International Urogynecology Journal (2023) 34:1121–1126
https://doi.org/10.1007/s00192-022-05445-6

ORIGINAL ARTICLE

Financial analysis of minimally invasive sacrocolpopexy compared with native tissue vaginal repair with concomitant hysterectomy

Amr S. El Haraki[1] · Jonathan P. Shepherd[2] · Candace Parker-Autry[1] · Catherine A. Matthews[1]

Received: 29 October 2022 / Accepted: 10 December 2022 / Published online: 2 February 2023

Abstract

Introduction Minimally invasive sacrocolpopexy (MISCP) is increasingly used for uterovaginal prolapse, but comparative cost data of MISCP versus native tissue vaginal repair (NTR) are lacking. The objective was to determine the cost difference, from a hospital perspective, between MISCP and NTR performed with hysterectomy for uterovaginal prolapse.

Methods This was a retrospective cohort study at a tertiary care center of women who underwent NTR or MISCP with concomitant hysterectomy in 2021. Hospital charges, direct and indirect costs, and operating margin (revenue minus costs) were obtained from Strata Jazz and compared using SPSS.

Results A total of 82 women were included, 33 MISCP (25 robotic, 8 laparoscopic) versus 49 NTR. Demographic and surgical data were similar, except that MISCP had younger age (50.5 vs 61.1 years, $p<0.01$). Same-day discharge and estimated blood loss were similar, but operative time was longer for MISCP (204 vs 161 min, $p<0.01$). MISCP total costs were higher (US$17,422 vs US$13,001, $p<0.01$). MISCP had higher direct costs (US$12,354 vs US$9,305, $p<0.01$) and indirect costs (US$5,068 vs US$3,696, $p<0.01$). Consumable supply costs were higher with MISCP (US$4,429 vs US$2,089, $p<0.01$), but the cost of operating room time and staff was similar (US$7,926 vs US$7,216, $p=0.07$). Controlling for same-day discharge, anti-incontinence procedures and smoking, total costs were higher for MISCP (adjusted beta = US$4,262, $p<0.01$). Mean charges (US$102,060 vs US$97,185, $p=0.379$), revenue (US$22,214 vs US$22,491, $p=0.929$), and operating margin (US$8,719 vs US$3,966, $p=0.134$) were not statistically different.

Conclusion Minimally invasive sacrocolpopexy had higher costs than NTR; however, charges, reimbursement, and operating margins were not statistically significantly different between the groups.

Keywords Cost · ERAS · Sacrocolpopexy · Minimally invasive · Uterosacral · Sacrospinous · Native tissue repair · Robotic

Introduction

Pelvic organ prolapse (POP) is a common disease and the lifetime risk of undergoing POP surgery varies between 6% and 19% [1–3]. The number of American women with at least one pelvic floor disorder will increase from 28.1 million in 2010 to 43.8 million in 2050 [1, 4]. The optimal surgical choice for primary uterovaginal prolapse correction depends on patient preferences and ranges from transvaginal native tissue repair (NTR; uterosacral ligament suspension and sacrospinous ligament suspension) to an abdominal mesh-based repair (sacrocolpopexy [SCP]), with or without a hysterectomy. Abdominal SCP is associated with a lower rate of reoperation than native tissue vaginal repair options but has associated graft risks [5]. Although previously performed via laparotomy with longer operative times, hospital stays, and extended recovery than NTR, the techniques have evolved toward laparoscopic or robotically assisted minimally invasive sacrocolpopexy (MISCP) [6, 7]. As each procedure has advantages and disadvantages, individual patient factors and patient preferences are considered and a joint decision is made.

The increase in medical expenses and financial burden is an important issue and may factor in patient surgical decision making as well. Contemporaneous to the evolution of MISCP as the standard of care for SCP patients, enhanced recovery after surgery (ERAS) pathways have emerged, with

✉ Catherine A. Matthews
camatthe@wakehealth.edu

[1] Departments of Urology and Obstetrics and Gynecology, Wake Forest Baptist Medical Center, Winston Salem, NC, USA

[2] Department of Obstetrics and Gynecology, University of Connecticut Health Center, Farmington, CT, USA

much higher rates of same-day discharge in patients undergoing both MISCP and NTR, which can reduce the costs of both procedures [8]. Operative costs are influenced by the length of procedure, the use of consumable medical instruments, and the use of graft and suture materials.

Although there have been studies comparing the costs of MISCP with those of transvaginal mesh-based repair, which showed that transvaginal repair has lower costs [9–11], there is an absence of comparative data regarding native tissue repair especially post-ERAS implementation, an intervention that has been shown to decrease hospital costs [12, 13]. In this study, we tested our hypothesis that MISCP has higher costs from a hospital perspective than NTR for the surgical treatment of primary uterovaginal prolapse. Our findings may impact shared decision making regarding surgical management of uterovaginal prolapse.

Materials and methods

This study was approved by the Wake Forest School of Medicine Institutional Review Board (IRB00080060). We performed a retrospective descriptive study of women undergoing apical pelvic organ prolapse repair with concomitant hysterectomy at Wake Forest Baptist Medical Center in the calendar year 2021. There were no contemporaneous published cost data to facilitate the performance of a power calculation. Instead, we analyzed consecutive cases of hysterectomy and apical suspension for women with uterovaginal prolapse in the 12 months post-ERAS adoption as part of the response to the COVID-19 pandemic and decreasing exposure to the inpatient setting. Optimal adoption of ERAS same-day discharge with normalization of the operative experience after post-COVID-19 adjustments was completed by January 2021. Eligible women were older than 21 years at the time of surgery and underwent apical repair for uterovaginal prolapse, either by laparoscopic or robotic MISCP (CPT 57425), or NTR including extraperitoneal vaginal colpopexy (sacrospinous ligament suspension, CPT 57282) or intraperitoneal vaginal colpopexy (uterosacral ligament suspension, CPT 57283). We combined laparoscopic and robotic SCP into one minimally invasive mesh-based repair group. Patients were excluded if they underwent a concomitant colorectal procedure (i.e., rectopexy), billing was not complete, reimbursement was not received or did not undergo hysterectomy at the time of prolapse repair. Hospital charges, direct and indirect costs and operating margin (net revenue minus all costs) were obtained from Strata Jazz, a cloud-based financial planning software used by our hospital system. Net revenue (reimbursement) was directly obtained from the record as the total payment received by the hospital from the payor. Eligible women were divided into two groups for comparison: MISCP vs NTR. Our primary outcome was the total costs associated with each procedure. This was divided into direct and indirect costs. Direct costs were further subdivided into supply costs and direct costs of operating room time and staff. Additional secondary outcomes included net revenue, operating margin, and hospital charges; revenue percentage of charges; and same-day discharge rate. We defined total charge as the charges by the hospital to the payor and net revenue as the total amount paid by the payor. Operating margin is defined in our institution as net revenue less total of variable and fixed costs associated with the procedure. Direct costs included the costs of procedure-specific staff, operating room times, and supplies. Indirect costs were the costs deemed by the hospital to be the "overhead" cost associated with the procedure, which includes maintenance costs.

All women during the study period participated in a standardized ERAS protocol that included preoperative hydration and multimodal pain control including acetaminophen, ibuprofen, and Pyridium. The goal was same-day hospital discharge, but all procedures were conducted in a setting that permitted < 24 hour admission.

All procedures were performed under the direct supervision of two board-certified female pelvic medicine and reconstructive surgeons. Trainees, including residents and fellows, were present and active in every case. MISCP procedures were performed laparoscopically by one faculty member (CPA) and robotically by the other (CAM). Transvaginal NTR procedures were performed using the uterosacral and sacrospinous ligaments according to attending preference for each individual case. For uterosacral ligament suspension, either three delayed-absorbable sutures or one delayed-absorbable and one permanent suture were used. For sacrospinous ligament fixation, a self-capturing suture device was used according to surgeon preference with one delayed-absorbable and one permanent suture to the right sacrospinous ligament. For sacrocolpopexy, permanent sutures were used to attach a tailored y-mesh to provide apical support. Each robotic case was performed with four robotic arms and we used a total of five robotic instruments per patient. Concomitant anterior and posterior repairs, midurethral slings, and perineorrhaphy procedures were all permitted according to attending choice.

Study data were collected and managed using a secure Excel file. Abstracted data included demographic characteristics, pertinent comorbidities, smoking status, preoperative Pelvic Organ Prolapse Quantification examination, date of surgery, estimated blood loss, duration of stay, and concomitant procedures performed.

The collected data were exported to SPSS for analysis. Categorical variables were analyzed using Chi-squared tests and Fisher exact tests. Continuous variables were analyzed using *t* test. Multivariate analysis using total cost as the dependent variable was also completed to control for

potential confounders, which included variables from the univariate analysis, including apical repair technique, anterior repair, posterior repair, anti-incontinence procedure, age, and age-adjusted Charlson comorbidity index (ACCI) score. It also included variables that could possibly act as confounding variables, including ethnicity and body mass index (BMI). We decided to include these variables as they likely impact costs. A p value of <0.05 was considered statistically significant. All variables with $p<0.2$ on univariate regressions were considered candidate variables when constructing multivariate models. Models were constructed using forward addition techniques where sequential models were created by adding the most impactful variables one by one. Model diagnostics calculated model appropriateness and iterations continued until the most appropriate model was constructed that best explained the variability within the data.

Results

A total of 82 women were included, 33 MISCP (25 robotic and 8 laparoscopic) versus 49 NTR. Demographic and surgical data are presented in Table 1. Patients were younger in the MISCP group (50.5 years vs 61.1 years, $p<0.01$). For the entire cohort, BMI was 29.2, median parity was 3, and

Table 1 Demographic and surgical characteristics

	Sacrocolpopexy (n=33)	Native tissue repair, vaginal (n=49)	p value
Patient characteristics			
Age[a]	50.5 ± 10.9	61.1 ± 11.1	<0.01
Number of children delivered[b]	3.00 (1.00)	2.00 (1.00)	0.1338
BMI (kg/m^2)[a]	27.0 ± 4.5	28.9 ± 5.4	0.093
Tobacco use, current	2 (6.1%)	2 (4.2%)	0.753
Ethnicity			0.31
White	24 (72.7%)	40 (81.6%)	
African–American	1 (3.0%)	5 (10.2%)	
Hispanic	5 (15.2%)	3 (6.1%)	
Asian	2 (6.1%)	1 (2.0%)	
Other	1 (3.0%)	0	
Payor			<0.01
Medicare	1 (3.0%)	21 (42.9%)	
Medicaid	1 (3.0%)	3 (6.1%)	
Employer-based	30 (91.0%)	19 (38.8%)	
Private	1 (3.0%)	5 (10.2%)	
Diabetes mellitus	3 (9.1%)	5 (10.2%)	0.844
Prior surgical history			
Any prior abdominal or pelvic surgery	23 (69.7%)	29 (60.4%)	0.391
Preoperative examination			
Preoperative prolapse stage			0.137
I	0 (0%)	1 (2.0%)	
II	16 (48.5%)	24 (49.0%)	
III	12 (36.4%)	23 (46.9%)	
IV	5 (15.25)	1 (2.0%)	
Preoperative stress urinary incontinence	23 (69.7%)	28 (58.3%)	0.298
Surgical characteristics			
Operative duration (min)[a]	204 ± 47	161 ± 34	<0.01
Blood loss (ml)[a]	100 ± 81	100 ± 110	0.5344
Anterior repair	0 (0%)	20 (41.7%)	<0.01
Posterior repair	22 (66.7%)	42 (87.5%)	0.237
Stress incontinence procedure performed	21 (63.6%)	26 (54.1%)	0.396
Same-day discharge	14 (42.4%)	18 (37.5%)	0.66

[a]Mean ± standard deviation

[b]Median (interquartile range)

the majority were white (78%). Same-day discharge (39%) and estimated blood loss were similar in the two groups, but operative time was longer in the MISCP group (204 vs 161 min, $p<0.01$). No regional anesthesia or patient-controlled anesthesia was used in any of our patient cohorts. In terms of payor mix, the MISCP group had predominantly employer-based insurance (91%) whereas the NTR group was split between Medicare (43%) and employer-based insurance (39%, $p<0.01$).

For our primary outcome, the total cost of MISCP was significantly higher than NTR (US$17,422 ± US$3,620 vs US$13,001 ± US$2,426, $p<0.01$). These results, along with the other measured outcomes, are presented in Table 2. Direct costs and indirect costs were also higher for MISCP than for NTR (US$12,354 ± US$2,621 vs US$9,305 ± US$1,745, $p<0.01$; US$5,068± US$1,047 vs $US3,696± US$766, $p<0.01$ respectively). Cost of supplies was higher in the MISCP group (US$4,429 ± US$1,296 vs US$2,089 ± US$834, $p<0.01$), but the costs of operating room time and staff were similar (US$7,926 ± US$1,803 vs US$7,216 ± US$1,493, $p=0.07$). Controlling for same-day discharge, anti-incontinence procedure, and smoking status, the total costs were higher for MISCP with an adjusted beta of US$4,262 ($p<0.01$). Mean charges were similar in the MISCP and the NTR group (US$102,060 vs $US97,185, $p=0.379$). Revenue was overall similar in the NTR group and the MISCP group (US$22,214 ± US$13,163 vs US$22,491 ± US$12,833, $p=0.929$). The operating margin was not statistically different (US$8,719 ± US$13,082 vs US$3,966 ± US$12,660, $p=0.134$). Additionally, there were no significant differences in the net revenue between the different payors ($p=0.90$).

Discussion

In this retrospective cohort study, we demonstrate that MISCP was approximately US$4,200 more costly to perform per case than NTR, largely because of consumable supplies such as disposable instruments and the mesh graft. These data may assist with hospital cost projections in response to rising demands for pelvic floor repair surgery. Given the lack of financial transparency of many health care systems, our comparative cost data also provide valuable insight into actual, attributable costs, as opposed to dramatically inflated charge data that are subject to variance by system and region. Regardless, discovery of the actual hospital charge rate of approximately US$100,000 for either type of repair is potentially eye-opening for many urogynecologists, who may be unaware of the significant financial burden in the USA of these prolapse repair procedures. Although the financial burden passed down to the patient is dependent on deductibles and co-payment rates, the surgeon's awareness of the overall charges from a hospital perspective may help in decision making. An interesting finding is that vaginal repair was more commonly performed in a Medicare-heavy population. This may reflect a possible disparity in care, but may also be simply a result of an older population that is less likely to receive a mesh-based repair with potentially more complications. Further research is recommended to determine is this is a true disparity in health care delivery.

Higher costs of MISCP have been demonstrated in other studies, although none included a homogeneous comparison group of hysterectomy with apical NTR, and none was conducted in patients exposed to ERAS with plans for same-day hospital discharge [8–11]. Like our findings, these studies showed that higher costs in the MISCP groups were associated with consumables. These studies differed from ours in that both used transvaginal mesh in the comparator vaginal group. In addition, it has been shown that vaginal and laparoscopic treatments are more cost-effective than expectant management and that after 5 years, starting with a laparoscopic or robotic approach may be cost effective [14]. With awareness, surgeons could significantly reduce direct costs of MISCP through the judicious use of consumables, especially if they had more awareness about the cost of supplies within their health care system [15].

Even though there was "no difference" in operating room time and staff, there was still a US$700 difference between MISCP and NTR. This is likely due to costs having high

Table 2 Cost breakup comparing minimally invasive sacrocolpopexy with hysterectomy vs native vaginal repair with hysterectomy

	Sacrocolpopexy (n=33)	Native tissue repair, vaginal (n=49)	p value
Charge	US$102,060 ± 24,286	US$97,185 ± 22,996	0.379
Total cost	US$17,422 ± 3,620	US$13,001 ± 2,427	<0.001
Direct cost	US$12,354 ± 2,621	US$9,304.89 ± 1,745	<0.001
Operating room cost	US$7,926 ± 1,803	US$7,215.83 ± 1,493	0.072
Supply cost	US$4,429 ± 1,296	US$2,090 ± 834	<0.001
Indirect cost	US$5,068 ± 1,047	US$3,696 ± 766	<0.01
Revenue	US$22,490.79 ± 13,163	US$22,213.85 ± 12,833	0.929
Revenue/charge (%)	21.1 ± 8.57	22.8 ± 11.4	0.481
Operating margin	US$3,966 ± 13,082	US$8,719 ± 12,660	0.134

variability from one patient to another, although this did not reach statistical significance (p=0.07). The method in which MISCP is performed could also influence costs. Prior studies comparing robotic with laparoscopic SCP have demonstrated higher costs of robot-assisted SCP [16], primarily due to longer operative times. On average, our MISCP surgeries took only a little over half an hour longer than NTR and were significantly shorter than in other studies. Furthermore, robot-assisted surgeries were quicker to perform at our center than laparoscopic surgeries (198 min vs 287 min, p<0.01). Over time, the proficiency of robot-assisted surgery has improved and, therefore, the impact of prolonged surgical time on cost is minimized.

Our study is limited by the retrospective design, potential selection bias for the procedures, and inclusion of data from a single academic medical center in the USA with participation of trainees, which affect procedural times, all of which could confound the results and decrease the external validity of the results. The limited external validity extends to applying this knowledge to institutions that are not located in the USA, as the specific US cost data are not as relevant in other countries. It is plausible, however, that the higher cost of consumables for mesh-based abdominal repair would have a similar cost impact in other countries. As individual hospital contracts with vendors may significantly influence the cost of consumables, our data may not be generalizable. We were also not powered to detect differences between patients who underwent laparoscopic versus robotic SCP and collectively analyzed them as the MISCP group. It is worth noting that it was shown that robot-assisted SCP achieved similar outcomes to laparoscopic SCP, but with increased operative times and costs [17, 18], and this may have decreased some of the differences in costs seen between the SCP and the vaginal repair group in our study. The strengths primarily lie in the collection of contemporaneous data following adoption of an ERAS protocol, which has direct applicability for patients planning for apical repair with concomitant hysterectomy. Another strength of our study is using data regarding hospital charges in addition to our total reimbursement received and operating margins. Owing to low transparency with insurance reimbursement, there is a paucity of data regarding the overall charges and reimbursement and this study provides that insight for surgeons and patients alike. The net financial burden on the patient is still difficult to study and an elusive topic, as there are multiple factors associated with this, such as their insurance specifics, their individual factors, and how much of their deductible they have met in the same year. Our next steps include a cost-effectiveness analysis to integrate long-term costs associated with minimally invasive SCP versus vaginal repair surgery as a primary repair for uterovaginal prolapse to account for costs associated with postoperative complications, as well as re-operation, for recurrent prolapse over time.

In conclusion, minimally invasive SCP had a higher total cost, with both higher direct and indirect costs, than native tissue vaginal repair with hysterectomy, which persisted after adjustment for confounders. However, operating margins and net reimbursement were similar in the groups. Surgeons should expand their awareness about the cost of consumable supplies.

Declarations

Conflicts of interest Catherine Matthews has grant support to her institution from Boston Scientific Corporation and Coloplast; Catherine Matthews is a consultant to Boston Scientific Corporation and has received honoraria from Neomedic. Parker Autry has received honoraria from Neomedic. No other authors have any conflicts to disclose.

References

1. Wu JM, Vaughan CP, Goode PS, Redden DT, Burgio KL, Richter HE, et al. Prevalence and trends of symptomatic pelvic floor disorders in U.S. women. Obstet Gynecol. 2014;123(1):141–8. https://doi.org/10.1097/AOG.0000000000000057.
2. Wu JM, Matthews CA, Conover MM, Pate V, Jonsson FM. Lifetime risk of stress urinary incontinence or pelvic organ prolapse surgery. Obstet Gynecol. 2014;123(6):1201–6. https://doi.org/10.1097/AOG.0000000000000286.
3. Smith FJ, Holman CD, Moorin RE, Tsokos N. Lifetime risk of undergoing surgery for pelvic organ prolapse. Obstet Gynecol. 2010;116(5):1096–100.
4. Olsen AL, Smith VJ, Bergstrom JO, Colling JC, Clark AL. Epidemiology of surgically managed pelvic organ prolapse and urinary incontinence. Obstet Gynecol. 1997;89(4):501–6.
5. Rogers RG, Nolen TL, Weidner AC, Richter HE, Jelovsek JE, Shepherd JP, et al. NICHD Pelvic Floor Disorders Network. Open sacrocolpopexy and vaginal apical repair: retrospective comparison of success and serious complications. Int Urogynecol J. 2018;29(8):1101–10. https://doi.org/10.1007/s00192-018-3666-7.
6. Maher C, Feiner B, Baessler K, Christmann-Schmid C, Haya N, Brown J. Surgery for women with apical vaginal prolapse. Cochrane Database Syst Rev. 2016;10(10):CD012376. https://doi.org/10.1002/14651858.CD012376.
7. Carter-Brooks CM, Du AL, Ruppert KM, Romanova AL, Zyczynski HM. Implementation of a urogynecology-specific enhanced recovery after surgery (ERAS) pathway. Am J Obstet Gynecol. 2018;219(5):495.e1–495.e10. https://doi.org/10.1016/j.ajog.2018.06.009.
8. Hoyte L, Rabbanifard R, Mezzich J, Bassaly R, Downes K. Cost analysis of open versus robotic-assisted sacrocolpopexy. Female Pelvic Med Reconstr Surg. 2012;18(6):335–9. https://doi.org/10.1097/SPV.0b013e318270ade3.
9. Carracedo D, López-Fando L, Sánchez MD, Jiménez MÁ, Gómez JM, Laso I, et al. Cost analysis of surgical treatment for pelvic organ prolapse by laparoscopic sacrocolpopexy or transvaginal mesh. Actas Urol Esp. 2017;41(2):117–22. https://doi.org/10.1016/j.acuro.2016.08.001.
10. Kaaki B, Lewis E, Takallapally S, Cleveland B. Direct cost of hysterectomy: comparison of robotic versus other routes. J Robot Surg. 2020;14(2):305–10. https://doi.org/10.1007/s11701-019-00982-7.

11. Myoga M, Sho T, Aoki H, Ishizuka T, Nakajima D, Yoshimura K. Cost analysis of four types of surgeries for pelvic organ prolapse in a Japanese population. J Obstet Gynaecol Res. 2021;47(4):1567–71. https://doi.org/10.1111/jog.14683.
12. Noba L, Rodgers S, Chandler C, Balfour A, Hariharan D, Yip VS. Enhanced recovery after surgery (ERAS) reduces hospital costs and improve clinical outcomes in liver surgery: a systematic review and meta-analysis. J Gastrointest Surg. 2020;24(4):918–32. https://doi.org/10.1007/s11605-019-04499-0.
13. Bogani G, Sarpietro G, Ferrandina G, Gallotta V, DI Donato V, Ditto A, et al. Enhanced recovery after surgery (ERAS) in gynecology oncology. Eur J Surg Oncol. 2021;47(5):952–9. https://doi.org/10.1016/j.ejso.2020.10.030.
14. Ehlert MJ, Gupta P, Park J, Sirls LT. Detailed cost analysis of robotic sacrocolpopexy compared to transvaginal mesh repair. Urology. 2016;97:86–91. https://doi.org/10.1016/j.urology.2016.05.072.
15. Zygourakis CC, Valencia V, Moriates C, Boscardin CK, Catschegn S, Rajkomar A, et al. Association between surgeon scorecard use and operating room costs. JAMA Surg. 2017;152(3):284–91. https://doi.org/10.1001/jamasurg.2016.4674.
16. Andiman SE, Bui AH, Ascher-Walsh C, Wright JD, Xu X. Surgical complications and hospital costs in robot-assisted versus conventional laparoscopic hysterectomy with concurrent sacrocolpopexy: analysis of the nationwide readmissions database. Female Pelvic Med Reconstr Surg. 2022;28(5):e142-8. https://doi.org/10.1097/SPV.0000000000001133.
17. Callewaert G, Bosteels J, Housmans S, Verguts J, Van Cleynenbreugel B, Van der Aa F, et al. Laparoscopic versus robotic-assisted sacrocolpopexy for pelvic organ prolapse: a systematic review. Gynecol Surg. 2016;13:115–23. https://doi.org/10.1007/s10397-016-0930-z.
18. Tan-Kim J, Menefee SA, Luber KM, Nager CW, Lukacz ES. Robotic-assisted and laparoscopic sacrocolpopexy: comparing operative times, costs and outcomes. Female Pelvic Med Reconstr Surg. 2011;17(1):44–9. https://doi.org/10.1097/SPV.0b013e3181fa44cf.