International Urogynecology Journal
https://doi.org/10.1007/s00192-024-05907-z

ORIGINAL ARTICLE

vNOTES versus Laparoscopic Uterosacral Ligament Suspension for Apical Pelvic Organ Prolapse: Perioperative and Short-Term Outcomes

Taylor Morganstein[1] · Mihnea Gangal[2] · Eric Belzile[4] · Dorsa Sohaei[1] · Jouhayna Bentaleb[3] · Adi Reuveni-Salzman[3] · Lisa Merovitz[3] · Jens-Erik Walter[3] · Maryse Larouche[3,4]

Received: 5 June 2024 / Accepted: 2 August 2024

Abstract

Introduction and Hypothesis Vaginal Natural Orifice Transluminal Endoscopic Surgery (vNOTES) is a novel approach in gynecological surgery. This study was aimed at comparing perioperative and short-term postoperative outcomes of vNOTES versus laparoscopic approaches to uterosacral ligament suspension (USLS) for apical pelvic organ prolapse.

Methods A retrospective cohort study included all women who underwent vNOTES versus laparoscopic USLS at two university-affiliated centers between 2017 and 2023. The relationships between variables were tested using Fisher's exact test or *t* test, including a sub-analysis comparing hysterectomy and hysteropexy outcomes within the groups. Logistic regression assessed the influence of baseline factors and operative factors on the primary and main secondary outcomes of interest.

Results This study comprised 47 vNOTES and 54 laparoscopic USLS cases (including 11 and 15 hysteropexies respectively). Baseline demographics in the two groups were similar. There were no differences in operative outcomes and no instances of ureteral injury. The vNOTES technique allowed for the use of significantly more sutures per side (2.0 [2.0–4.0] vs 1.0 [1.0–1.0], $p=0.001$). Postoperative complications within 6 weeks demonstrated no significant differences. Both groups exhibited comparable rates of baseline subjective POP symptoms (100% vs 96.2%, $p=1.00$) which improved significantly at 6 weeks (4.3% vs 11.1%, $p=0.282$). At 6 weeks, anatomical success was achieved by significantly more patients with vNOTES (93.5% vs 78.6%, $p=0.042$). Baseline and 6-week POP symptoms in the hysterectomy and hysteropexy subgroups were similar.

Conclusion Both vNOTES and laparoscopic USLS demonstrated comparable subjective success rates at 6 weeks postoperatively. The vNOTES approach demonstrated improved anatomical success at 6 weeks, but the difference was not significant after adjusting for operative factors.

Keywords Hysterectomy · Laparoscopy · Pelvic organ prolapse · Transvaginal natural orifice transluminal endoscopic surgery · Uterosacral ligament suspension · vNOTES

Introduction

Apical pelvic organ prolapse (POP) is common, affecting up to 50% of parous women over age 50 [1, 2]. A woman's lifetime risk of undergoing surgery for POP is 11–20%; among those, 29% undergo a second corrective surgery for recurrence [2, 3]. Uterosacral ligament suspension (USLS) is one of the most commonly used native tissue repairs for apical POP [2, 4, 5]. It has been shown to increase vaginal elasticity and improve sexual function [6]. The traditional surgical access route to the uterosacral ligament (USL) is vaginal. However, ureteric injury is of significant concern during vaginal USLS owing to the proximity of the USL to

Handling Editor: Catherine Matthews
Editor in Chief: Maria A. Bortolini

Presentations at RI-MUHC Summer Student Research Day in Montreal, QC, Canada on 11 August 2023, at McGill University Student Research Day in Montreal, QC, Canada on 17 November 2023, and at the Canadian Society for Pelvic Medicine Annual Meeting in Montreal, QC, Canada on 13 April 2024

Extended author information available on the last page of the article

the ureter [7], and as such, can occur in up to 4% of cases [8]. Further, vaginal USLS was found to have significant deterioration in success over time, with approximately two-thirds of patients reporting surgical failure within 5 years of surgery [7]. The laparoscopic approach to USLS provides improved visualization of the course of the ureter [4, 9], but was shown to have comparable subjective and objective POP outcomes with that of vaginal USLS [10]. In addition, USLS through any approach lacks standardization, as the type (permanent versus absorbable), number, and exact placement of sutures vary across studies.

The most recent technological advancement in (uro) gynecological surgery is vaginal Natural Orifice Transluminal Endoscopic Surgery (vNOTES). Using a vNOTES approach, laparoscopic instruments are inserted into the peritoneal cavity through vaginal colpotomy using a specialized port, combining the benefits of laparoscopic and transvaginal surgery [5]. vNOTES has been shown to offer several advantages including direct visualization of the ureter and peritoneal cavity, lack of visible scarring, less postoperative pain, decreased operative time, and decreased duration of hospital stay, compared with other surgical access routes [11–15].

There is currently sparse literature concerning vNOTES USLS [3, 11, 14, 16], including only a few cases of uterosacral hysteropexy [17, 18]. Limited data exist comparing vNOTES with laparoscopic USLS for apical POP. We aimed to compare perioperative and short-term postoperative outcomes of vNOTES versus laparoscopic USLS for apical POP. We hypothesized that vNOTES USLS is a safe and effective innovative surgical approach to apical POP, and that perioperative and short-term postoperative outcomes will be superior using vNOTES compared with the laparoscopic approach.

Materials and Methods

We performed a retrospective cohort study including all women who underwent vNOTES versus laparoscopic USLS with concomitant hysterectomy or hysteropexy at university-affiliated centers between 2017 and 2023. Women were excluded if no baseline or follow-up information was available. The research protocol was approved by the local ethics committee. A total of 101 charts were reviewed. All surgeries were performed by one of three fellowship-trained Urogynecologists.

The primary outcome was subjective success rate, which was defined as the absence of patient-reported POP symptoms up to 6 weeks' follow-up. POP symptoms include vaginal bulge, pressure, and bother. This was assessed through a comprehensive review of clinical chart notes, where symptoms reported by patients during follow-up visits were documented. The main secondary outcome was overall anatomical success rate as defined by stage 0 or 1 in all compartments at the 6-week follow-up [19]. Other secondary outcomes included rate of intraoperative complications, use of narcotics and pain scores during postoperative admission, length of hospital stay, rates of postoperative complications, and use of medical services between hospital discharge and the 6-week postoperative visit, changes in pelvic floor symptoms between baseline and the 6-week postoperative visit, pain measures between groups at the 6-week postoperative visit or readmission, and the role of demographic and surgical factors in outcomes.

Data Collection

Through chart review, we collected baseline information, including demographics, medical comorbidities, and previous procedures for POP or stress urinary incontinence. Operative variables included surgery date, surgical access route (vNOTES or laparoscopic), surgery type (hysterectomy or hysteropexy), USLS technique details (number of suture, placed per side, type of suture used, size of suture used, and passing of the suture relative to the cervix or vaginal vault), concomitant procedures (incontinence procedures, salpingectomy ± oophorectomy, colporrhaphy, or other), type of anesthesia, surgeon, and uterine weight (when hysterectomy was part of the procedure). Intraoperative complications of interest included estimated blood loss, hemorrhage (defined as > 500 ml), operative time (defined by the time from the initial incision to the final skin closure), ureteral obstruction/injury, bladder injury, bowel injury, and anesthesia complication. The perioperative period was defined as the time from surgery to hospital discharge and outcomes of interest included narcotic use (as determined by morphine equivalent) [20], pain scores (mean per day and maximum during hospital admission), length of admission, and presence of urinary retention at discharge (defined by failure of trial of void when postvoid residual was > 200 ml and discharge with urinary catheter). Postoperative complications were collected up to 6 weeks and included readmission or visit to clinic or emergency department, reoperation, and a pre-determined list of medical complications including ileus, hemorrhage, hematoma, abscess, urinary retention, urinary infection, pulmonary complication or infection, excessive pain or deep vein thrombosis (DVT), or other. Finally, pelvic floor symptoms, pain measures, anatomical prolapse stage (as determined by Pelvic Organ Prolapse Quantification [POP-Q]) and patient satisfaction were collected at 6 weeks. Ten percent of records were verified for an error spot check at the completion of data entry to ensure the consistency and accuracy of data entry.

Statistical Analysis

The relationship between the study groups (vNOTES versus laparoscopy) and each independent variable (baseline characteristics, operative factors, surgical techniques, perioperative factors and postoperative complications) was tested using a *t* test for continuous variables and Fisher's exact test for categorical variables. Other tests were performed in the case of any departure from underlying test assumptions: Mann–Whitney *U* test for continuous distribution and Chi-squared test for categorical variables. When relevant, the change from baseline to 6 weeks for a given outcome and study group was tested using a paired *t* test or Wilcoxon signed-rank test for continuous variables and a McNemar's test was used for binary outcome variables. We further conducted logistic regression to assess the influence of baseline factors and operative factors on the primary and main secondary outcome of interest. We conducted a separate subanalysis comparing hysterectomy and suspension versus hysteropexy outcomes within groups. Continuous data are presented as mean (standard deviation; SD) if a normal distribution of values was present and median (interquartile range; IQR) if not. Categorical data are presented as counts (percentages). Missing data were excluded from the analysis. Paired data points were only included if data were available at both time points. Statistical analysis was performed using GraphPad Prism and STATA 17.0. Analysis was conducted under supervision of a statistician. All analyses were two-tailed and the level of statistical significance was set to 0.05.

Results

Our study comprised 47 vNOTES and 54 laparoscopic USLS cases (including 11 and 15 hysteropexies respectively). Baseline demographics of the groups were similar (Table 1). Mean age of the study participants was 60 (12.9 SD) and 56 (11.1 SD) years respectively. Almost

Table 1 Demographics and baseline characteristics by group[a]

Characteristics	vNOTES USLS ($n=47$)	Laparoscopic USLS ($n=54$)	Missing values (n)	p value*
Age at surgery (years)	60 (12.9)	56 (11.1)		0.160
BMI (kg/m^2)	25.2 (23.6–30.2)	25.4 (22.7–28.6)		0.877
Menopaused	33 (70.2)	31 (58.5)	1	0.089
Parity	2.0 (2.0–3.0)	2.0 (2.0–3.0)		*0.049*
Vaginal delivery	46 (100)	48 (94.1)	3	0.118
C/S delivery	3 (6.5)	4 (7.7)	3	1.000
Use of vaginal estrogen	8 (17.4)	12 (22.6)	2	0.700
Use of vaginal lubricant	0	1 (1.9)	1	1.000
Medical comorbidities				
Hypertension	15 (31.9)	10 (18.5)		0.166
Diabetes	6 (12.7)	2 (3.7)		0.141
Cholesterol	9 (19.1)	10 (18.5)		1.000
Cancer + pelvic radiation	0	0		1.000
Cancer – pelvic radiation	4 (8.5)	6 (11.1)		0.748
Past pelvic/gyn surgery	0	3 (5.6)		
Other[a]	25 (53.2)	31 (57.4)		0.246
Previous procedures for POP or SUI				
Hysterectomy	0	0		NA
Colporrhaphy	3 (6.5)	1 (1.9)	1	0.336
Apical suspension	2	0		0.214
Incontinence procedure	3 (6.4)	3 (5.6)		1.000
Current or previous use of pessary	27 (57.4)	23 (42.6)		0.165

Data are presented as *n* (%), mean (SD = standard deviation); or median (IQR = inter-quartile range, 1st and 3rd quartiles)

BMI body mass index, *C/S* cesarean section, *POP* pelvic organ prolapse, *SUI* stress urinary incontinence, *vNOTES* vaginal Natural Orifice Transluminal Endoscopic Surgery, *USLS* uterosacral ligament suspension, *NA* not applicable

*p value computed using Independent t test, Mann–Whitney U test, or Fisher's exact test, when appropriate

[a]Other comorbidities included anemia, anxiety, arthritis, asthma, gastroesophageal reflux disease, hypothyroidism, migraine disorder, osteoporosis, and uterine fibroids

Table 2 Operative factors, surgical techniques and intraoperative complications by group[a]

Variables	vNOTES USLS ($n=47$)	Laparoscopic USLS ($n=54$)	Missing value (n)	p value*
Surgery type				0.655
Hysterectomy	36 (76.5)	39 (72.2)		
Hysteropexy	11 (23.4)	15 (27.7)		
USLS technique details				
Number of sutures/side	2.0 (2.0–2.0)	1.0 (1.0–1.0)	8	*0.001*
Number of sutures in total	4.0 (4.0–4.0)	2.0 (2.0–2.0)	6	*0.001*
Type of USLS suture			5	*0.001*
Delayed absorbable	33 (71.7)	32 (64.0)		
Absorbable	0	0		
Permanent	0	17 (34.0)		
Combination: delayed/permanent	12 (26.1)	1 (2.0)		
Combination: delayed/absorbable	1 (2.2)	0		
Size of USLS suture			5	0.753
0	24 (53.3)	29 (56.9)		
2–0	21 (46.7)	20 (39.2)		
Combination: 0 and 2–0	0	1 (2.0)		
Passing of USLS suture relative to the cervix or vault			13	*0.001*
Anterior	6 (13.3)	0		
Posterior	2 (4.4)	33 (76.7)		
Both	37 (82.2)	10 (23.2)		
Concomitant procedures			2	
Salpingectomy ± oophorectomy	40 (85.1)	45 (86.5)		1.000
Colporrhaphy	47 (100)	48 (92.3)		0.119
Incontinence procedures	17 (36.2)	23 (44.2)		0.424
Other[a]	3 (6.4)	4 (7.7)		1.000
Type of anesthesia			1	
General	46 (100)	54 (100)		0.465
Concomitant neuraxial anesthesia	1 (2.2)	4 (7.4)		0.369
Uterine weight (g)[b]	78 (50–134)	100 (60–150)		0.197
Estimated blood loss (ml)	200 (100–250)	150 (100–250)		0.242
Hemorrhage	0	1 (1.9)		1.000
Operative time (min)	174 (145–212)	184 (156–207)	1	0.857
Intraoperative complications				
Ureteral obstruction/injury	0	0		NA
Bladder injury	0	0		NA
Bowel injury	0	1 (1.9)		1.000
Anesthesia complication	0	0		NA
Other complication[c]	0	1 (1.9)		1.000

Data are presented as n (%), mean (SD = standard deviation); or median (IQR = inter-quartile range, 1st and 3rd quartiles)

vNOTES vaginal Natural Orifice Transluminal Endoscopic Surgery, *USLS* uterosacral ligament suspension, *NA* not applicable

*p value computed using Mann–Whitney U test or Fisher's exact test, when appropriate

[a]Other concomitant procedures included: lysis of adhesions, excision of a labial cyst, labioplasty, cervical biopsy, Bartholinectomy, and partial trachelectomy

[b]Data provided for hysterectomy cases only, $n=36$ and $n=39$ respectively

[c]Other complications included minor urethral injury

Table 3 Postoperative complications and additional visits (0 weeks to 6 weeks) by group

Variables	vNOTES USLS ($n=47$)	Laparoscopic USLS ($n=54$)	p value*
Readmission or visit (0–6 weeks)			0.751
Clinic visit	3 (6.4)	5 (9.3)	
Emergency department visit	6 (12.7)	5 (9.3)	
Readmission	0	0	
No readmission or visit prior to planned 6-week visit	38 (80.9)	44 (81.5)	
Overall complications			
Urinary infection	4 (8.5)	4 (7.4)	1.000
Bleeding	2 (4.3)	2 (3.7)	1.000
Pain	1 (3.8)	2 (3.7)	1.000
Other[a]	4 (8.5)	2 (7.4)	0.413
Reoperation	0	0	NA

Data are presented as *n* (%)

vNOTES vaginal Natural Orifice Transluminal Endoscopic Surgery, *USLS* uterosacral ligament suspension, *NA* not applicable

*p value computed using Fisher's exact test

[a]Other complications included vaginal cuff cellulitis, radial neuropathy, peri-anal rash, constipation, and increased vaginal discharge

all participants had undergone a previous vaginal delivery (100% vs 94.1%, $p=0.118$) with a mean parity of 2.0 (2.0–3.0 IQR) in both groups.

Intraoperative data are summarized in Table 2. There were no significant differences in operative time or estimated blood loss and both groups had similar rates of concomitant procedures. Concomitant incontinence procedures in both groups included bulking injections and retropubic TVT mid-urethral slings, whereas the laparoscopic group also underwent laparoscopic Burch procedures and urethropexy. Concomitant colporrhaphies in the vNOTES group included 4 anterior repairs, 8 posterior repairs, and 35 anterior/posterior repairs, whereas the laparoscopic group included 2 anterior repairs, 16 posterior repairs, and 29 anterior/posterior repairs. Overall, there were low rates of intraoperative complications, with no instances of ureteral injury. In the laparoscopic group, intraoperative complications occurred during two cases. First, a 0.5-cm serosal abrasion on the rectosigmoid bowel was noted at the conclusion of the case and was sutured laparoscopically using a figure-of-eight 2.0 Polysorb suture. Second, a minor urethral injury occurred during Foley catheter insertion and was managed with short-term continuous bladder irrigation. There were no intraoperative complications in the vNOTES group. When comparing surgical techniques, it was noted that the vNOTES approach allowed for the use of significantly more sutures per side (2.0 [2.0–4.0] vs 1.0 [1.0–1.0], $p=0.001$). There was a significant association between the group and type of suture used ($p=0.001$). When evaluating the passing of the suture relative to the cervix or vaginal vault, the laparoscopic group predominantly exhibited posterior passage, whereas the vNOTES group demonstrated both anterior and posterior passage ($p=0.001$). There was a uniform distribution of cases among all three surgeons; however, surgical techniques, such as the type and size of suture used, exhibited variability. Perioperative factors can be found in Supplementary Table 1 and postoperative complications can be found Table 3. No differences were found between the groups.

Pelvic floor symptoms and pain measures were evaluated at baseline and at 6 weeks (Table 4). Both groups exhibited comparable rates of baseline subjective POP symptoms (100% vs 96.2%, $p=1.00$), which improved significantly at 6 weeks (4.3% vs 11.1%, $p=0.282$). Both groups had significant reductions in their symptoms ($p=0.001$). Logistic regression modeling revealed no impact of baseline factors such as baseline POP symptoms, age, BMI, and preoperative POP stage ($p=0.249$), and no impact of operative factors such as number of sutures, type of suture, and type of surgery ($p=0.984$). Both groups experienced a significant decrease in incontinence ($p=0.001$) and subjective voiding dysfunction ($p=0.002$ and 0.001 respectively). At baseline, the laparoscopic group experienced higher rates of ongoing pelvic pain (2.4% vs 18.9%, $p=0.020$); however, rates in groups were similar at 6 weeks (14.3% vs 17.0%, $p=0.389$). Rates of sexual activity at 6 weeks were low in both groups (11.8% vs 8.3%, $p=1.000$) as patients are instructed to refrain from sexual activity until their follow-up appointment. Participants were only included in this analysis if measures could be collected at both time points; please see the Appendix for additional reference data (Supplementary Table 2).

Anatomical prolapse stage (POP-Q) assessments are summarized in Table 5. At baseline, both groups had similar POP-Q scores and most participants had a POP-Q stage ≥ 2 (100% vs 92.9%, $p=0.105$). At 6 weeks, both groups achieved significant improvements in anatomical success as defined by POP-Q stage 0–1 ($p=0.001$), but, the vNOTES group had significantly more patients with success at this time (93.5% vs 78.6%, $p=0.042$). Logistic regression modeling revealed no impact of baseline factors on the difference in anatomical success between groups ($p=0.018$). However, adjusting for operative factors such as number of sutures, type of suture, and type of surgery (hysterectomy versus hysteropexy) caused the difference in anatomical success between the two groups to no longer be significant ($p=0.117$).

Table 6 compared outcomes of hysterectomy and hysteropexy within each group. Baseline and 6-week POP symptoms in the hysterectomy and hysteropexy subgroups were

Table 4 Baseline and 6-week postoperative pelvic floor symptoms by group

Variables	vNOTES USLS				Laparoscopic USLS			
	n	Baseline	6 weeks	*p* value[b]	*n*	Baseline	6 weeks	*p* value*
POP symptoms (vaginal bulge/pressure/bother)	45	45 (100)	2 (4.4)	**0.001**	53	51 (96.2)	6 (11.3)	*0.001*
Urinary symptoms								
Incontinence	45	30 (66.7)	11 (24.4)	**0.001**	47	29 (61.7)	6 (12.8)	*0.001*
Stress		9 (20.0)	8 (17.8)			10 (34.5)	2 (33.3)	
Urgency		11 (24.4)	2 (4.4)			8 (27.6)	3 (50.0)	
Mixed		10 (22.2)	0			11 (37.9)	1 (16.7)	
Nocturia	15	9 (60.0)	2 (13.3)	**0.045**	18	8 (44.4)	6 (33.3)	0.683
Subjective voiding dysfunction	38	15 (39.5)	3 (7.9)	**0.002**	40	19 (47.5)	4 (10.0)	*0.001*
Urinary frequency	22	8 (36.4)	2 (9.1)	0.077	25	8 (32.0)	6 (24.0)	0.752
Urinary tract infections	37	5 (13.5)	3 (8.1)	0.683	40	6 (15.0)	3 (7.5)	0.505
Patient satisfaction	33			NA	41			NA
Yes		NA	29 (87.8)			NA	38 (92.6)	
No		NA	1 (3.0)			NA	2 (4.9)	
Intermediate		NA	3 (9.1)			NA	1 (2.4)	
Sexual activity	17	7 (41.2)	2 (11.8)	0.074	12	7 (58.3)	1 (8.3)	*0.041*
Constipation	30	12 (40.0)	7 (23.3)	0.182	21	8 (38.1)	2 (9.5)	*0.041*
Ongoing pelvic pain	42	1 (2.4)	6 (14.3)	0.131	53	10 (18.9)	9 (17.0)	1.000
Pelvic pain on examination[a]	44	10 (22.7)	10 (22.7)	1.000	52	6 (11.5)	6 (11.5)	1.000
Use of pain medications	44	0	3 (6.8)	0.248	52	1 (1.9)	0	1.000

Data are presented as *n* (%)

POP pelvic organ prolapse, *vNOTES* vaginal Natural Orifice Transluminal Endoscopic Surgery, *USLS* uterosacral ligament suspension, *NA* not applicable

**p* value computed using McNemar's test

[a]Regions of pain included vulvar introitus, pelvic floor muscles, cervix/uterus, or unspecified

similar. Anatomical success in the vNOTES group did not demonstrate differences between hysterectomy and hysteropexy (94.3% vs 90.9%, $p=1.000$). However, rates of anatomical success were significantly higher in laparoscopic USLS hysteropexy than in laparoscopic hysterectomy and USLS (100% vs 67.9%, $p=0.019$). Among all hysteropexy cases, there were no significant differences in anatomical success at 6 weeks when comparing vNOTES and laparoscopic approaches. However, among all hysterectomy cases, there was a significant difference in anatomical success between vNOTES and laparoscopic approaches (94.3% vs 67.9%, $p=0.023$). These findings were not impacted when adjusting for baseline prolapse stage. Please see the Appendix for demographics and baseline characteristics in hysterectomy and hysteropexy by group (Supplementary Table 3).

Discussion

Previously, USLS has been performed through various surgical access routes including vaginal and laparoscopic. vNOTES is a novel approach in gynecological surgery. Recently, its use has been explored in USLS for POP. However, there is a paucity of literature comparing outcomes of laparoscopic and vNOTES USLS. Our retrospective study reported on surgical, perioperative, and short-term postoperative results among a cohort of 47 vNOTES and 53 laparoscopic USLS cases. We found that at 6 weeks postoperatively, both groups had similar rates of subjective POP symptoms, but the vNOTES group had greater anatomical success, as defined by POP-Q stage 0–1. However, this difference was no longer significant after adjusting for operative factors.

We selected subjective surgical success as our primary outcome, as symptomatic relief holds a greater significance than anatomical correction in enhancing patients' quality of life [21]. We found high rates of subjective success at 6 weeks in both study groups. Further, our analysis revealed that neither baseline factors such as POP symptoms, age, BMI, and preoperative POP stage nor operative factors such as the number and type of sutures or the type of surgery (hysterectomy versus hysteropexy) had a significant impact on subjective surgical success.

Anatomically, at the 6-week follow-up, both groups demonstrated significant cure. Interestingly, the vNOTES

Table 5 Baseline and 6-week postoperative anatomic prolapse stage (POP-Q) by group

Variables	vNOTES USLS ($n=46$)			Laparoscopic USLS ($n=42$)		
	Baseline	6 weeks	p value[b]	Baseline	6 weeks	p value*
POP-Q score						
Aa	0 (0 to 2.0)	−2 (−2.5 to 2.0)	*0.001*	0 (−1.1 to 1.0)	−2 (−2.8 to −2.0)	*0.001*
Ba	0.75 (0 to 3.0)	−2 (−2.5 to 2.0)	*0.001*	1 (−1.0 to 2.0)	−2 (−2.8 to −2.0)	*0.001*
C	0 (−3.6 to 2.0)	−8 (−9.0 to −6.8)	*0.001*	−1 (−3.0 to 1.0)	−7 (−8.0 to −6.0)	*0.001*
GH	4 (3.0 to 5.0)	3 (2.5 to 3.0)	*0.001*	4 (3.0 to 5.0)	3 (2.5 to 3.0)	*0.001*
PB	3 (2.5 to 3.3)	3 (3.0 to 4.0)	0.038	3 (2.5 to 3.5)	3.5 (3.0 to 3.5)	0.303
TVL	9 (8.0 to 10.1)	10 (7.0 to 10.1)	0.139	9.5 (8.0 to 11.0)	9 (8.0 to 10.0)	0.147
Ap	−1 (−2.0 to 0)	−3 (−3.0 to −2.5)	*0.001*	−2 (−2.0 to −1.0)	−3 (−3.0 to −2.5)	*0.001*
Bp	−1 (−2.0 to 0)	−3 (−3.0 to −2.5)	*0.001*	−1.5 (−2.0 to 0)	−3 (−3.0 to −2.3)	*0.001*
D[a]	−5 (−6.0 to −4.0)	−8.25 (−9.0 to 7.8)	*0.005*	−6 (−6.0 to −4.0)	−8 (−9.0 to −6.8)	0.075
POP-Q stage ≥ 2						
Apical	17 (40.0)	1 (2.1)	*0.001*	13 (31.0)	3 (7.1)	*0.024*
Anterior	28 (60.9)	1 (2.1)	*0.001*	25 (60.0)	2 (9.5)	*0.001*
Posterior	8 (17.4)	1 (2.1)	*0.023*	6 (14.3)	4 (9.5)	0.752
Any compartment	46 (100)	3 (6.4)	*0.001*	39 (92.9)	9 (21.4)	*0.001*

Data are presented as n (%), or median (IQR = inter-quartile range, 1st and 3rd quartiles)

POP-Q Pelvic Organ Prolapse Quantification, *GH* genital hiatus, *PB* perineal body, *TVL* total vaginal length, *vNOTES* vaginal Natural Orifice Transluminal Endoscopic Surgery, *USLS* uterosacral ligament suspension

*p value computed using Wilcoxon signed-rank test or McNemar's test, when appropriate

[a]Comparative data provided for hysteropexy cases only, $n=10$ and $n=13$ respectively

group demonstrated a statistically higher proportion of patients achieving anatomical success than the laparoscopic approach. This finding suggests a potential advantage of vNOTES in achieving favorable anatomical outcomes in the short term. Importantly, the inclusion of operative factors attenuated this difference, suggesting that the number of sutures, type of suture, and type of surgery might play an important role in anatomical outcomes. Thus, long-term investigation is warranted to further explore the impact of surgical technique on the observed short-term differences in anatomical success between vNOTES and laparoscopic USLS.

Our study also evaluated several other secondary outcomes to further compare the two surgical approaches. Regarding the operative technique, vNOTES was observed to use significantly more sutures per side during surgery. This might be explained by the vNOTES Gel-Port device providing an interface where numerous sutures can be held without twisting around each other, thus encouraging surgeons to use additional sutures to create a secure and long-lasting suspension. Of note, both groups still had similar mean operating room time, despite the addition of the additional sutures. In evaluating the passing of the suture relative to the cervix or vaginal vault, vNOTES was strongly associated with attachment of the USLS sutures, both anteriorly and posteriorly, whereas laparoscopy was associated more commonly with a posterior approach. This is consistent with previous vNOTES studies, which reported similar techniques in their centers [3, 12, 22]. Further analysis is necessary to assess the impact of the direction of the suture attachment on subjective and objective outcomes, as well as the impact of methodological variations between the two surgical approaches. Other relevant findings from the intraoperative analysis include the low rate of complications in both groups, including no instances of ureter injury. This confirms previous findings of limited ureteral injury when using vNOTES [12, 14]. In the perioperative period, both groups had similar narcotic use, pain scores, and hospital stay. Moving forward, we plan to explore the implementation of same-day surgery protocols, which have been shown to have success across various gynecological surgeries [23, 24].

We completed a sub-analysis to better understand the differences in outcomes between hysterectomy and USLS versus uterine-sparing hysteropexy USLS. When analyzing vNOTES cases independently, hysteropexy and hysterectomy cases exhibited similar results in anatomical success at the 6-week follow-up. Conversely, within the laparoscopic group, patients who underwent hysteropexy demonstrated superior outcomes to those who underwent hysterectomy. Further exploration revealed that hysteropexy cases yielded

Table 6 Baseline and 6-week postoperative outcomes between hysterectomy and hysteropexy by group

	vNOTES USLS baseline			Laparoscopic USLS baseline			vNOTES USLS 6 weeks			Laparoscopic USLS 6 weeks		
	Hysterectomy ($N=35$)	Hysteropexy ($N=11$)	*p* value*	Hysterectomy ($N=39$)	Hysteropexy ($N=15$)	*p* value*	Hysterectomy ($N=35$)	Hysteropexy ($N=11$)	*p* value[b]	Hysterectomy ($N=28$)	Hysteropexy ($N=14$)	*p* value*
POP symptoms (vaginal bulge/pressure/bother)	34 (97.1)	11 (100)	1.000	36 (92.3)	15 (100)	0.552	1 (2.9)	1 (9.1)	0.4172	4 (14.3)	2 (14.3)	1.000
POP-Q stage ≥ 2												
Apical	15 (42.9)	2 (18.2)	0.172	13 (33.3)	3 (20.0)	0.508	1 (2.9)	0	1.000	3 (10.7)	0	0.539
Anterior	21 (60.0)	7 (63.6)	1.000	21 (53.8)	9 (60.0)	0.766	1 (2.9)	0	1.000	6 (21.4)	0	0.083
Posterior	5 (14.3)	3 (27.3)	0.374	6 (15.4)	3 (20.0)	0.696	0	1 (9.1)	0.239	0	0	NA
Any compartment	35 (100)	11 (100)	1.000	35 (89.7)	14 (93.3)	1.000	2 (5.7)	1 (9.1)	1.000	9 (32.1)	0	*0.019*

Data are presented as *n* (%)

POP pelvic organ prolapse, *POP-Q* Pelvic Organ Prolapse Quantification, *vNOTES* vaginal Natural Orifice Transluminal Endoscopic Surgery, *USLS* uterosacral ligament suspension, *NA* not applicable

*p value computed using Fisher's exact test

comparable results at 6 weeks, irrespective of the surgical access route used. However, hysterectomy cases had superior outcomes at 6 weeks in the vNOTES group. This finding suggests a potential advantage of vNOTES over laparoscopy, particularly in cases involving hysterectomy.

To our knowledge, our study is the first to directly compare vNOTES and laparoscopic approaches to USLS for treatment of apical POP. Previously, vNOTES USLS had only been compared with the vaginal approach. Aharoni et al. demonstrated that vNOTES USLS had a lower incidence of intraoperative complications, shorter surgical time, and lower estimated blood loss than the conventional vaginal approach [3]. A recent systematic review compared vNOTES and laparoscopic hysterectomy [25]. In this review, vNOTES hysterectomy was shown to have lower operative time, shorter duration of hospitalization, lower pain scores, and fewer postoperative complications. They observed no difference in estimated blood loss, narcotics use, or intraoperative complications between the approaches. Notably, this paper highlights the benefit of enhanced cosmesis using vNOTES owing to its lack of abdominal ports [25]. Although this review does not refer to USLS for POP, it still provides helpful insight when comparing the vNOTES and laparoscopic surgical access routes.

Limitations of our study include the relatively short follow-up period of 6 weeks, as our focus was on perioperative outcomes. Future studies with longer follow-up are warranted to assess the durability of symptomatic relief and anatomical outcomes. Second, our sample size may have limited the statistical power to detect small differences between the study groups. Larger multicenter trials are needed to explore potential subgroup differences. Otherwise, the retrospective nature of this study led to a few instances of missing data, limiting interpretation of paired data across time points. Finally, our primary outcome of subjective success was derived from chart review. Future studies should utilize validated pelvic floor symptoms questionnaires [26].

Conclusion

Laparoscopic and vNOTES USLS demonstrated comparable subjective success rates at 6 weeks postoperatively. The vNOTES approach resulted in improved anatomical success at 6 weeks postoperatively, which was no longer significant after adjusting for operative factors. Future research should assess long-term outcomes and explore the underlying mechanisms driving differences in surgical outcomes between the two techniques, including the specific role of operative technique variations.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00192-024-05907-z

Authors' Contributions T. Morganstein: protocol/project development, data collection and management, data analysis, manuscript writing/editing; M. Gangal: protocol development, manuscript editing; E. Belzile: data analysis, manuscript writing/editing; D. Sohaei: data collection and management, data analysis; J. Bentaleb: project conceptualization, manuscript editing; A. Reuveni-Salzman: protocol development, manuscript editing; L. Merovitz: project conceptualization, manuscript editing; J.E. Walter: project conceptualization, manuscript editing; M. Larouche: project conceptualization, protocol/project development, project supervision, manuscript writing/editing.

Data Availability Data supporting the findings of this study are available upon request.

Declarations

Ethical/Institutional Review Board Approval Ethical and scientific review was approved by the Research Ethics Board (REB) of the Centre intégré universitaire de santé et de services sociaux (CIUSSS) de l'Ouest-de-l'Île-de-Montréal (SMHC 2023–866).

Conflicts of Interest T. Morganstein received the McGill Faculty of Medicine and Health Sciences Summer Research Bursary for her work on this project. M. Gangal received honoraria from Applied Medical Inc and holds a position of influence in FemTherapeutics. D. Sohaei received the McGill Faculty of Medicine and Health Sciences Summer Research Bursary. J.E. Walter is a consultant for Boston Scientific, AbbVie, Searchlight Pharma, Astellas, and FemTherapeutics, and received honoraria from Boston Scientific, AbbVie, Searchlight Pharma, and Astellas. M. Larouche is a consultant for AbbVie and FemTherapeutics. The other authors have no conflicts of interest to declare.

References

1. Barber MD, Maher C. Epidemiology and outcome assessment of pelvic organ prolapse. Int Urogynecol J. 2013;24(11):1783–90.
2. Vermeulen CKM, Veen J, Adang C, van Leijsen SAL, Coolen ALWM, Bongers MY. Pelvic organ prolapse after laparoscopic hysterectomy compared with vaginal hysterectomy: the POP-UP study. Int Urogynecol J. 2021;32(4):841–50.
3. Aharoni S, Matanes E, Lauterbach R, Mor O, Weiner Z, Lowenstein L. Transvaginal natural orifice transluminal endoscopic versus conventional vaginal hysterectomy with uterosacral ligament suspension for apical compartment prolapse. Eur J Obstet Gynecol Reprod Biol. 2021;260:203–7.
4. Rardin CR, Erekson EA, Sung VW, Ward RM, Myers DL. Uterosacral colpopexy at the time of vaginal hysterectomy: comparison of laparoscopic and vaginal approaches. J Reprod Med. 2009;54(5):273–80.
5. Huang L, Yu J, Li Y, Gong ZL, Feng D, He L, et al. Transvaginal natural orifice transluminal endoscopic surgery versus conventional vaginal surgery for sacrospinous ligament fixation of apical compartment prolapse: a retrospective analysis. BMC Surg. 2023;23(1):24.
6. Lauterbach R, Gruenwald I, Matanes E, Matar K, Weiner Z, Lowenstein L. The impact of vaginal hysterectomy and uterosacral ligament suspension on vaginal elasticity and sexual function. Eur J Obstet Gynecol Reprod Biol. 2021;258:29–32.
7. Jelovsek JE, Barber MD, Brubaker L, Norton P, Gantz M, Richter HE, et al. Effect of uterosacral ligament suspension vs sacrospinous ligament fixation with or without perioperative behavioral therapy for pelvic organ vaginal prolapse on surgical outcomes and prolapse symptoms at 5 years in the OPTIMAL Randomized Clinical Trial. JAMA. 2018;319(15):1554–65.
8. Barber MD, Brubaker L, Burgio KL, Richter HE, Nygaard I, Weidner AC, et al. Comparison of 2 transvaginal surgical approaches and perioperative behavioral therapy for apical vaginal prolapse: the OPTIMAL randomized trial. JAMA. 2014;311(10):1023–34.
9. Donaldson K, Huntington A, De Vita R. Mechanics of uterosacral ligaments: current knowledge, existing gaps, and future directions. Ann Biomed Eng. 2021;49(8):1788–804.
10. Larouche M, Belzile E, Geoffrion R. Surgical management of symptomatic apical pelvic organ prolapse: a systematic review and meta-analysis. Obstet Gynecol. 2021;137(6):1061–73.
11. Lu Z, Chen Y, Wang X, Li J, Hua K, Hu C. Transvaginal natural orifice transluminal endoscopic surgery for uterosacral ligament suspension: pilot study of 35 cases of severe pelvic organ prolapse. BMC Surg. 2021;21(1):286.
12. Lowenstein L, Matanes E, Lauterbach R, Mor O, Burke YZ, Weiner Z, et al. Feasibility and learning curve of transvaginal natural orifice transluminal endoscopic surgery for hysterectomy and uterosacral ligament suspension in apical compartment prolapse. Female Pelvic Med Reconstr Surg. 2021;27(1):e171–6.
13. Tekin AB, Yassa M, Kaya C, Budak D, Ilter PB, Mutlu MA, et al. Implementing the transvaginal natural orifice transluminal endoscopic surgery (vNOTES) "first" strategy in benign gynecological surgeries. Arch Gynecol Obstet. 2023;307(4):1007–13.
14. Alay I, Kaya C, Cengiz H, Yildiz S, Aslan O, Yasar L, et al. Apical pelvic organ prolapse repair via vaginal-assisted natural orifice transluminal endoscopic surgery: initial experience from a tertiary care hospital. Asian J Endosc Surg. 2021;14(3):346–52.
15. Kheirbek N, Delporte V, Hajj HE, Martin C, Delplanque S, Kerbage Y, et al. Comparing v-NOTES hysterectomy to laparoscopic hysterectomy for large uteri. J Minim Invasive Gynecol. 2023;30(11):877–83.
16. Farah S, Albaini O, Al Jardali M, Daccache A, Jallad K. The feasibility and safety of vNOTES hysterectomy and uterosacral ligament suspension: a case series. J Minim Invasive Gynecol. 2023;30(5):414–7.
17. Serati M, Salvatore S, Torella M, Scancarello C, De Rosa A, Ruffolo AF, et al. Hysteropexy and anterior vaginal native tissue repair in women with anterior and central compartment prolapse: a long term follow-up. J Clin Med. 2023;12(7):2548.
18. Lowenstein L, Ben-David C, Mick I, Levi G, Matanes E, Mor O. Transvaginal natural orifice transluminal endoscopic uterosacral ligament hysteropexy: an innovative approach for treatment of uterine prolapse. J Minim Invasive Gynecol. 2021;28(11):1818–9.
19. Bump RC, Mattiasson A, Bø K, Brubaker LP, DeLancey JO, Klarskov P, et al. The standardization of terminology of female pelvic organ prolapse and pelvic floor dysfunction. Am J Obstet Gynecol. 1996;175(1):10–7.
20. Dowell D, Ragan KR, Jones CM, Baldwin GT, Chou R. CDC clinical practice guideline for prescribing opioids for pain—United States, 2022. MMWR Recomm Rep. 2022;71(3):1–95.
21. Barber MD, Brubaker L, Nygaard I, Wheeler TL, Schaffer J, Chen Z, et al. Defining success after surgery for pelvic organ prolapse. Obstet Gynecol. 2009;114(3):600–9.
22. Housmans S, Stuart A, Bosteels J, Deprest J, Baekelandt J. Standardized 10-step approach for successfully performing a hysterectomy via vaginal natural orifice transluminal endoscopic surgery. Acta Obstet Gynecol Scand. 2022;101(6):649–56.

23. Mehr AA, Elmer-Lyon CG, Maetzold EC, Bradley CS, Kowalski JT. 49 Effect of enhanced recovery protocol in urogynecologic surgery. Am J Obstet Gynecol. 2021;224(6):S774–5.
24. Aubrey C, Nelson G. Enhanced Recovery after Surgery (ERAS) for minimally invasive gynecologic oncology surgery: a review. Curr Oncol. 2023;30(10):9357–66.
25. Marchand GJ, Masoud AT, Ulibarri H, Arroyo A, Moir C, Blanco M, et al. Systematic review and meta-analysis of vaginal natural orifice transluminal endoscopic surgery vs laparoscopic hysterectomy. AJOG Glob Rep. 2024;4(1):100320.
26. Barber MD, Walters MD, Bump RC. Short forms of two condition-specific quality-of-life questionnaires for women with pelvic floor disorders (PFDI-20 and PFIQ-7). Am J Obstet Gynecol. 2005;193(1):103–13.

Authors and Affiliations

Taylor Morganstein[1] · Mihnea Gangal[2] · Eric Belzile[4] · Dorsa Sohaei[1] · Jouhayna Bentaleb[3] · Adi Reuveni-Salzman[3] · Lisa Merovitz[3] · Jens-Erik Walter[3] · Maryse Larouche[3,4]

✉ Maryse Larouche
ml.larouche@mcgill.ca

[1] Faculty of Medicine and Health Sciences, McGill University, Montreal, QC, Canada

[2] Department of Obstetrics and Gynecology, University of Montreal, Montreal, QC, Canada

[3] Division of Urogynecology, Department of Obstetrics and Gynecology, McGill University, Montreal, QC, Canada

[4] St. Mary's Research Centre, Montreal, QC, Canada