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Sacrocolpopexy: Surgical Technique, Outcomes, and Complications

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Abstract
Purpose of Review Pelvic organ prolapse is a non-life-threatening condition that has a wide variety of symptoms. Sacrocolpopexy has been the "gold standard" for management of apical pelvic organ prolapse with reported high success rates for anatomic correction. Herein, we review the surgical procedure, anatomic, and functional outcomes, as well as the intraoperative and postoperative complications.
Recent Findings Findings suggest that the ASC has an acceptably low overall complication rate comparable between open and minimally invasive approach. Mesh extrusion and anatomic failure have been shown to increase over time.
Summary Patient education and counseling are important preoperatively. It is important to discuss with the patient risks of the surgical procedure, specifically mesh-related extrusion, longer term anatomic recurrence rates, rates of functional improvement, or worsening of bladder and bowel symptoms, as well as rates of dyspareunia.

Keywords Voiding dysfunction · Pelvic organ prolapse · Dyspareunia · Sacrocolpopexy

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Introduction

Pelvic organ prolapse is a common problem among women with an estimated lifetime risk of surgery estimated to be 11–19 % [1, 2]. Wu et al. compared data from the National Health and Nutritional Examination Survey (NHANES) from 2005 to 2006, 2007 to 2008, and 2009 to 2010 [3]. Overall, 25 % of women experienced one or more pelvic floor disorders (moderate to severe urinary incontinence, monthly fecal incontinence, or visual or palpable pelvic organ prolapse), but the incidence was stable over the time period. Though the prevalence of the condition appears to be stable, the approaches to management change with time. Skoczylas et al. retrospectively evaluated changes in trends of POP repair at their institution during release of the initial FDA warnings on transvaginal mesh [4]. From 2008 to 2011, there was a decrease in transvaginal mesh procedures from 25 to 2 % of cases, an increase in native tissue repairs, and overall a decrease in the number of sacral colpopexies (ASC) performed. ASC was still the most commonly performed procedure with an overall increase in the number performed by minimally invasive technique.

Although there are many different approaches to the management of pelvic organ prolapse, the type of surgical repair chosen is dictated by stage of prolapse, involved compartments, patient characteristics, and surgeon preference. Identification of apical descent and management of the apex is a critical step for the success of prolapse repairs. The ASC is preferred for repair of vaginal vault (apical) prolapse in patients having concomitant abdominal surgeries, recurrent prolapse, or surgeons who have limited experience with vaginal approaches to apical suspension [5] or when vaginal shortening or narrowing is a concern [6].

Surgical Technique

The technique for ASC has evolved over time. In 1949, Arthure described using the anterior longitudinal ligament for fixation of the vaginal apex [7] and the practice of using a graft interposition to secure the apex of the vagina to the sacrum was described in 1962 [8]. There has been evolution of the surgical procedure with technical changes including the location of fixation, type of graft material, the degree of dissection vaginally, and transitioning from an open abdominal procedure to minimally invasive techniques of laparoscopic and robotic approaches.

The general principles of the ASC are to use an interposition graft with fixation of the vaginal apex to the anterior longitudinal ligament of the sacrum, recreating suspensory support and aligning the vagina along the normal midline axis. Variability in the surgical technique is related to patient factors, surgeon preference, and major technical considerations. Patient variables include stage of prolapse, compartments involved, vaginal tissue quality, and comorbid conditions. O'Sullivan et al. in 2012 surveyed members of the American Urogynecologic Society and the International Urogynecological Association attending a workshop on SCP and determined there was no consensus on the degree of dissection of the anterior and posterior vagina, the number of sutures for fixation, and the type of suture used to secure the graft to the vagina [9]. The difference between suture type and the impact on surgical outcome and extrusion and infection rates is unclear, and method of fixation is often not reported in the literature [5].

Three major technical considerations that impact outcomes are the sacral fixation point, peritoneal closure over the interposition graft, and type of interposition graft used.

Sacral Fixation The recommended sacral fixation point has changed due to concerns for hemorrhage and maintenance of the most natural vaginal axis. In the early 1970s, fixation of the graft was at the level of S3/S4, but this was associated with a significant risk for hemorrhage [10]. In 1981, Sutton et al. described fixation at the S1/S2 level for better visualization of the middle sacral artery and less risk of bleeding [11]. Fixation at the S2/S3 level will provide the most natural vaginal axis; however, there are concerns of potential denervation injury to the rectum when dissection of the lateral pedicle is performed, resulting in a high outlet obstruction [12]. Further subtle changes of the fixation point have been described and will be further discussed herein.

Posterior Peritoneal Closure There is some debate as to whether the peritoneum should be closed over the interposition graft, effectively retroperitonealizing the graft. In our opinion, if the graft material is synthetic the peritoneum needs to be closed or the mesh tunneled underneath the posterior peritoneum in order to decrease the risk of bowel adhesions to the synthetic mesh. If the interposition graft is autologous tissue, closure would probably be preferred due to reduced risk of bowel adhesions to the graft.

Interposition Grafts An ideal graft is one that is available in large quantity, permanent, and is not subject to erosion, infection, shrinkage, or foreign body reaction. The interposition graft has evolved both in configuration and type of graft material. Several techniques for mesh fixation have been described, including a single graft [13], a cone-shaped material to envelope the entire vagina [14], and, more recently, a Y-shaped double graft with a limb secured anteriorly and posteriorly on the vagina [15]. The graft material used has varied over time and currently there is no universally accepted graft, although the majority of surgeons are currently using a polypropylene mesh [9]. Different materials have advantages and disadvantages that need to be considered. There are four broad categories of graft materials: (1) autologous, (2) allograft, (3) xenograft, and (4) synthetic materials. Table 1 provides a detailed description of the types of grafts, advantages, disadvantages, and outcomes.

Autologous tissues were initially used for correction of urinary incontinence. Disadvantages of autologous tissue are increased in operative time, risk of hematoma formation, wound infection or hernia formation, more postoperative pain, and longer recovery. Allografts, xenografts, and synthetic materials were introduced in an effort to decrease patient morbidity and further improve outcomes. Allografts have a lower extrusion rate relative to synthetic meshes and even if extrusion does occur it may not be necessary to surgically remove the graft [5]. However, allografts have the potential for disease transmission to the recipient. Although serologic testing is done for HIV and hepatitis, there is the risk of false negatives and prion transmission has occurred in corneal and dura mater grafts. There have been no reports of disease transmission with cadaveric fascia or dermis; however, the potential exists and patients need to be counseled on this risk. Another concern with the use of allografts is the processing and preservation process. Processing and preservation techniques have not been standardized and the methods used appear to affect tensile strength [16, 17]. Cadaveric allografts serve as acellular scaffolding that requires remodeling and patient response is variable. Some patients are able to remodel while in others the allograft is completely resorbed [18]. Fitzgerald et al. reported an 83 % failure rate of ASC using freeze-dried, irradiated cadaveric fascia lata. Viable graft was identified in only 3 of 16 patients at the time of repeat surgery [18].

Both absorbable and non-absorbable synthetic meshes are available. For ASC, only permanent synthetic materials have been described. The choice of synthetic material does not impact success of the procedure but does impact risks of complications related to mesh. The underlying substance from which the synthetic material is constructed is not the most

Table 1 Types of mesh

	Type	Origin	Advantages	Disadvantages
Autologous	• Fascia lata • Rectus fascia	Patient's native tissue	• Biocompatible • No extrusion	• Increased operative time • Risk of hematoma • Wound infection • Hernia formation • Longer postoperative recovery
Allografts	• Fascia lata (Tutoplast®, Coloplast, Minneapolis, MN) • Dermis (Repliform™, Boston Scientific, Marlborough, MA) • Dura mater	Tissue from same species (i.e., cadaveric)	• Lower extrusion rate than mesh • Less patient morbidity	• Disease transmission • (HIV, hepatitis, prions) • Decrease in strength with processing and preservation • Graft resorption
Xenografts	• Porcine small intestine submucosa (SIS, Surgisis®, Cook Medical, Bloomington, IN) • Porcine dermis (Pelvicol™, Bard, Murray Hill, NJ) • Bovine pericardium	Biologic material from other species	Less patient morbidity	Variable biocompatibility and tissue response
Synthetic mesh		Synthetic (types 1–IV)	Less patient morbidity	Risk of infection, erosion and extrusion
Type I Macroporous Monofilament	Polypropylene (Marlex®, Bard, Murray Hill, NJ; Prolene®, Ethicon, Somerville, PA)		Less reactive, risk of infection and extrusion relative to other synthetic mesh	
Type II Microporous solely, Multifilament	Expanded PTFE (Gore-Tex)			Increased risk of extrusion compared to Type 1 mesh
Type III Macroporous with microporous areas, Multifilament	• Polytetra fluoroethylene (Teflon®, DuPont, Wilmington, DE) • Dacron (Mersilene®, Ethicon)			Increased risk of extrusion compared to type 1 mesh
Type IV Submicronic pore size	Not available (ObTape, Mentor, Minneapolis, MN)			

important factor; rather, the configuration of the material related to pore size, fiber type, and stiffness appears to be the most important characteristics of the mesh [19]. Synthetic mesh materials are classified by pore size (macroporous verses microporous) and fiber type (monofilament verses multifilament). Pore size is important in the ability of the host to eliminate bacteria. Macrophages and leukocytes are unable enter into microporous mesh (<10 μg) but can enter macroporous mesh (>75 μg) and prevent infection. Fiber composition is interconnected to pore size; in the multifilament mesh material, there are microporous interstices between the filaments. Type 1 mesh is macroporous and monofilament; type II mesh is solely microporous and multifilament; type III mesh is macroporous but due to the multifilament nature has microporous areas; and type IV mesh has submicronic pore size and is not currently used in pelvic reconstructive surgeries. Stiffness of the material is also related to pore size, i.e., the larger the pore size the more flexible the material and theoretically less likely to cause extrusion or erosion.

Outcomes

ASC is often believed to be the gold standard for correction of apical prolapse, with a reported success rate of 77–100 % [6]. There is level 1 evidence for better anatomic outcomes with ASC compared to vaginal approaches [20••]. In a recent publication, one third of patients met criteria for either anatomic or symptomatic failure; however, only about 5 % had retreatment for POP [21••]. At 7 years follow-up, the estimated probability for anatomic treatment failure between the urethropexy and no urethropexy groups was 27 and 22 %, and symptomatic failure was 29 and 24 %, respectively. In patients monitored over time, it is clear that the success continues to decline. This is an important consideration when ASC is performed in younger patients who may still have a life expectancy of 20 or more years.

Outcomes are challenging to evaluate across studies due to the complexity of POP. As multiple compartments are often involved, it is therefore difficult to control for the variety of

ancillary repairs performed in conjunction with an ASC. Success and failure are not only defined by anatomic outcomes but also by the type of graft material and the restoration or preservation of bladder, bowel, and sexual function.

Materials Various interposition grafts have been used; however, outcomes are difficult to interpret due to limited follow-up and small numbers of patients for materials other than synthetic mesh.

Xenografts: Based on available data, there is insufficient evidence for conclusion on the use of porcine matrix.

Allografts: Cadaveric fascia lata appears to have inferior anatomic outcomes with success rates of 68 % at 12 months and 62 % at 5 years [22].

Autologous: Autologous fascia initially appears to have successful outcome rates of more than 90 % with up to 4 years follow-up [23–26]; however, there is no long-term follow-up and numbers are small.

Synthetic: Synthetic materials appear to have robust outcomes even at extended follow-up periods.

There is minimal data available on complications of grafts other than the synthetic materials. It is our belief that autologous fascia lata and rectus fascia have a role in management of apical prolapse. The advantages of autologous tissues are that it is non-reactive, has a low rate of infection, and based on what we have seen from use in pubovaginal slings, and minimal extrusion, or with exposure, the tissue often epithelializes without need for intervention.

Anterior Compartment The effect of POP on urinary tract function can be divided into symptoms of obstruction, irritative symptoms or overactive bladder (OAB), and stress urinary incontinence.

The CARE trial is often considered a pivotal trial in addressing SUI and is a platform for many clinicians trying to determine which patient needs and anti-incontinence procedure at the time of surgical correction of prolapse overall [21••]. Baessler et al. reviewed the English literature and provided levels of recommendations [27]. Specific to ASC, they concluded there is conflicting data that colposuspension should be performed in continent women (no occult SUI). However, in women with occult SUI undergoing POP repair, addition of an anti-incontinence procedure reduces the rate of postoperative SUI.

Perhaps less controversial is the effect of surgical correction of a cystocele on obstructive and irritative symptoms. A cystocele may cause a functional obstruction or kinking at the bladder neck, especially in women with prior urethral continence procedures. However, these patients may be older and have comorbidities that predispose to underlying detrusor underactivity. A pessary trial or preoperative voiding studies with reduction of the prolapse with a pessary may provide information on whether surgical correction is likely to improve incomplete bladder emptying [28]. Correction of cystocele may resolve symptoms of OAB in up to 40 % of patients; however, approximately 12 % may develop de novo OAB symptoms [27].

Anatomic outcomes are variable and difficult to compare across studies due to difference in degree of dissection on the anterior vaginal wall and variations in ancillary procedures performed. Overall, the ASC has an anatomic recurrence rate of 5–25 %.

Posterior Compartment The posterior compartment is evaluated based on prolapse stage and defecatory symptoms. Defining success based on physical examination is a straightforward objective measure; however, defecatory dysfunction and bowel symptoms are more obscure. Overall, defecatory dysfunction appears to be a prevalent condition among aging women. In a national survey of women 60 years old or greater, 16 % meet symptomatic criteria for constipation and 25 % used digital assistance for bowel movement [29]. Several measures of outcome studies in prolapse surgery have demonstrated there is no correlation between symptoms and severity of posterior wall prolapse [30, 31]. Weber et al. reported on the bowel symptoms of women with uterovaginal prolapse [30]. Greater than 50 % of the women reported having to strain for a bowel movement at least sometimes, and 30 % reported having to splint vaginally at least sometimes. Bradley et al. established baseline data for the patients in the CARE trial using the Colorectal-Anal Distress Inventory [31]. In this study, 28 % responded "yes" to having to "push on the vagina or around the rectum to have or complete a bowel movement."

Studies of the effect of ASC on bowel functions have produced variable results with short mean follow-up. Fox et al. in reported in their patients that there was an improvement in fecal soilage, but worsening constipation and incomplete defecation following ASC [32]. Baessler et al. reported on a small subset of eight patients with both outlet constipation and slow transit constipation in which six patients had resolution of symptoms [12]. None of the three patients with only slow transit had improvement highlighting the complexity of bowel dysfunction. The more significant finding was development of what was described as "high outlet obstruction" whereby patients have fecal urgency with inability to defecate or sensation of stool stuck high in the rectum. It was at this time they abandoned taking down the lateral ligaments to the rectum.

A more recent report of 5-year outcomes on the extended CARE trial evaluated bowel symptoms specifically [33]. Patients with a posterior repair (posterior colporrhaphy, perineorrhapy, or sacocolpoperineopexy) performed at the time of ASC had the highest recurrence of posterior prolapse (12 %) followed by the no-posterior repair with baseline Ap <0 group (9 %). With regard to obstructive defecatory symptoms, while all groups had improvement in symptoms, at

5 years, 17–19 % of patients still reported the presence of obstructive defecatory symptoms.

Though SCP appears to have high success in resolution of posterior prolapse with recurrence rates of approximately 12 % [33], it is clear that defecatory dysfunction and constipation have complex etiologies that likely have underlying mechanisms beyond simply the presence of a rectocele. In counseling patients on the success of ASC in improving symptoms, it needs to be emphasized that patients can anticipate symptomatic improvement but not likely resolution of the defecatory symptoms.

Sexual Function Robust outcomes on sexual function are lacking and the available data conflicting. Virtanen in 1994 reported 7 of 16 patients (43 %) had dyspareunia after ASC [34]. In more recent studies using validated questionnaires, there appears to be improvement and de novo dyspareunia rates of 1–8 % postoperatively [35, 36]. There appears to be a trend toward improvement in sexual function.

ASC Complications

Pelvic organ prolapse is a non-life threatening condition and treatment is often aimed at restoring function and improving quality of life. Thus, there must an acceptably low risk of complications. The general population is aging and living longer, and it is estimated that 4.1 % of women >80 years of age have symptomatic pelvic organ prolapse [37]. In elderly patients, studies suggest a low complication rate for vaginal and robotic surgeries, but robotic complications are more severe (Clavien-Dindo grade III, requiring surgical, endoscopic, or radiologic intervention), all were intraoperative complications recognized at the time of surgery [38]. Women ≥65 years of age appear to be at greater risk for major complications with minimally invasive (laparoscopic and robotic) sacrocolpopexy relative to patients <65 years old [39].

Recognized complications include intraoperative and immediate postoperative complications, mesh extrusions, and osteomyelitis/spondylodiscitis.

Intraoperative and Immediate Postoperative Complications By its nature, ASC is an abdominal surgery and thus carries inherent risk to the bowels and wound complications. Nygaard et al. published a comprehensive review of abdominal sacral colpopexy and found wound issues ranging from infection, hematoma, or superficial separation occurred in 4.6 % (0.4–19.8 %), and the more serious complication of fascial dehiscence was <0.01 % [21••]. The reported rate of hemorrhage or transfusion was 4.4 % (0.18–16.9 %), the rate of incidental cystotomy was 3.1 % (0.4–15.8 %), and the rate of ureteral injury was 1.0 % (0.8–1.9 %). Incidence of enterotomy or proctotomy was 1.6 % (0.4–2.5 %), and small bowel obstruction or ileus was 3.6 % (1.1–9.3 %) with a reoperation rate of 1.1 % (0.6–8.6 %). If a rectal or bowel injury occurs during dissection, a synthetic mesh should not be placed and the ASC terminated [40, 41]. The overall rate of intraoperative and postoperative complications is similar between robotic and open approaches, acceptably low, and summarized in Table 2.

Specific to the performance of an ASC are risks of bleeding and injury to the bladder or ureter. Reported rate of hemorrhage or transfusion was 4.4 % (0.18–16.9 %). And, rate of incidental cystotomy was 3.1 % (0.4–15.8 %), and ureteral injury was 1.0 % (0.8–1.9 %) [21••].

The sacral promontory or presacral space are the most common sites of significant bleeding. Careful dissection and ensuring suture placement at the S1–S2 position decreases the risk of hemorrhage. If bleeding occurs during placement of the fixation suture, a figure of eight may be completed and tried. Persistent bleeding that does not respond to this maneuver should be managed with pressure, hemostatic clips or cautery, fibrin glue, or Gelfoam® (Pfizer, Kalamazoo, MI). The use of bone wax and thumbtacks should be reserved for severe bleeding that fails to stop with the above measures [42].

The best way to prevent an incidental cystotomy is careful dissection of the anterior vaginal wall with placement of vaginal dilator to provide distention. When there is difficulty identifying the edge of the bladder, retrograde filling of the bladder may help to delineate the bladder margin and facilitate dissection. In addition, the plane between the anterior vaginal wall and bladder should be relatively avascular; therefore, if bleeding is encountered during this dissection, it probably is because dissection is within the detrusor muscle or the vaginal muscularis. Care should also be taken to avoid exaggerated lateral dissection of the vagina. In this location, ureteral injury as well as bleeding is possible. Ureteral injury can include transection, ligation, or kinking causing obstruction. The right ureter is at risk for injury during the dissection of the promontory and opening of the posterior peritoneum. The ureter is generally easily identified as it courses anterior to the iliac vessels and can be traced into the pelvis. Knowing the course of the ureter will help decrease risk of injury. Cystoscopy may be performed to ensure patency of both ureters at the end of the case and to confirm no intravesical sutures from fixation of the graft; we often use either IV indigo carmine or fluorescence to assist in visualization of the ureteral jets. In the event of an incidental cystotomy, primary closure should be performed and the ASC may be carefully completed even if synthetic mesh is planned.

Mesh Extrusion Mesh extrusion is one of the more common and troublesome complications of ASC and most common when a synthetic mesh graft is used. In the CARE trial, the reported mesh or suture exposure rate was 6 % at 2 years [43]. In the CARE extension trial, the rate of suture or mesh exposure increased to approximately 10 % at 7 year follow-up [21••].

Table 2 Abdominal sacral colpopexy complications

		Open ASC	Robotic ASC
Wound	Infection, hematoma, superficial separation	4.6 % (0.4–19.8 %)	
	Fascial dehiscence	<0.01 %	
	Incision hernia	5 % (0.4 %–15 %)	<1 %
Bowel	Enterotomy/proctotomy	1.6 % (0.4 %–2.5 %)	
	SBO/ileus	3.6 % (1.1–9.3 %)	<1 %
	Reoperation for SBO	1.1 % (0.6–8.6 %)	
Urinary tract	Cystotomy	3.1 % (0.4 %–15.8 %)	2 %
	Ureteral injury	1.0 % (0.8–1.9 %)	<1 %
Bleeding or transfusion		4.4 % (0.18 %–16.9 %)	
Mesh extrusion		6–10 %	0–8 %

As further research examines the nuances of surgical outcomes, we are gaining a better understanding of factors that may play a role in extrusion, including patient factors, surgical technique, and type of mesh.

Patient Factors It is commonly believed that smoking status, diabetes, and estrogen status increase risk of mesh extrusion. Smoking has been shown to increase the risk of mesh extrusion; therefore, smoking cessation is recommended. Diabetes and estrogen status have not consistently shown to be associated with an increased risk of mesh extrusion [43, 44].

Surgical Technique A vaginal incision for mesh or suture placement increases mesh extrusion rates. Visco et al. reported on a retrospective review of sacral colpopexy versus sacral colpoperineopexy [45]. They noted that when an abdominal-vaginal approach was used for passage of either sutures or mesh through the vagina an unacceptably high rate of erosion was noted (16–40 %) compared to the abdominal only group (3.2–5.5 %). The reported literature since 2006 supports that concomitant total hysterectomy is a risk factor for mesh extrusion [43, 46–49]. If concomitant hysterectomy is planned, a subtotal hysterectomy is recommended.

Type of Mesh Numerous types of mesh have been used over the years, including Mersilene® (Ethicon, Somerville, NJ) from the 1970s through 1990s, Marlex® (Bard, Murray Hill, NJ) in the 1980s and 1990s, Gore-tex® (Gore Medical, Flagstaff, AZ) in the early 1990s, and more recently polypropylene. Iglesia et al. reviewed mesh outcomes and concluded that while there appears to be no superior mesh product in terms of subjective outcomes, there are objective differences in mesh qualities and extrusion rates [50]. The ideal mesh minimizes foreign body reaction, carries a low risk of infection, and no host rejection or extrusion. The current literature supports polypropylene (type I, macroporous and monofilament) as the best currently available synthetic product [43]. Cundiff et al. noted a higher extrusion rate of 19 % in those who received a ePTFE (Gore-tex) (type 2, solely microporous and multifilament) graft either alone or in combination with other grafts [43]. In a more recent review of robotic sacral colpopexy, a lower erosion rate was noted with a lightweight polypropylene (1 %) when compared with a standard polypropylene mesh (3.6 %) [51].

Osteomyelitis/Spondylodiscitis Osteomeylitis and spondylodiscitis are potential devastating complications associated with graft fixation to the sacrum. In 1997, Weidner et al. reported on two cases of sacral osteomyelitis following sacral colpopexy [52]. A literature search demonstrated a series of case reports or small series of osteomyelitis. In 2015, Api et al. presented a review of spondylodiscitis [53]. In this review, three mechanisms of discitis were hypothesized: (1) infection, (2) graft rejection with infection, and (3) graft rejection alone due to antibiotic failure or failure to identify microorganisms on culture. Both conditions can present at any time in the postoperative period and a high index of suspicion needs to be present in patients with low back complaints postoperatively. Recommendations to minimize the risks include aggressive treatment of any bacteriuria, use of perioperative antibiotics, and performance of a subtotal hysterectomy when needed and careful placement of the fixation sutures so as to avoid the L5-S1 disc space.

Conclusions

As with all surgical procedures, the best way to avoid complications is to actively work to prevent the complications from occurring. In 2012, the French College of Obstetrics and Gynecology published guidelines to decrease the risk of mesh complications [40]:

- Recommended graft material was polypropylene material (grade C)

- Avoid using porcine dermis, cadaveric fascia lata, and PTFE materials (grade B)
- Retroperitonealize the graft (expert opinion)
- Subtotal hysterectomy at the time of ASC (expert opinion)
- Non-absorbable mesh can still be placed at the time of bladder injury but should not be placed in the case of a rectal injury (expert opinion)

Compliance with Ethical Standards

Conflict of Interest Elizabeth B. Takacs declares no potential conflicts of interest.

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Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
•• Of major importance

1. Olsen AL, Smith VJ, Bergstrom JO, Colling JC, Clark AL. Epidemiology of surgically managed pelvic organ prolapse. Obstet Gynecol. 1997;89:501–6.
2. Smith FJ, Holman CD, Moorin RE, Tsokos N. Lifetime risk of undergoing surgery for pelvic organ prolapse. Obstet Gynecol. 2010;116:1096–100.
3. Wu JM, Vaughan CP, Goode PS, et al. Prevalence and trends of symptomatic pelvic floor disorders in U.S. women. Obstet Gynecol. 2014;123:141–8.
4. Skoczylas LC, Turner LC, Wang L, Winger DG, Shepherd JP. Changes in prolapse surgery trends relative to the FDA notifications regarding vaginal mesh. Int Urogynecol J. 2014;25:471–7.
5. Govier FE, Kobashi KC, Hsiao K. Use of synthetics and biomaterials in vaginal reconstructive surgery. In Raz S, Rodriguez LV (eds): Female Urology. Philadelphia: Saunders, 2008, chapter 59, pp. 609–23.
6. Nygaard IE, McCreery R, Brubaker L, et al. Abdominal sacrocolpopexy: a comprehensive review. Obstet Gynecol. 2004;104:805–23.
7. Arthure HG. Vault-suspension. Proc R Soc Med. 1949;42:388–90.
8. Lane FE. Repair of posthysterectomy vaginal vault prolapse. Obstet Gynecol. 1962;20:72–7.
9. O'Sullivan OE, Matthews CA, O'Reilly BA. Sacrocolpopexy: is there a consistent surgical technique? Int Urogynecol J. 2016;27:747–50.
10. Birnbaum SJ. Rational therapy for the prolapsed vagina. Am J Obstet Gynecol. 1973;115:411–9.
11. Sutton GP, Addison WA, Livengood 3rd CH, Hammond CB. Life-threatening hemorrhage complicating sacral colpopexy. Am J Obstet Gynecol. 1981;140:836–7.
12. Baessler K, Schuessler B. Abdominal sacrocolpopexy and the antatomy and function of the posterior compartment. Obstet Gynecol. 2001;97:678–84.
13. Snyder TE, Krantz KE. Abdominal-retroperitoneal sacral colpopexy for the correction of vaginal prolapse. Obstet Gynecol. 1991;77:944–9.
14. Addison WA, Timmons MC, Wall LL, Livengood 3rd CH. Failed abdominal sacral colpopexy: observations and recommendations. Obstet Gynecol. 1989;74:480–3.
15. Cosson M, Rajabally R, Bogaert E, Querleu D, Crépin G. Laparoscopic sacrocolpopexy, hysterectomy, and Burch colposuspension: feasibility and short-term complications of 77 procedures. JSLS. 2002;6:115–9.
16. Maeda A, Inoue M, Shino K, et al. Effects of solvent preservation with or without gamma irradiation on the material properties of canine tendon allografts. J Orthotop Res. 1993;11:181–9.
17. Haut RC, Powlison AC. Order of irradiation and lyophilization on the strength of patellar tendon allografts. Trans Orthop Res Soc. 1989;13:514.
18. FitzGerald MP, Edwards SR, Fenner D. Medium-term follow-up on use of freeze-dried, irradiated donor fascia for sacrocolpopexy and sling procedures. Int Urogynecol J Pelvic Floor Dysfunct. 2004;15:238–42.
19. Cervigni M, Natale F. The use of synthetics in the treatment of pelvic organ prolapse. Curr Opin Urol. 2001;11:429–35.
20.•• Brubaker L, Bump R, Jacquetin B, et al. Pelvic organ prolapse. In Abrams P, Cardozo L, Khoury S, Wein A (eds): Incontinence. 5th International Consultation on Incontinence, Paris, Februray 2012. Bristol, UK: ICUD-EAU, 2013. **Collaborations of 23 committees of the European Association of Urology and International Consultation on Incontinence on all areas of incontinence**.
21.•• Nygaard I, Brubaker L, Zyczynski HM, et al. Long-term outcomes following abdominal sacrocolpopexy for pelvic organ prolapse. JAMA. 2013;309:2016–24. **Comprehensive and review of long-term follow-ups of ASC with important clinical implications**.
22. Tate SB, Blackwell L, Lorenz DJ, Steptoe MM, Culligan PJ. Randomized trial of fascia lata and polypropylene mesh for abdominal sacrocolpopexy: 5-year follow-up. Int Urogynecol J. 2011;22:137–43.
23. Blaivas JG, Chaikin DC. Pubovaginal fascial sling for the treatment of all types of stress urinary incontinence: surgical technique and long-term outcome. Urol Clin North Am. 2011;38:7–15.
24. Culligan PJ, Blackwell L, Goldsmith LJ, Graham CA, Rogers A, Heit MH. A randomized controlled trial comparing fascia lata and synthetic mesh for sacral colpopexy. Obstet Gynecol. 2005;106:29–37.
25. Quiroz LH, Gutman RE, Shippey S, et al. Abdominal sacrocolpopexy: anatomic outcomes and complications with Pelvicol, autologous and synthetic graft materials. Am J Obstet Gynecol. 2008;198:557.e1–5.
26. Latini JM, Brown JA, Kreder KJ. Abdominal sacral colpopexy using autologous fascia lata. J Urol. 2004;171:1176–9.
27. Baessler K, Maher C. Pelvic organ prolapse surgery and bladder function. Int Urolgynecol J. 2013;24:1843–52.
28. Fitzgerald MP, Kulkarni N, Fenner D. Postoperative resolution of urinary retention in patient with advanced pelvic organ prolapse. Am J Obstet Gynecol. 2000;183:1361–4.
29. Stewart WF, Liberman JN, Sandler RS, et al. Epidemiology of constipation (EPOC) study in the United States: relationship of clinical subtypes to sociaodemographic features. Am J Gastroenterol. 1999;94:3530–40.
30. Weber AM, Walters MD, Ballard LA, Booher DL, Piedmonte MR. Posterior vaginal prolapse and bowel function. Am J Obstet Gynecol. 1998;179:1446–50.
31. Bradley CS, Brown MB, Cundiff GW, et al. Bowel symptoms in women planning surgery for pelvic organ prolapse. Am J Obstet Gynecol. 2006;195:1814–9.
32. Fox SD, Stanton SL. Vault prolapse and rectocele: assessment of repair using sacrocolpopexy with mesh interposition. Br J Obstet Gynecol. 2000;107:1371–5.

33. Grimes CL, Lukacz ES, Gantz MG, et al. What happens to the posterior compartment and bowel symptoms after sacralcolpopexy? Evaluation of 5-year outcomes from E-CARE. Female Pelvic Med Reconstr Surg. 2014;20:261–6.
34. Virtanen H, Hirvonen T, Mäkinen J, Killholma P. Outcome of thirty patients who underwent repair of posthysterectomy prolapse of the vaginal vault with abdominal sacral colpopexy. Am Coll Surg. 1994;178:283–7.
35. Sarlos D, Kots L, Ryu G, Schaer G. Long-term follow-up of laparoscopic sacrocolpopexy. Int Urogynecol J. 2014;25:1207–12.
36. Liang S, Zhu L, Song X, Xu T, Sun Z, Lang J. Long-term outcomes of modified laparoscopic sacrocolpopexy for advanced pelvic organ prolapse: a 3-year prospective study. Menopause. 2016. doi:10.1097/GME.0000000000000670.
37. Nygaard I, Barber MD, Burgio KL, et al. Prevalence of symptomatic pelvic floor disorders in US women. JAMA. 2008;300:1311–6.
38. Robinson BL, Parnell BA, Sandbulte JT, Geller EJ, Connolly A, Matthews CA. Robotic versus vaginal urogynecologic surgery: a retrospective cohort study of perioperative complications in elderly women. Female Pelvic Med Reconst Surg. 2013;19:230–7.
39. Turner LC, Kantartzis K, Lowder JL, Shepherd JP. The effect of age on complications in women undergoing minimally invasive sacral colpopexy. Int Urogynecol J. 2014;25:1251–6.
40. Deffieux X, Letouzey V, Savary D, et al. Prevention of complications related to the use of prosthetic meshes in prolapse surgery: guidelines for clinical practice. Eur J Obstet Gynecol Reprod Biol. 2012;165:170–80.
41. Whitehead WE, Bradley CS, Brown MB, et al. Gastrointestinal complications following abdominal sacrocolpopexy for advanced pelvic organ prolapse. Am J Obstet Gynecol. 2007;197:78.e1–7.
42. Chen CCG, Paraiso MFR. Open abdominal sacral colpopexy. In In Raz S, Rodriguez LV (eds): Female urology. Philadelphia: Saunders, 2008; chapter 73, pp. 724–8.
43. Cundiff GW, Varner E, Visco AG, et al. Risk factors for mesh/suture erosion following sacral colpopexy. Am J Obstet Gynecol. 2008;199:688.e1–5.
44. Sun Z, Zhu L, Xu T, Shi X, Lang J. Effects of preoperative vaginal estrogen therapy for the incidence of mesh complication after pelvic organ prolapse surgery in postmenopausal women: is it helpful or a myth? a 1-year randomized controlled trial. Menopause. 2016. doi:10.1097/GME.0000000000000614.
45. Visco AG, Weidner AC, Barber MD, et al. Vaginal mesh erosion after abdominal sacral colpopexy. Am J Obstet Gynecol. 2001;184:297–302.
46. Bensinger G, Lind L, Lesser M, Guess M, Winkler HA. Abdominal sacral suspensions: analysis of complications using permanent mesh. Am J Obstet Gynecol. 2005;193:2094–8.
47. Wu JM, Wells EC, Hundley AF, Connolly A, Williams KS, Visco AG. Mesh erosion in abdominal sacral colpopexy with and without concomitant hysterectomy. Am J Obstet Gynecol. 2006;194:1418–22.
48. Akyol A, Akca A, Ulker V, et al. Additional surgical risk factors and patient characteristic for mesh erosion after abdominal sacrocolpopexy. J Obstet Gynecol Res. 2014;40:1368–74.
49. Ehsani N, Ghafar MA, Antosh DD, et al. Risk factors for mesh extrusion after pelvic organ prolapse surgery: a case-control study. Female Pelvic Med Reconstr Surg. 2012;18:357–61.
50. Iglesia. The use of mesh in gynecologic surgery. Int Urogynecol. 1997;8:105–15.
51. Serati M, Bogani G, Sorice P, et al. Robot-assisted sacrocolpopexy for pelvic organ prolapse: a systematic review and meta-analysis of comparative studies. Eur Urol. 2014;66:303–18.
52. Weidner AC, Cundiff GW, Harris RL, Addison WA. Sacral osteomyelitis: an unusual complication of abdominal sacral colpopexy. Obstet Gynecol. 1997;90:689–91.
53. Api M, Kayatas S, Boza A. Spondylodiscitis following sacral colpopexy procedure: is it an infection or graft rejection? Eur J Obstet Gynecol Reprod Biol. 2015;194:43–8.