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Current surgical management of pelvic organ prolapse: Strategies for the improvement of surgical outcomes

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There are a variety of surgical management strategies to help surgeons repair pelvic organ prolapse (POP). Surgical treatment for POP includes native tissue repair, augmentation with mesh, and minimally invasive surgeries. Currently, laparoscopic or robotic techniques for POP repair are increasing in popularity and continuing to evolve. The aim of this review is to present an up-to-date review of surgical techniques used for POP repair and to discuss ways to optimize surgical outcomes.

Keywords: Cystocele; Pelvic organ prolapse; Review; Surgical mesh

INTRODUCTION

Pelvic organ prolapse (POP) is the descent of one or more of the anterior vaginal wall, posterior vaginal wall, the uterus, or the apex of the vagina (vaginal vault after hysterectomy) [1]. POP is seen on vaginal examinations in 40% to 60% of parous women; the most common sites for repair are the anterior and posterior compartments [2]. Women have an estimated 12.6% lifetime risk of undergoing POP repair [3]. Recent studies of POP surgery suggest that composite success should be evaluated not only through objective outcomes but also subjective symptomatic outcomes, reoperation rates, and complications. Due to the characteristics of POP, it is more important to improve patient satisfaction and reduce complications than to achieve anatomic success, considering concerns regarding native tissue repair and U. S. Food and Drug Administration (FDA) warnings. The popularity of minimally invasive surgery has increased the use of laparoscopic and robotic approaches in POP repair. The purpose of this article is to review the state of the art regarding surgery for POP.

SURGERY TO TREAT ANTERIOR COMPARTMENT PROLAPSE

There are various treatment of options for anterior compartment prolapse, including conservative management, pessaries, or surgical reconstruction. Unfortunately, there is no standard surgical treatment for anterior prolapse and it is crucial to discuss the risks and benefits of different surgical options with each patient. Generally, reconstruction of the anterior vaginal wall is performed by placing sutures

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that plicate and reduce the weakened tissues, and other native techniques have been introduced to further augment tissue and improve durability. Native tissue repair, although associated with lower success rates compared with mesh-augmented repair, has been well-studied. Using current composite definitions of success, native repair is effective for relieving vaginal bulge symptoms and reducing prolapse within the vagina.

The success rate of POP surgery varies tremendously depending on the definition of treatment success that is used (19.2%–97.2%). Thus, it is difficult to compare outcomes because of variation among patients, surgical techniques, and definitions of success. The pelvic organ prolapse quantification (POPQ) system has been shown to be a valuable measurement tool that has improved our understanding of POP over the last 15 years and allowed reliable assessments of the anatomical success of POP surgeries. In 2001, an NIH workshop was held for the standardization of terminology between pelvic floor disorder researchers, where it was decided that the definition of "optimal anatomic outcome" requires perfect anatomic support (POPQ stage 0) and that the definition of "satisfactory anatomic outcome" requires support higher than 1 cm proximal to the hymen. "Cure" was defined as achieving an optimal or satisfactory anatomic outcome. More recently, it has been suggested that these anatomic definitions area are too strict, as more than 75% of women presenting for annual examinations without POP symptoms would not meet the criteria for "optimal anatomic outcome" and almost 40% of patients would not meet the criteria for "satisfactory anatomic outcome" [4]. Dividing stage 2 into stage 2a (-1 cm to hymen) and stage 2b (hymen to 1 cm) has also been considered. Recently, some studies have defined Ba point <0 as anatomical success, since the use of less stringent criteria to define "cure" are currently under discussion.

According to Barber et al. [5], the absence of vaginal bulge symptoms has the strongest relationship to patient assessments of overall improvement and treatment success. Additionally, definitions based on anatomic success had weak or no correlations with patient perceptions of outcomes. The goal of surgical repair is to maximize patient satisfaction, as well as return the pelvic organs to their original positions [6].

1. Anatomic success

Table 1 summarizes the results of a randomized controlled study comparing the results of anterior colporrhaphy (AC) to those of mesh repair over the last 10 years [7-23]. When anatomic success was defined as achieving a POPQ stage 0 or 1, the results ranged from 39.5% to 75% for AC and 81.0% to 95% for mesh repair, with superior outcomes for mesh repair at 1-year follow-up [7,8,10,13,15-18]. In the mid-term follow-up (24–36 months), the results ranged from 39.5% to 86% for AC and 39.5% to 91.4% for mesh repair, indicating that mesh repair was superior in most studies [9,12,14,20,22].

Defining anatomic success as "No descent beyond the hymen (Ba ≤0)" yields different results. In some studies, AC showed anatomic success rates as high as 86% to 89%, which was not significantly different from the 84% to 96% success rates seen in mesh repair [11,21,23]. However, in patients with severe POP (POPQ stage 3–4), the success rate for mesh repair (86.4%) was better than that for AC repair (70.4%) (p=0.019) [19].

2. Symptomatic success

Redefining the success of POP surgery has recently been suggested, and improvement of quality of life and patient satisfaction are now considered more important factors than anatomic success alone. The postoperative absence of vaginal bulge symptoms is significantly related to patient assessments of overall improvement and improvement in quality of life after surgery, while anatomic success alone does not ensure that vaginal bulge symptoms remain an important outcome assessment tool after POP surgery [5]. Several randomized trials have examined symptomatic success, using various measures such as the absence of vaginal bulge symptoms and several types of validated questionnaires (Table 1). When symptomatic success was defined as amelioration of vaginal bulge symptoms, symptoms remained in 0% to 37.9% of patients after AC, and in 5% to 24.6% after mesh repair [8-11,14,17,18,21,22]. In half of the studies, the amelioration of bulging symptoms was superior to that in the mesh repair group, and the remaining studies did not reveal any significant differences between AC and mesh repair. A 2016 Cochrane review of anterior compartment prolapse reported that awareness of prolapse (risk ratio [RR], 0.56; 95% confidence interval [CI], 0.43–0.73) was significantly less common after mesh repair, compared to AC [24]. However, most questionnaires related to quality of life showed significant improvement after both treatments, but there was no significant difference in improvement between AC and mesh repair [7,12,13,19,20,23]. Although the anatomic success of AC is inferior to that of mesh repair, it has some advantages for quality of life. However, the use of mesh should be considered for treating anterior compartment prolapse in order to reduce the risk of recurrence and improve symptoms.

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Table 1. Summary of anatomic success and symptomatic success comparing anterior colporrhaphy and mesh repair (selected studies 2008–2017)

Study	Year	POPQ system	Follow-up (mo)	Anatomic success				Symptomatic success			
				Definition	Anterior colporrhaphy	Mesh	p-value	Definition	Anterior colporrhaphy	Mesh	p-value
Nguyen and Burchette [7]	2008	Stage ≥2	12	Stage 0 or I	55.0%	87.0%	0.005	UDI	-28	-33	0.01
											0.01
Carey et al. [8]	2009	Stage ≥2	12	Stage 0 or I	65.6% (40/61)	81.0% (51/63)	0.07	Satisfaction	81.0% (51/63)	76.3% (45/59)	0.12
								Bulging symptom	11.3% (7/62)	4.9% (3/61)	0.32
Nieminen et al. [9]	2010	Stage ≥2	36	Stage 0 or I	58.8% (57/97)	86.7% (91/105)	<0.001	Bulging symptom	18.8% (18/96)	9.6% (10/104)	0.07
Altman et al. [10]	2011	Stage ≥2	12	Stage 0 or I	47.5% (87/183)	82.3% (153/186)	<0.001	Bulging symptom	37.9% (66/174)	24.6% (44/179)	0.008
Chmielewski et al. [11]	2011	Stage ≥2	12	Ba ≤0	89.3% (25/28)	95.7% (22/23)	NS	Bulging symptom	0.0% (0/38)	8.7% (2/23)	NS
Menefee et al. [12]	2011	Stage ≥2	24	Stage 0 or I	41.7% (10/24)	82.1% (23/28)	0.004	UDI	-25	-25	0.961
								POPIQ	-14	-33	0.311
Vollebregt et al. [13]	2011	Stage ≥2	12	Stage 0 or I	41.1% (23/56)	91.4% (53/58)	<0.001	UDI	Significant improvement	Significant improvement	NS
								IIQ	Significant improvement	Significant improvement	NS
El-Nazer et al. [14]	2012	Stage ≥2	24	Stage 0 or I	70.0% (14/20)	95.0% (19/20)	<0.01	Bulging symptom	31.6%	5.3%	<0.05
de Tayrac et al. [15]	2013	Stage ≥2	12	Stage 0 or I	64.2% (43/67)	89.4% (59/66)	0.006	Satisfaction	92.0% (46/50)	96.2% (50/52)	0.2
Delroy et al. [16]	2013	Stage ≥2	12	Stage 0 or I	56.4% (22/39)	82.5% (33/40)	<0.05	At least 1 bothersome POP symptom	25.6% (10/39)	5.0% (2/40)	-
Turgal et al. [17]	2013	Stage 2 or 3	12	Stage 0 or I	75.0% (15/20)	95.0% (19/20)	0.04	Bulging symptom	25.0% (5/20)	5.0% (1/20)	0.04
Rudnicki et al. [18]	2014	Stage ≥2	12	Stage 0 or I	39.7% (31/78)	88.2% (67/76)	<0.001	Bulging symptom	Perceived significantly more often than mesh group		0.044
Dos Reis Brandão da Silveira et al. [19]	2015	Stage 3 or 4	12	Ba ≤0	70.4% (57/81)	86.4% (76/88)	0.019	Prolapse QOL	-37.8	-39.8	0.008
Tamanini et al. [20]	2015	Stage ≥2	24	Ba ≤-2	64.0% (32/50)	76.2% (32/42)	0.206	ICIQ-VS.	34.0% (17/50)	47.6% (20/42)	0.185
				Ba ≤-1	86.0% (43/50)	95.2% (40/42)	0.173	No vaginal symptom No QOL impact	84.0% (42/50)	88.1% (37/42)	0.574
Dias et al. [21]	2016	Stage ≥2	24	Ba ≤-1	39.5% (17/43)	39.5% (17/43)	1.000	Bulging symptom	9.1% (3/33)	5.4% (2/37)	-
				Ba ≤0	51.2% (22/43)	74.4% (32/43)	0.022	Satisfaction	81.8%	97.3%	0.032
Rudnicki et al. [22]	2016	Stage ≥2	36	Stage 0 or I	41.2% (28/68)	91.4% (64/70)	<0.001	Bulging symptom	32%	16%	0.03
Glazener et al. [23]	2017	Stage ≥2	24	Ba ≤0	86.1% (291/338)	83.9% (282/336)	0.52	POPSS	4.9	5.3	0.37
								P-QOL	1.9	2.2	0.44

UDI, urogenital distress inventory; POPIQ, pelvic floor impact questionnaire-prolapse; IIQ, incontinence impact questionnaire; ICIQ-VS, international consultation on incontinence questionnaire-vaginal symptoms; POPSS, pelvic organ prolapse severity of symptoms; P-QOL, prolapse quality of life; NS, nonsignificant.

3. Mesh issues: Is synthetic mesh really dangerous?

The use of transvaginal mesh has been the subject of academic debate over the past decade. Vaginal mesh kits were first introduced in the USA in 2005 after being approved by the FDA in 2001 for POP repair. The vaginal mesh-kit is a simple device used for augmentation of native tissue in POP. Typically, the mesh consists of four arms and a main body that effectively covers both central defects and paravaginal defects. These standardized kits represent a departure from individualized assessments of patient anatomy [10]. Since their introduction into the market, the clinical use of mesh-kits has increased explosively, more quickly than evaluations of long-term safety have accumulated. In 2008, Sung et al. [25] reviewed studies comparing mesh use with native tissue for POP repair, and found that there was insufficient evidence to suggest that transvaginal mesh improves outcomes for POP. Adverse events associated with mesh were also evaluated, including erosion (0%–30%), visceral injury (1%–4%), urinary tract infection (0%–19%), and fistula formation (1%). Overall, the results suggested that well-designed and adequately powered randomized trials are needed. Feiner et al. [26] also assessed success and complications in all trials to date that used transvaginal mesh and found that apical augmentation with transvaginal mesh resulted in good surgical outcomes with the most common complication being mesh erosion, occurring in 4.6% to 10.7% of patients. In 2008, the FDA issued the first public health notification regarding complications associated with transvaginal mesh for POP repair. In 2009, Bako and Dhar [27] reported mesh erosion rates of 2% to 25% for anterior POP repair and mesh-related infection rates of up to 8%. In 2011, the FDA issued a safety communication updating the 2008 notification, as follows [28].

- Recognize that in most cases POP can be treated successfully without mesh, thus avoiding mesh-related complications
- Choose mesh surgery only after weighing risks and benefits of surgery with mesh versus all surgical and nonsurgical alternatives
- Consider the following factors prior to placing mesh:
  - Surgical mesh is a permanent implant that may make future repairs more challenging.
  - A mesh procedure may put the patient at risk for requiring additional surgery or for the development of new complications.
  - Removal of mesh may involve multiple surgeries and significantly impair the patient's quality of life.
  - Complete removal may not be possible and may not result in resolution of complications, including pain.
  - Mesh placed abdominally may result in lower rates of mesh complications compared with transvaginal mesh placement.
  - Inform the patient about the benefits and risks of nonsurgical options, non-mesh surgery, abdominally placed mesh, and the likely success of these alternatives when compared with transvaginal mesh placement.
  - Notify the patient if mesh will be used in her POP surgery and provide information about the specific product used.
  - Ensure that the patient understands the postoperative risks and complications of mesh surgery and the limited long-term outcome data.

In response to increased reports of adverse events, the FDA concluded that transvaginal mesh has a higher complication rate than transabdominal mesh. In 2012, the FDA ordered mesh manufacturers to conduct post-market surveillance studies to evaluate efficacy and safety. In 2014, the FDA finally reclassified surgical mesh for POP as a class 3 (high-risk) device, with the reclassification formally implemented in January 2016. According to one study, vaginal mesh repairs decreased from 27% of POP repairs before 2008 to 15% after the first FDA notification in 2008 and 5% after the second notification in 2011, while the rates of minimally invasive surgeries such as laparoscopic or robotic sacral colpopexy or native tissue repair increased [29]. And finally, the FDA stopped selling transvaginal mesh for POP in April 2019. It does not apply to mesh products used to treat other conditions such as hernias or incontinence. The situation in Europe regarding the use of meshes in POP repair is no different. In 2014, the Medicines and Healthcare Products Regulatory Agency (MHRA) announced an official position on mesh for POP surgery, concluding that the use of mesh for POP surgery is safe and effective for the majority of patients, and that further research should be performed regarding implant types and surgical techniques. According to the official announcement of the National Institute for Health and Care Excellence (NICE) in April 2019, mesh should be considered as a final option for POP repair. In addition, when using a mesh, it is recommended that the patient be fully informed of outcomes and the possibility of mesh complication [30].

Is the use of synthetic mesh dangerous? It is important to not misunderstand the FDA's warning. Mesh exposure rates range from 3.2% to 20.5% according to recent randomized controlled studies and 3.1% to 14.4% according to single-arm studies. Mesh erosion rates vary between studies, so the risk of using synthetic mesh for POP cannot be determined. The mesh erosion rates for midurethral slings in

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patients with SUI also vary from study to study. In a study that analyzed 388 complications, the mesh erosion rate of the retropubic approach was 11.4% (24/210) and that of the transobturator approach was 25.7% (18/70) [31], which were moderately higher than the general mesh erosion rate of midurethral slings (3%–5%) [32]. Even when higher complication rates are reported, midurethral slings are not considered risky. In addition, when mesh exposure occurs, most cases are asymptomatic and conservative management can be expected to resolve symptoms. Patients who needed surgical treatment due to mesh exposure made up 0% to 16.4% of patients in randomized controlled trials [7-10,12-23] and 1.7% to 8.9% in single-arm studies [33-37], accounting for only half of all patients with mesh exposure (Table 2). Comprehensively judging the recent literature and based on our experience, we suggest that how to select the proper patient is more important. Proper patient selection as well as improvements of surgical technique is essential for optimizing the success of mesh repair. Severe prolapse (stage 3 or 4), patient age younger than 60 years, diabetes mellitus, and recurrent prolapse are associated with recurrent prolapse after native tissue repair, and it is necessary to consider mesh repair

Table 2. Summary of mesh exposure rates and management after anterior compartment prolapse repair with mesh

Study	Year	Follow-up (mo)	Exposure rate	Management	Reoperation rate due to mesh exposure
Randomized control study					
Nguyen and Burchette [7]	2008	12	5.4% (2/37)	2: conservative	0.0% (0/27)
Carey et al. [8]	2009	12	5.8% (4/69)	3: surgical excision 1: conservative	4.3% (3/69)
Vollebregt et al. [13]	2011	12	3.4% (2/59)	2: surgical excision	3.4% (2/59)
Menefee et al. [12]	2011	24	13.9% (5/36)	3: conservative 2: surgical excision	5.6% (2/36)
El-Nazer et al. [14]	2012	24	5.0% (1/20)	1: surgical excision	5.0% (1/20)
Delroy et al. [16]	2013	12	5.0% (2/40)	2: conservative	0.0% (0/40)
de Tayrac et al. [15]	2013	12	9.3% (7/75)	1: conservative 4: surgical excision 2: follow-up loss	5.3% (4/75)
Turgal et al. [17]	2013	12	15.0% (3/20)	3: surgical excision	15.0% (3/20)
Rudnicki et al. [18]	2014	12	12.8% (10/78)	8: conservative 2: surgical excision	2.6% (2/78)
Dos Reis Brandão da Silveira et al. [19]	2015	12	20.5% (18/88)	15: conservative 3: surgical excision	3.4% (3/88)
Altman et al. [10]	2011	12	3.2% (6/186)	6: surgical excision	6.8% (6/88)
Nieminen et al. [9]	2010	12	20.8% (20/96)	6: conservative 14: surgical excision	14.6% (14/96)
Tamanini et al. [20]	2015	24	16.7% (7/42)	7: surgical excision	16.7% (7/42)
Rudnicki et al. [22]	2016	36	14.7% (10/68)	10: conservative	0.0% (0/68)
Dias et al. [21]	2016	24	11.6% (5/43)	3: conservative 2: surgical excision	4.7% (2/43)
Glazener et al. [23]	2017	24	5.7% (25/435)	17: surgical excision 4: conservative 4: no treatment	3.9% (17/435)
Single arm study					
Jacquetin et al. [33]	2010	40	14.4% (13/90)	8: surgical excision 4: no treatment 1: conservative	8.9% (8/90)
Bjelic-Radisic et al. [34]	2014	19	12.1% (28/231)	21: conservative 4: surgical excision	1.7% (4/231)
Song et al. [35]	2016	38	3.1% (5/163)	5: surgical excision	3.1% (5/163)
Barski et al. [36]	2017	12	5.9% (2/34)	1: surgical excision 1: conservative	2.9% (1/34)
Aubé et al. [37]	2018	36	6.0% (20/334)	10: surgical excision 10: conservative	3.0% (10/334)

in these patients [38]. To date, known risk factors for mesh complications include diabetes, smoking, pelvic irradiation, and vaginal surgery [32]. In terms of surgical technique, full thickness vaginal wall dissection into the true vesicovaginal spaces is an integral technique for optimal mesh placement. The mesh should be placed flat without folding or excessive tension on the mesh.

4. Importance of concurrent correction of apical prolapse

The identification and correction of apical prolapse is critical to reduce recurrence after POP repair. Clinically significant apical prolapse is virtually always present in cases with both anterior and posterior compartment prolapse. If the anterior vaginal wall was at least 2 cm outside the hymen, 80% of the vaginal apices prolapsed to at least 2 cm inside the hymen, and 55% of the apices prolapsed >2 cm outside the hymen [39]. Another study also found that almost 60% of patients with stage 2 or greater cystoceles had clinically significant apical vaginal descent. As cystocele stage increases, the predictive value of apical prolapse also increases [40]. A study of over 2,700 women comparing isolated anterior repair versus combined anterior and apical repair found that 10-year reoperation rates were lower in the combined anterior and apical repair group (11.6% vs. 20.2%) [41]. These findings are important as a basis for preventing recurrences, apart from a simple correlation between apical support and anterior support. Proper suspension of the vaginal apex is an essential factor for treatment success in cases of anterior compartment prolapse. Although concurrent apical repair is an obvious modifiable factor that can reduce the risk of recurrence, there are surgeons who perform anterior compartment repair without prior careful vaginal examination. According to US data, the proportion of anterior repairs without apical suspension decreased from 77.7% in 2004 to 41.4% in 2012 ($p<0.001$). Since 2011, there has been a decrease in the number of anterior repairs without apical suspension, notably among clinicians applying for Female Pelvic Medicine and Reconstructive Surgery (FPMRS) certification (17.1% vs. 30.7% by all other urologists, $p<0.001$). Nonacademically-affiliated urologists are 2.1 times more likely to report anterior repair without apical suspension than academically-affiliated colleagues ($p<0.001$) [42]. Therefore, it is necessary to improve POP repair practice through lifelong education, and surgeons who incapable of adequately assessing apical prolapse and correspondingly performing apical suspension should not attempt anterior compartment prolapse repair.

SURGERY FOR APICAL VAGINAL PROLAPSE

Apical prolapse surgeries can broadly be separated into obliterative and restorative approaches. Restorative approaches can be performed transvaginally or abdominally. For patients desiring restorative outcomes, abdominal sacrocolpopexy remains the gold standard. Abdominal sacrocolpopexy can be performed via laparotomy, conventional laparoscopic sacrocolpopexy (LSC), or robot assisted-laparoscopic sacrocolpopexy (RSC). In a recent Cochrane review [43], sacrocolpopexy including open or laparoscopic approaches were associated with lower risk of awareness of prolapse (RR, 2.11; 95% CI, 1.06–4.21), recurrent prolapse (RR, 2.28; 95% CI, 1.20–4.32), repeat surgery for prolapse (RR, 1.89; 95% CI, 1.33–2.70), postoperative stress urinary incontinence (RR, 1.86; 95% CI, 1.17–2.94) and dyspareunia (RR, 2.53; 95% CI, 1.173–5.50) than a variety of vaginal approaches.

1. Laparoscopic/robotic sacrocolpopexy vs. open sacrocolpopexy

Although open sacrocolpopexy is a good treatment option for apical prolapse repair, with long-term success rates of 78% to 100%, it is associated with increased length of hospital stay, analgesic requirements, and cost compared with transvaginal procedures [44,45]. New surgical techniques such as LSC or RSC have been developed to overcome these limitations. Compared with open sacrocolpopexy, LSC or RSC decreases overall morbidity and has good anatomical durability [46-52]. Freeman et al. [47] performed a randomized study comparing open sacrocolpopexy and LSC in patients with vault prolapse, and found that the methods demonstrated clinical similar recurrence rates at 1 year. In 2016, Costantini et al. [52] conducted the longest randomized follow-up study (mean follow-up of 41.7 months) comparing open sacrocolpopexy and LSC, and found that both techniques are efficacious with no patients in their sample experiencing apical recurrences. The 2016 Cochrane review [43] reported that there may be no difference between the results of LSC and open sacrocolpopexy for repeat surgery for prolapse (RR, 1.04; 95% CI, 0.16–6.80).

Although LSC seems to overcome the shortcomings of open sacrocolpopexy, LSC is technically more challenging for those who are not proficient in laparoscopy. Since 2004, the implementation of RLC has allowed surgeons with good dexterity and precision to offer the procedure as an alternative to LSC. The learning curve is feasible without the need for laparoscopic skills. One of the largest prospective studies of RSC (n=120) showed that the anatomical success rate was

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89% with 12-month follow-up [53]. According to a recent systematic review of LSC vs. RSC, RSC is associated with longer operation time, increased postoperative pain, and higher cost than LSC. However, both surgical options showed similar results regarding improvement of symptoms [54].

2. Sacrohysteropexy for uterine preservation

There are three options for the presence of prolapsed uterus in patients with apical prolapse: sacrohysteropexy, which fixes the uterus and vagina with a mesh to the sacral promontory, thereby preserving the uterus; supracervical hysterectomy with sacrocervicocolopopexy, which does not preserve the uterus; and sacrocolpopexy after total hysterectomy with closure of the vaginal cuff. Hysteropexy has the advantage of maintaining fertility and natural menopausal timing by preserving the uterus, and 36% to 60% of female patients choose uterine preservation assuming equal surgical efficacy. In addition, removal of the uterus may result in disruption of the uterosacral-cardinal ligaments and further weaken vaginal support. If there is no contraindication for uterine preservation, sacrohysteropexy may offer benefits. However, there is less surgical outcome data available for sacrohysteropexy, and the procedure requires continuous surveillance of the cervix and endometrium.

1) Sacrohysteropexy vs. total hysterectomy and sacrocolpopexy

There are no randomized trials comparing hysteropexy to hysterectomy and concurrent sacrocolpopexy. Costantini et al. [55] conducted prospective studies comparing abdominal sacrohysteropexy to total hysterectomy and sacrocolpopexy. In this study, 72 patients with grade 3 to 4 POP self-selected to undergo either sacrohysteropexy or total hysterectomy and sacrocolpopexy. Both groups demonstrated similar, good success rates (100% and 100%) with no reoperations due to recurrence. The sacrohysteropexy group experienced shorter average operation time (89 vs. 115 minutes) and greater improvement in sexual function when compared to the total hysterectomy and sacrocolpopexy group. Another retrospective study comparing laparoscopic sacrohysteropexy (n=65) to total laparoscopic hysterectomy and sacrocolpopexy demonstrated advantages in performing total hysterectomy and sacrocolpopexy [56]. The subjective satisfaction rate was significantly higher (92.3% vs. 100%, p<0.001) and the postoperative Pelvic Floor Impact Questionnaire 7 (p=0.043) and pelvic floor distress inventory-short form 20 (p=0.035) scores were significantly better in the total laparoscopic hysterectomy and sacrocolpopexy group, while the anatomical cure rates (72.3% vs. 88.2%, p=0.07) did not differ significantly between groups.

Based on current knowledge, there are significantly higher reoperation rates for POP in patients treated with hysteropexy, while the mesh exposure rate is 3.5-fold higher after sacrocolpopexy among patients treated with concomitant total hysterectomy. It is difficult to determine whether sacrohysteropexy and total hysterectomy and sacrocolpopexy results in superior outcomes given our current knowledge [57-60].

2) Supracervical hysterectomy and sacrocolpopexy

The benefits of supracervical hysterectomy may reduce the risk of mesh erosion, thus avoiding cautery-induced thermal injury to the vagina [61]. Warner et al. [57] observed a 4.9% mesh exposure rate for the total hysterectomy group, but no mesh exposures were seen in the supracervical hysterectomy group (p=0.03). However, evidence for the efficacy of supracervical hysterectomy is still lacking. A small study comparing laparoscopic sacrohysteropexy (n=15) to laparoscopic sacrocolpopexy with concomitant supracervical hysterectomy showed that the overall success rate was significantly higher for laparoscopic supracervical hysterectomy with sacrocolpopexy (67% vs. 27%), but major complications and vaginal mesh erosions were not registered [62]. A retrospective study demonstrated that supracervical hysterectomy with sacrocolpopexy was 2.8 times more likely to result in recurrent prolapse than total hysterectomy with sacrocolpopexy, when recurrent prolapse was defined as prolapse greater than or equal to stage 2. This study did not have sufficient power to detect differences in rates of mesh exposure, with 7.5% in the total hysterectomy with sacrocolpopexy group vs. 2.3% in the supracervical hysterectomy with sacrocolpopexy group (p=0.35) [61].

3. Mesh fixation techniques

In an effort to decrease the morbidity associated with open sacrocolpopexy, RSC, which decreases the difficulty associated with laparoscopic knot tying, and 3-dimensional visualization aiding sacral dissection, has rapidly gained popularity. However, variation in surgical technique includes the amount of vaginal dissection, type of mesh, number or location of sutures that should be placed to secure the suspending mesh, retroperitonealization of the mesh, and cervix preservation [63,64].

1) Absorbable vs. non-absorbable suture

Traditional open sacrocolpopexy uses nonabsorbable suture to prevent the mesh detaching from the vagina and

sacral promontory and to decrease the risk of mesh exposure and suture erosion. After synthetic mesh implantation, porcine models showed that 74% of the final strength of tissue ingrowth into mesh is achieved by 2 weeks, and maximum strength is reached by 3 months. Delayed absorbable monofilament suture lost 50% of its tensile strength by 4 weeks, 100% by 2 to 3 months, and was completely absorbed by 6 to 8 months [65]. In terms of risk of mesh complications, the mesh/suture exposure rate was 3.7% (6/161) for braided non-absorbable suture (2-0 Ethibond; Ethicon, Somerville, NJ, USA) while no erosions occurred with monofilament delayed-absorbable suture (2-0 polydioxanone suture, Ethicon) (p=0.002) [66]. In a series of RSC patients with median 33 months follow-up, the use of absorbable sutures for both vaginal and sacral mesh attachment was effective, with a 3-year rate of survival without repeat prolapse surgery of 93%. However, in this study the benefit of risk of mesh erosion was not assessed [67]. Although evidence is lacking, it is unlikely that absorbable sutures are a risk factor for mesh detachment. Further studies will be needed to determine the proper location of sutures and the number of sutures, as well as the best type of suture to use in POP repair.

2) Barbed suture

The most challenging procedure during LSC or RSC is the attachment of the polypropylene mesh to the anterior and posterior vaginal walls and retroperitonealization over the mesh, which can be time-consuming. In LSC, suturing and knot tying are related to steeper learning curves compared to RSC [68-70]. To overcome this step, the use of barbed sutures has been described in several studies. Tan-Kim et al. [71] conducted a randomized study comparing non-barbed interrupted sutures to barbed suture (Quill™) for anchoring the mesh to the vaginal wall during LSC or RSC. Among all patients, those treated with non-barbed suture had significantly longer operation times than those treated with barbed suture (42 vs. 29 minutes, p<0.001) and there were no significant differences in anatomic failure between the groups at 12 months. Another retrospective study reported 1-year outcomes in 20 patients who underwent RSC using barbed delayed absorbable sutures (3-0 V-Loc 180, Covidien, Dublin, Ireland). The barbed delayed absorbable suture was used only for fixing the mesh to the vagina wall and performing retroperitonealization. There was no recurrence of apical prolapse or mesh exposure at 1-year follow-up [72]. Kallidonis et al. [73] also demonstrated that using barbed sutures for mesh fixation and peritoneal closure during LSC was safe and associated with reduced operating time. It is believed that the use of barbed suture plays reduces operation time by facilitating retroperitonealization of mesh. However, further studies should be performed for elucidating the ideal role of barbed suture for securing the mesh to the vaginal wall.

4. Single port approach

Single port approaches herald a new era in the field of minimally invasive surgery, with good cosmetic results and reduced patient morbidity compared with multiport surgery. Although single port robotic surgery is in an early stage of development, it has been implemented in various surgical fields. Since 2017, a few reports describing single port RSC have demonstrated that it is a feasible technique [74-77]. In 2017, Matanes et al. [76] reported their first 25 experiences with single port RSC and demonstrated significant decreases in median total operative and console times (226 minutes for the first 15 cases vs. 156 minutes for the next 10 cases), decreases that were within the same range as that reported for initial experiences with multiport access. There were no intraoperative adverse events. There was 1 case of small bowel obstruction that required reoperation, but this patient did not achieve retroperitonealized over the mesh, which altered the surgeon's approach toward all subsequent patients. Recently, Liu et al. [75] published a case series of patients treated with single port RSC following a modified technique. They attempted retroperitoneal tunneling techniques and asserted that they could more easily perform these techniques via a single port approach. A retroperitoneal tunnel was created by undermining the peritoneum with an articulated needle driver. The needle driver was placed in the peritoneal opening over the sacral promontory, and the tunnel was created just medial to the right uterosacral ligament in the direction of the vaginal vault by using forward pressure and a sweeping motion to create a space within the retroperitoneum. This approach allowed for easier adjustment and maintenance of mesh tension during the placement of sutures in the sacral promontory compared with opening the entire retroperitoneal space, and may reduce operative time and adhesion formation.

SURGERY FOR POSTERIOR COMPARTMENT PROLAPSE

Posterior vaginal wall prolapse can cause the sensation of bulging in the vagina and symptoms of obstructed defecation. The overall prevalence of posterior compartment prolapse alone is not certain, because it is usually accompanied by anterior or apical prolapse. As up to 80% of rectoceles are reported to be asymptomatic, its prevalence may be under-

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estimated [78]. Surgical treatment of posterior compartment prolapse can be approached either transvaginally, transperineally, or transanally, and can be repaired with native tissue or using mesh. Traditionally, central and lateral defects have been repaired with plication of rectovaginal fascia (known as posterior colporrhaphy). In 2006, Paraiso et al. [79] conducted a randomized study comparing outcomes of 3 different rectocele repair techniques: posterior colporrhaphy, site-specific repair, and site-specific repair augmented with a porcine small intestinal submucosal graft. After 1 year, subjects who received graft augmentation had a significantly greater anatomic failure rate (12/26; 46%) than those who received site-specific repair alone (6/27; 22%) or posterior colporrhaphy (4/28; 14%) (p=0.02). Although there are many studies of using mesh for posterior compartment repair, they do not separate the results of anterior and posterior repair. Anatomic success rates for posterior compartment repair with graft have ranged from 54% to 92%, and have not been shown to have superior outcomes to native tissue repair. A 2018 Cochrane review identifying 10 randomized trials indicated that transvaginal repair may be more effective than other approaches for preventing recurrence of prolapse and that using mesh or graft materials offered no benefits for posterior compartment repair [80]. There does not appear to be controversy about posterior compartment prolapse repair anymore. We believe that the best option for treating posterior compartment prolapse is posterior colporrhaphy, which results in excellent outcomes with the lowest rates of recurrence.

CONCLUSIONS

In different cases, POP repair is achieved using slightly different techniques depending on the surgeon's skills. The definitions of treatment success and study designs are diverse in the literature, making it difficult to draw consistent conclusions. However, all previous research indicates that the goal of surgery is to maximize patient satisfaction as well as return the pelvic organs to their original positions. It is not an exaggeration to state that the success of POP repair is closely related to the experience of the surgeon, though the FDA warning against vaginal mesh has resulted in a decrease in the use of mesh. In addition, minimally invasive surgery has become more popular and is gradually evolving to be comparable to traditional techniques for POP repair.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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