changes of symptom distress and quality of life. The PGI-I scale is 7-point Likert scale that ranks the response to a single question from “1. very much better” to “7. very much worse” [15]. A PGI-I score ≤ 2 (“1. very much better” and “2. much better”) was defined as a subjective success [16].

2.1. Statistical analysis

SPSS Version 26.0 (IBM Corp., Armonk, NY) was used for statistical analysis. Descriptive statistics were calculated as the mean with standard deviation, median with interquartile range, or frequencies and proportions. Student's *t*-test, and rank sum test were used to compare continuous variables between groups. Categorical data were analyzed by the χ^2 test or Fisher's exact test. Logistic regression analysis was used for bivariate and multivariate analyses. A *P* value of <0.05 was considered statistically significant.

3. Results

From 2009 to 2021, a total of 253 eligible patients were enrolled in this prospective study. The flow chart of patient enrollment is shown in Fig. 1. A total of 245 (96.8 %) patients completed the 3-month follow-up and were included in the final analysis. The median follow-up time was 5 (range, 1–12) years, with 118 patients completing ≥ 3 years of follow-up. A total of 8 patients died from non-gynecological causes during the follow-up period. The demographic and clinical baseline characteristics of 245 patients who completed the 3-month follow-up are presented in Table 1. The mean (SD) age at the time of surgery was 73.0 (5.3) years old. 42.4 % out of patients had two or more comorbidities, and 53 out of 245 patients (21.6 %) were diagnosed with diabetes (Supplementary Table 1). A total of 85.7 % of patients were diagnosed with stage 3 POP, and 91.8 % of patients had an anterior vaginal prolapse. Thirty-three patients had previously undergone conservative therapies for POP, and 57 patients underwent POP surgeries before colpocleisis. Sixty patients had concurrent urinary incontinence, including 34 with SUI, 14 with urgent urinary incontinence (UUI) and 12 with mixed urinary incontinence (MUI). The most common LUTS was voiding difficulty (68, 27.6 %), followed by urinary frequency (54, 22.0 %).

The perioperative data are shown in Table 2. Concomitant procedures included 133 hysterectomies, 16 anti-incontinence surgeries and 14 perineoplasties. The median operative time was 82.5 min, the median blood loss was 50 ml, and the median length of hospital stay was 4 days. No intraoperative complications occurred. The overall rate of postoperative complications was 11.0 % (27/245). According to the Clavien–Dindo classification, 4 patients suffered from grade II complications, and 23 patients had grade I complications. No serious adverse events were reported. The most common postoperative complication after colpocleisis was transient UR (7.8 %, 19/245). Transient postoperative UR was managed with physical therapy (medium frequency electrotherapy or pulsed magnetic therapy) in 16 patients, catheterization in 12 patients, and anticholinesterase in 1 patient. Multivariate analysis revealed that there was no association between concomitant hysterectomy or mid-urethral sling (MUS) and postoperative UR.

The postoperative outcomes of preexist UI in 60 patients with preoperative UI were summarized in Table 3. 16 out of 60 patients underwent concomitant anti-incontinence surgery at the time of colpocleisis, among whom 11 patients (68.8 %) had complete remission of urinary incontinence, and 5 patients (31.2 %) felt obvious relief. Otherwise, half of patients who didn't had anti-incontinence surgery had complete relief after colpocleisis, and 9 patients (20.5 %) felt improved. Four patients (9.1 %) complained of aggravated symptoms after surgery.

At 3 months after surgery, 10 out of 185 patients (10/185, 5.4 %) without preoperative UI developed de novo UI after colpocleisis, including 5 cases of SUI, 4 cases of MUI and 1 case of UUI. According to the Ingelman-Sundberg classification, nine patients had grade I urinary incontinence, and one patient had grade III urinary incontinence. The patient with UUI received solifenacin orally to relieve urinary leakage symptoms, and the remaining patients did not receive medical or surgical treatment. The univariate regression analysis suggested that age at surgery, BMI, diabetes, and concomitant hysterectomy had no relationship with the development of de novo UI (Supplementary Table 2). The incidences of de novo UI in patients with and without hysterectomy were 6.4 % and 4.4 % (*P* =

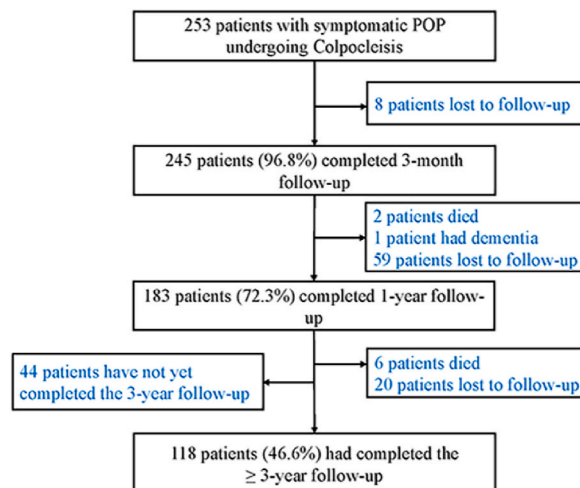


Fig. 1. Flow chart of patient enrollment Patients with symptomatic POP who completed the 3-month follow-up (245/253, 96.8 %) were included in the final analysis.

Table 1
The demographic baseline characteristics of 245 patients.

Baseline characteristic	Value
Age, y, Mean (SD)	73.0 (5.3)
BMI, kg/m ² , Mean (SD)	24.41 (3.03)
Parity, Mean (SD)	2.53 (1.33)
Postmenopausal, y, Mean (SD)	23.7 (6.3)
Prolapse stage, n (%)	
2	3 (1.2 %)
3	210 (85.7 %)
4	32 (13.1 %)
Comorbidity, n (%)	
≤1	141 (57.6 %)
≥2	104 (42.4 %)
Previous POP therapies, n (%)	
None	155 (63.2 %)
Conservative treatment ^a	33 (13.5 %)
Surgery	57 (23.3 %)
previous hysterectomy for POP	33 (13.5 %)
Urinary incontinence, n (%)	
stress urinary incontinence	34 (13.9 %)
urgent urinary incontinence	14 (5.7 %)
mixed urinary incontinence	12 (5.0 %)

BMI: body mass index.

^a Conservative treatment included pessary and pelvic floor muscle training.

Table 2
The perioperative characteristics of 245 patients.

Perioperative characteristic	Value
Concomitant procedure	
hysterectomy	133
anti-incontinence	16
perineorrhaphy	14
Operative time, min, Median (IQR)	82.5 (61.25, 105)
Blood loss, ml, Median (IQR)	50 (30, 50)
Length of stay, d, Median (IQR)	4 (3, 5)
Postoperative morbidity, n (%)	
Yes	10 (4.1 %)
No	235 (95.9 %)
Postoperative complications, n (%)	
Yes	27 (11.0 %)
No	218 (89.0 %)

Table 3
The postoperative changes in 60 patients with preoperative UI.

	anti-incontinence surgery	no anti-incontinence surgery	<i>P</i>
Number of patients	16	44	
Change (n, %)			0.109
cured	11 (68.8 %)	22 (50.0 %)	
improved	5 (31.2 %)	9 (20.5 %)	
no change	0	9 (20.5 %)	
aggravated	0	4 (9.1 %)	

0.785), the difference showed no statistical significance.

During the long-term follow-up, objective success, defined as the absence of prolapse beyond the hymen, was achieved in all 118 patients (100 %) who completed the long-term follow-up. Overall subjective success, defined as a PGI-I score ≤2, was achieved in 116 of 118 patients (98.3 %). No one regretted undergoing the obliterative procedures. At 3-year follow-up, the UDI-6 score of patients with de novo UI was higher than that of patients without de novo UI (22.50 vs. 10.30), but the difference was not statistically significant ($P = 0.276$). Moreover, subjective satisfaction rate was not significantly different between the patients who developed and those who did not develop de novo UI after colpocleisis (100 % vs. 98.9 %, $P = 0.250$). During follow-up visits, the postoperative UDI-6 and UIQ-7 scores significantly decreased after colpocleisis (Table 4). The negative changes of UIQ-7 scale after colpocleisis showed steady at short-term, intermediate, and long-term follow-up, while the UDI-6 scores were slightly decreased at the 1-year follow-up.

Table 4

The overall scores of UDI-6 and UIQ-7 of patients.

	preoperative				3-month postoperatively			1-year postoperatively			3-year postoperatively		
	Mean (SD)	Mean (SD)	Difference (95%CI) ^a	<i>P</i> ^b	Mean (SD)	Difference (95%CI) ^a	<i>P</i> ^b	Mean (SD)	Difference (95%CI) ^a	<i>P</i> ^b	Mean (SD)	Difference (95%CI) ^a	<i>P</i> ^b
UDI-6	26.27 (21.51)	17.07 (19.53)	-9.20 (-15.85, -2.55)	0.003	17.92 (20.20)	-8.35 (-17.48, 0.78)	0.083	13.39 (15.94)	-12.88 (-19.38, -6.39)	< 0.001			
UIQ-7	19.13 (22.73)	6.95 (15.53)	-12.18 (-18.90, -5.47)	< 0.001	8.68 (19.83)	-10.46 (-20.21, -0.70)	0.031	6.05 (8.17)	-13.09 (-23.86, -2.31)	0.012			

^a Values indicated the mean difference between baseline and follow-up.^b *P* values in bold are significant.

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The individual scores of each item in the UDI-6 indicated reduced urinary frequency and relieved difficulty emptying and discomfort, rather than urinary leakage. Significant reductions were shown in each item of the UIQ-7, suggesting a comprehensive improvement in the patients' quality of life after colpocleisis (Fig. 2). The most common LUTS after colpocleisis was urinary frequency (19.4 %), which was as frequent as the preoperative baseline, while the incidences of voiding difficulty decreased significantly after colpocleisis. The proportion of patients with voiding dysfunction, defined as a PVR volume less than 50 ml in uroflowmetry, decreased significantly at long-term follow-up following colpocleisis (22.9 % vs. 4.2 %, $P < 0.001$) (Table 5).

4. Discussion

In this prospective study, the objective and subjective success rates of colpocleisis were 100 % and 98 %, respectively. The incidence of de novo UI after colpocleisis was 5.4 % (10/185). The LUTS, especially voiding dysfunction, improved significantly after colpocleisis. The quality of life was also notably improved following colpocleisis.

Colpocleisis is a highly effective and safe surgical method for managing advanced POP in elderly patients. The objective success rate was 93 % ~ 98.1 % in the literature [9,17,18], while the subjective success rate was 92.9 % ~ 97 % [9,19–21]. The objective and subjective success rates of colpocleisis in this study are 100 % and 98.0 %, respectively, which again highlights that colpocleisis is highly effective for managing advanced POP in elderly patients.

De novo UI is a major complication of POP repair surgery, and its prediction and management still require further investigation. The incidence of de novo UI varies from 9.9 % to 54.5 % [22–27]. In a random control clinical trial, the researchers reported that de novo UI was present in 49.4 % and 43.0 % of patients at the 3-month and 12-month follow-ups, respectively, after vaginal prolapse surgery [28]. Compared to reconstructive approaches, obliterative procedures carry a similar risk of worsening or unmasking occult urinary incontinence. However, research focusing on the incidence of de novo UI after colpocleisis is scarce, the reported incidence of de novo UI ranges from 9.7 % to 27 % [8,9]. Zebede et al. reported that the incidence of de novo UI was 9.7 % in patients followed for a median of 25 weeks [9], while the study by FitzGerald et al. suggested that the incidence of de novo UI was 27 % [8]. In this prospective study, 96.8 % of patients completed the 3-month follow-up, and the incidence of de novo UI following colpocleisis was 5.4 %, which was notably lower than that reported in previous literature. Interestingly, the reasons for the discrepancies observed between various studies regarding the incidence of de novo UI remain unclear and warrant further investigation. Demographic characteristics that may increase the risk of UI in general, such as age, race, obesity and parity, may be contributing factors [29]. The different prolapse compartments and surgical procedures may influence the incidence of de novo UI [30]. The univariate analysis failed to find any risk factor for the occurrence of de novo UI in this study. In addition, studies investigating the occurrence of de novo UI following colpocleisis were conducted retrospectively, and there is still a lack of large-sample prospective studies accurately evaluating the incidence of de novo UI after colpocleisis.

Recently, the occurrence of de novo UI after colpocleisis has been well recognized by all gynecologists, however, studies considering the long-term quality of life of patients who developed de novo UI following colpocleisis are scarce. The UDI-6 and PGI-I scores were compared between the patients with and without de novo UI at the long-term follow-up. The UDI-6 score in patients with de novo UI was higher than that in patients without de novo UI (22.50 vs. 10.30), however, the difference was not statistically significant ($P = 0.276$). In addition, both groups of patients showed significant improvement after colpocleisis, with subjective satisfaction rates of 100 % and 98.9 %, respectively ($P = 0.250$). No significant deterioration of the quality of life of patients with de novo UI was found in this study.

The decision of prophylactic concomitant anti-incontinence procedures at the time of colpocleisis was difficult for both gynecologists and patients. As validated in a multicenter randomized controlled trial, a MUS placed at the time of prolapse repair can reduce

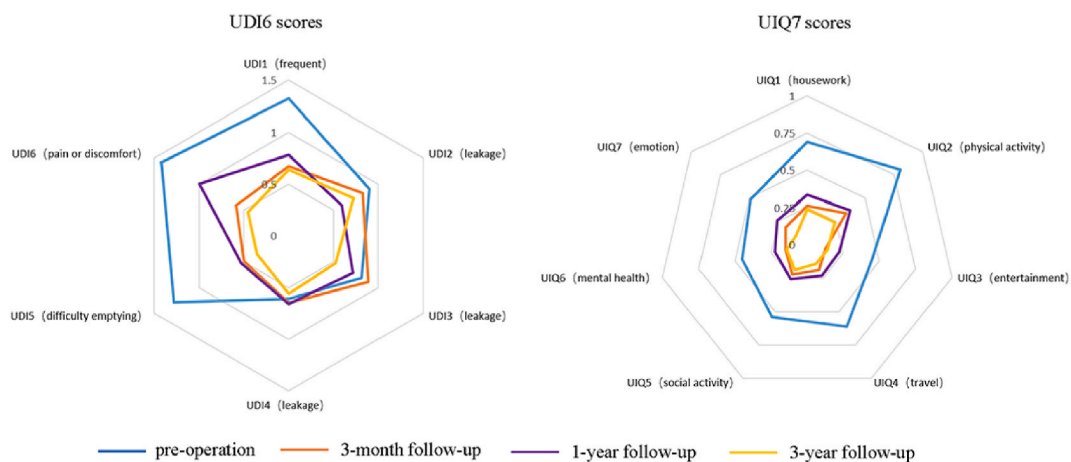


Fig. 2. The detailed scores of UDI-6 and UIQ-7, The UDI-6 scores showed relieved symptoms of urinary frequency, difficulty emptying and discomfort, and the detailed UIQ-7 scores suggested a comprehensive improvement in the patients' quality of life after colpocleisis.

Table 5
The preoperative and postoperative LUTSs and voiding function of patients with long-term follow-up.

	preoperatively	postoperatively	<i>P</i> ^a
Number of patients	245	118	
Low urinary tract symptoms			
frequency	54 (22.0 %)	28 (23.7 %)	0.789
urgency	40 (16.3 %)	22 (18.6 %)	0.655
nocturia	25 (10.2 %)	5 (4.2 %)	0.066
voiding difficulty	68 (27.8 %)	0 (0.0 %)	< 0.001
incomplete emptying	37 (15.1 %)	16 (13.6 %)	0.753
PVR (uroflowmetry)			< 0.001
≤50 ml	189 (77.1 %)	113 (95.8 %)	
>50 ml	56 (22.9 %)	5 (4.2 %)	

^a *P* values in bold are significant.

the risk of postoperative UI (23.6 % vs. 49.4 % at 3 months and 27.3 % vs. 43.0 % at 12 months). However, prophylactic MUS insertion also resulted in adverse events, including bladder perforation, bleeding and urinary tract infection [28]. Staged MUS placement was recommended for patients with OSUI, which can greatly reduce the number of MUSs performed [31]. In our department, concomitant MUS was not routinely performed in POP patients who were continent before surgery, the rates of de novo UI and retreatment for incontinence were still low, and the quality of life in patients with de novo UI was not significantly impaired at the long-term follow-up. These results indicated that de novo UI was not harmful and that prophylactic anti-incontinence procedures were not necessary.

Urinary symptoms are often found to be concurrent symptoms of POP, with a reported prevalence of more than 50 % [32]. Storage symptoms, such as urinary frequency and urgency, were equally as prevalent in POP patients as in women without POP. In cohort studies, researchers have suggested that women with POP have more obstructive voiding symptoms than women without POP [33]. In our cohort, 48.5 % of patients had storage symptoms, including urinary frequency, urgency and nocturia, before surgery and 37.9 % had storage symptoms after surgery. However, the proportion of patients with voiding symptoms decreased significantly after colpocleisis, especially the proportion of those with voiding difficulty, which was reduced from 27.8 % preoperatively to 0.0 % postoperatively ($P < 0.001$). It was suggested that voiding and postmicturition dysfunction was causally related to utero-vaginal descent, which was also indicated by a significant decrease in the ratio of voiding dysfunction categorized by PVR volume in uroflowmetry following colpocleisis. The research of Ferdi Kinci et al. showed different results, in which the risks of frequency and nocturia decreased significantly postoperatively [34]. It is interesting to discuss. First of all, the storage symptoms, such as frequency and urgency, may gradually worsen with the age, the differences between pre- and postoperative symptoms may become indistinctive with prolonged follow-up. In addition, the demographic characteristics, such as race, age, BMI, and the surgical factors, such as hysterectomy, may had impact on the LUTSs. In this study, the UDI-6 and UIQ-7 scores decreased significantly after colpocleisis, suggesting a significant improvement in quality of life. Previous retrospective studies also showed a significant decrease in PFDI-20 scores [20,35,36]. In our cohort, the UDI-6 scale scores indicated a significant improvement in LUTS rather than urinary leakage symptoms, while the UIQ-7 scale scores suggested a notable improvement in quality of life in all categories, which indicated that mild leakage symptoms may have less impact on quality of life.

5. Strength and limitation

This was a prospective study with a long-term follow-up. In the study, 46.6 % (118/253) of patients were followed up 3 years after colpocleisis. The incidence of de novo UI after colpocleisis was assessed in this study, and the improvement in LUTS following colpocleisis was evaluated objectively and comprehensively using patient-reported questionnaires. The limitations of this study include the single-center design and the large proportion of patients followed up via phone due to advanced age. In addition, the risk factors for de novo UI following colpocleisis were not identified in this study, and additional large-sample studies are needed.

6. Conclusions

Colpocleisis is an effective and safe procedure for patients with advanced POP who are no longer sexually active. The incidence of de novo UI after colpocleisis is low, and quality of life in patients experiencing de novo UI did not exhibit a notable decline. LUTS, especially voiding dysfunction, is significantly improved after colpocleisis.

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Ethics statement

This study was approved by the hospital's ethics committee Peking Union Medical College Hospital (S-166). Written informed consent was obtained from all participants.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Qianqian Gao: Writing – original draft, Methodology, Data curation. **Wenjia Lou:** Data curation. **Xiaochen Song:** Data curation. **Jianbin Guo:** Data curation. **Yang Ye:** Data curation. **Yiwei Zhang:** Data curation. **Zhiyuan Dou:** Data curation. **Xiaoyue Zhao:** Data curation. **Honghui Shi:** Data curation. **Zhijing Sun:** Data curation. **Juan Chen:** Data curation. **Lan Zhu:** Writing – review & editing, Conceptualization.

Declaration of competing interest

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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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e30805>.

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