

# Functional and anatomic comparison of 2 versus 3 suture placement for uterosacral ligament suspension: a cadaver study

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**OBJECTIVE:** The objective of the study was to compare the vaginal apex pullout distance using 2 vs 3 suspension sutures during transvaginal uterosacral ligament suspension (USLS) and to describe relationships to ipsilateral ureter and nerve structures.

**STUDY DESIGN:** Eight fresh-frozen female cadavers were studied. After hysterectomy, a transvaginal USLS was performed with placement of 3 suspension sutures per side. The 2 most distal sutures on each ligament were tied. A screw-and-washer attachment was secured in the middle of the vaginal cuff and tied to a pulley system with surgical filament. Distal traction was applied with sequentially increasing weight loads. Distal migration of the vaginal apex from baseline with each weight load was recorded. The most proximal suspension suture was tied and the procedure repeated. Horizontal distances between each USLS suture to the ipsilateral ureter were measured. Three discrete points were marked on sacral nerves S1-S3, and the shortest distance between each point and each ipsilateral USLS suture was

measured. Descriptive statistics and repeated-measures analysis of variance were performed.

**RESULTS:** Application of each load resulted in greater migration distances for the 2 suture configuration when compared with 3 sutures ( $P < .05$ ). Differences were greatest for the 3 kg load (mean  $\pm$  SEM,  $2.0 \pm 0.2$  vs  $1.5 \pm 0.1$  cm, respectively). Distances to ipsilateral ureter between the 2 most cranial sutures were comparable ( $P > .05$ ). The most cranial USLS suture was closest to sacral nerves S1-S3.

**CONCLUSION:** In this cadaveric study, 3 USLS sutures provided more support to the vaginal apex than 2 sutures, although the absolute difference may not be clinically significant. The most cranial suture had the smallest distances to sacral nerves S1-S3.

**Key words:** uterosacral ligament suspension, vaginal prolapse repair

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The uterosacral ligament suspension (USLS) is a procedure performed for the correction of prolapse of the vaginal apex. The procedure consists of fixing the vaginal apex to the uterosacral ligaments bilaterally at or above the level of the ischial spines using interrupted sutures.<sup>1</sup> The procedure is safe overall and

associated with favorable outcomes.<sup>1,2</sup> However, possible complications during suspension suture placement include injury to structures present in close proximity to the uterosacral ligaments, including the ureters and sacral nerves.<sup>3,4</sup>

Ureteral involvement has been reported to be up to 11%,<sup>1</sup> whereas the reported sacral neuropathy incidence is up to 6.9%.<sup>5</sup> Variations in procedural technique exist, including approach (ie, transvaginal, abdominal, laparoscopic), type of suture material (ie, permanent versus absorbable), and number of suspension sutures placed per ligament. There is scant information in the literature regarding procedure efficacy and safety related to the number of suspension sutures used.<sup>1,2</sup> A higher number of sutures may provide more support to the vaginal cuff, whereas a lower number of suspension sutures may be associated with a lower risk of ureteral or sacral nerve injury.

The objective of our study was to compare vaginal apex strength (as a measure of procedure efficacy) using 2 vs

3 suspension sutures during transvaginal USLS and to describe the anatomic relationships to the ureter and nerve structures near the suspension sutures.

## MATERIALS AND METHODS

Eight fresh female cadavers were obtained from the Willed Body Program at the University of Texas Southwestern Medical Center in Dallas. Exemption from institutional review board approval was obtained in accordance with the Code of Federal Regulations, Title 45, Part 36, subpart 101 (b) (1).

The age, race, height, weight, and cause of death were recorded. For each cadaver, after hysterectomy, a transvaginal USLS was performed by passing 3 sutures (1 0-polyglactin 910 followed by 2 2-0 polyester sutures) through each uterosacral ligament (USL), starting at the level of the ischial spine and moving cranially along the ligament at 1 cm intervals similar to that described by Shull et al.<sup>1</sup>

The sutures were passed through the anterior and posterior vaginal cuff,

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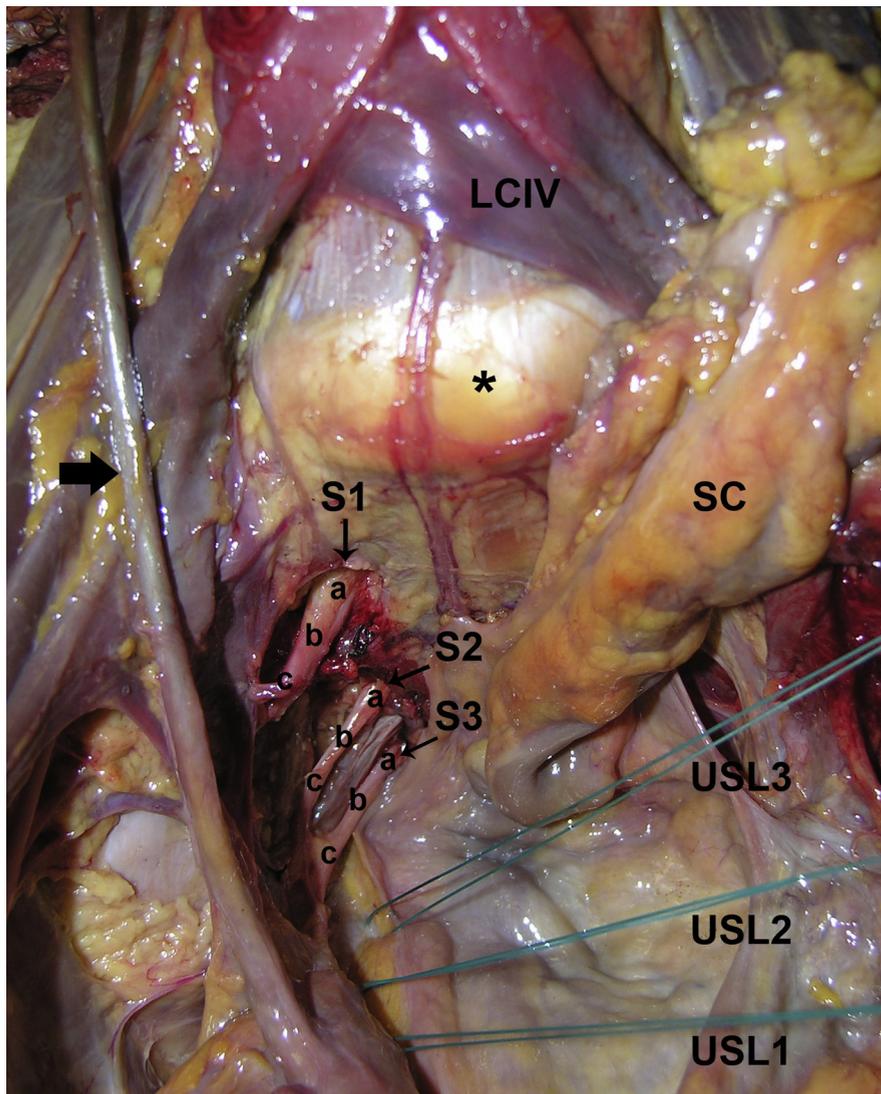
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**FIGURE 1**  
**Relationships of ipsilateral sacral nerves and ureter to uterosacral ligament suspension sutures**



Sacral nerves S1, S2, and S3 with 3 discrete points: a (sacral foramen), b (1 cm distal to foramen), and c (2 cm distal to foramen). The *thick arrow* indicates right ureter, and the *asterisk* indicates L5-S1 disc.

LCIV, left common iliac vein; SC, sigmoid colon; USL, uterosacral ligament suspension suture.

Montoya. Two vs 3 suture comparison in transvaginal uterosacral ligament suspension. *Am J Obstet Gynecol* 2013.

respectively, distributed evenly along the entire width of the cuff. To study the differences between using 2 vs 3 sutures bilaterally in each cadaver, the 2 more caudal sutures (suture 2 [middle] and suture 1 [most caudal]) on each uterosacral ligament were tied first, leaving the most cranial suture (suture 3) on each side untied and held individually with hemostats for subsequent tying and testing. All sutures were placed by the primary author

(T.I.M.), who is right handed, with placement visualized and in agreement by the senior author (C.Y.W.).

After the cuff was closed, a 9/16 inch (14 mm) diameter metal metric fender washer (Servalite, East Moline, IL) was placed above the vaginal cuff. A 1/8 inch diameter bolt (Servalite) was threaded through the washer and passed through the center of the cuff and out the vagina in which it was affixed to a number 7

waxed polyester surgical filament (catalog no. 761403; Dodge, Cambridge, MA). This same filament has been used in previous studies and resists forces greater than 38 pounds per square inch without deformation.<sup>6</sup> The surgical filament was oriented parallel to the table's surface using a carpenter's level and passed over a 3 inch fixed single pulley (National, Sterling, IL) attached at the table's end by 2 2½ inch, 3-way edging clamps (Pony, Chicago, IL) as described previously.<sup>6</sup> Successive 500 g slotted weights (Rice Lake Weighing Systems, Rice Lake, WI) were added to a weight hanger to provide increasing loads of 0.5, 1, 1.5, 2, 2.5, and 3 kg against the vaginal cuff.

The measurements of the distance traversed by the vaginal apex and supported by the 2 suture configuration from a baseline position after application of each weight load were recorded. On the same cadaver, the tagged remaining most cranial uterosacral ligament sutures on each side (suture 3) were subsequently tied, and the distances traversed with each weight load were measured to evaluate the effect of 3 sutures placed bilaterally on the support of the vaginal apex.

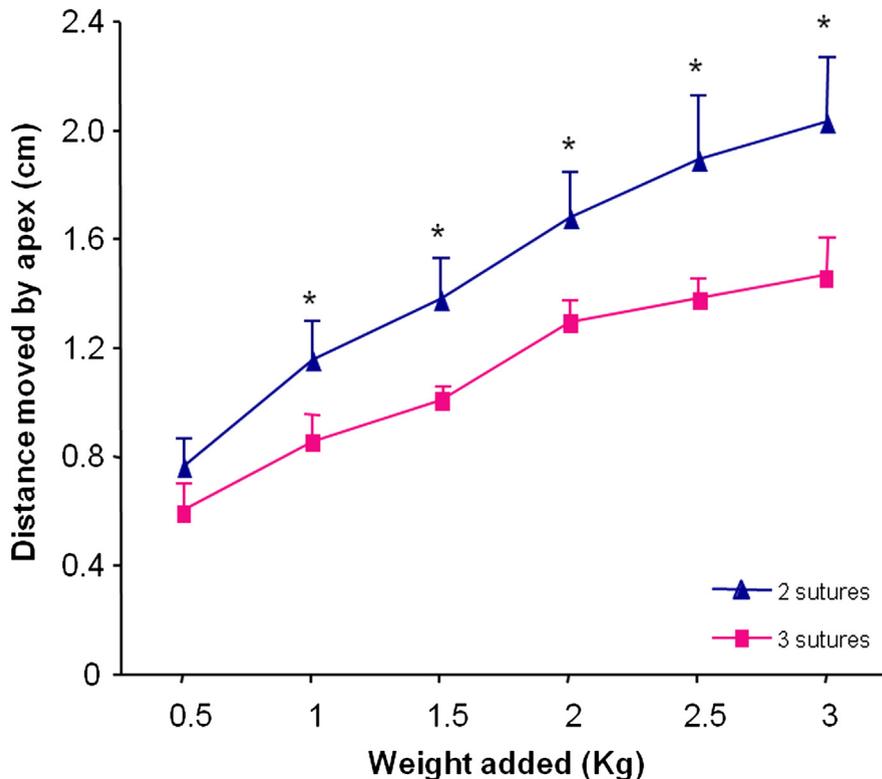
The site of attachment of each suspension suture on the uterosacral ligaments was marked on each side after application of the suspension sutures. Prior to tying the sutures and performing weight load testing, measurements were taken from each suture on the uterosacral ligaments to the following structures: smallest horizontal distance to ipsilateral ureter; smallest distance to ipsilateral sacral nerves S1, S2, and S3 at 3 discrete points along each nerve: sacral foramen (point a), 1 cm distal to sacral foramen (point b), and 2 cm distal to sacral foramen (point c) (Figure 1). Data were analyzed using repeated measures analysis of variance using SAS version 9.2 (SAS Institute, Cary, NC).

## RESULTS

The mean ± SEM age of the cadavers was 88 ± 3 years (range, 77–103), and the mean body mass index (BMI) was 22 ± 2 kg/m<sup>2</sup> (range, 14–29). All 8 were white, and the most common cause of death

FIGURE 2

## Distance traversed by the vaginal apex with application of weight loads



Mean distance ( $\pm$ SEM) traversed by the vaginal apex (centimeters) with application of successive 500 g slotted weights to provide increasing loads of 0.5, 1, 1.5, 2, 2.5, and 3 kg against the vaginal cuff. Blue triangles indicate 2 sutures, and pink squares indicate 3 sutures. Asterisk indicates  $P < .03$ , 2 vs 3 sutures.

Montoya. Two vs 3 suture comparison in transvaginal uterosacral ligament suspension. *Am J Obstet Gynecol* 2013.

was from cardiopulmonary causes (4 of 8; 50%). The mean total vaginal length was  $8.6 \pm 0.2$  cm.

### Distance moved by apex

The distal migration of the vaginal cuff for each weight load with 2 and 3 sutures per side is illustrated in Figure 2. With the exception of the 0.5 kg load, application of each load in this study resulted in significantly greater migration distances for the 2-suture configuration when compared with 3 sutures. The differences between the 2 were greatest for the 3 kg load, with the 2-suture configuration moving a mean ( $\pm$ SEM) distance of  $2.0 \pm 0.2$  cm compared with a distance of  $1.5 \pm 0.1$  cm for 3 sutures ( $P = .030$ ). For one of the specimens, the apex descended a distance as large as 2.7 cm for the 2-suture configuration.

### Location with respect to ureter

Distances from each of the 3 uterosacral ligament sutures to the ipsilateral ureter were not significantly different between the left and right (Figure 3). Of the 3 levels of sutures (cranial to caudal), the most caudally placed sutures on each uterosacral ligament were located significantly closer to the ureters than either of the 2 more cranially placed sutures, with a mean distance of  $1.0 \pm 0.2$  cm on the right and  $1.4 \pm 0.3$  cm on the left. There was no significant difference in proximity to the ureters between the 2 most cranial sutures (ie, between suture 3 vs suture 2).

### Sacral nerve anatomy

The proximity of each uterosacral ligament suture to 3 discrete points along sacral nerves S1, S2, and S3 (at the nerve

root as they exited the sacral foramina [point a], and at 1 cm [point b] and 2 cm [point c] from the foramina along the nerve) was examined (Table).

All 3 discrete points of the S3 nerve were closer than those of either the S2 or S1 nerves to each individual USLS suture ( $P < .05$ ). Conversely, the S1 nerve was the farthest away from each suture. When comparing the differences in the USLS sutures (cranial to caudal), the most caudally placed suture (suture 1) was the farthest from the sacral nerves and their discrete points, followed by the middle suture (suture 2), with the most cranial suture (suture 3) being the closest to the sacral nerves. There was no significant difference in distances between sacral nerve structures and the sutures placed in either the right or left uterosacral ligaments. No nerve entrapment was seen in any of the dissections.

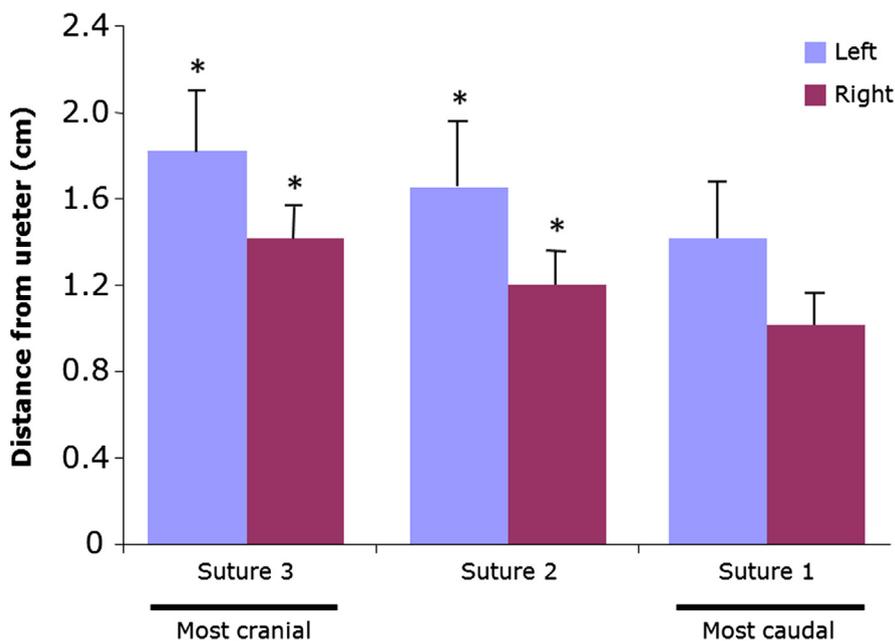
### COMMENT

In this anatomic cadaver study comparing 2 versus 3 suspension sutures for vaginal apex support in USLS, the use of 3 sutures per side appears to provide greater vaginal apical support as demonstrated by lesser distal migration of the vaginal cuff with applied loads greater than 0.5 kg. Although statistically significant, the observed differences in distal migration of the cuff, however, were small and may not be clinically significant in the majority of women. The greatest differences in cuff migration were observed with the highest weight loads. One may speculate that, in patients with conditions associated with chronic or sustained increases in abdominal pressure, the placement of 3 sutures may be considered for potential for better longer-term support.

With regard to nearby anatomic structures, the nearest relationship present on either side was that of the ureter to the ipsilateral, most caudal USL suture (usually placed at the level of the ischial spine). This was not entirely unexpected because the anatomic course of the ureter starts more lateral on the sidewall and becomes more medial as it descends deeper in the pelvis.

Based on this finding, when ureteral ligation or kinking is encountered during

**FIGURE 3**  
Distance ( $\pm$ SEM) of suspension sutures to ipsilateral ureter



#### Position of uterosacral ligament suture

Red bars indicate right ureter, and purple bars indicate left ureter. Asterisk indicates  $P < .05$ , compared with the most caudal suture (suture 1).

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a transvaginal USLS procedure, the most caudal suture should be removed first. Distances to the ipsilateral ureter between

the 2 most cranial USL sutures were similar, suggesting that, starting caudally and moving cranially along the ligament,

the addition of a third USL suture may not increase the risk for ureteral compromise during suture placement.

The relationship of the sacral nerves to the sutures along the uterosacral ligament was closest to the S3 nerve, with the closest distances observed between this nerve and the most cranial USL suture. Neural injury or entrapment of S3 by USL suspension sutures has been reported in previous anatomic studies.<sup>7,8</sup> However, the statistically significant difference in distances, when compared with the second USL suture, was small, ranging from 4 to 8 mm. When considering this difference in the context of a 2.1 cm average absolute distance between this suture and S3, this may not translate clinically to additional risk for nerve injury with the placement of the third USL suture.

Consistent with these findings are results from a previous study from our institution evaluating neuropathy symptoms following transvaginal USLS, in which there was no difference in the incidence of neuropathy between different numbers of suspension sutures used.<sup>5</sup>

There are several strengths and limitations associated with this anatomical study. Similar to prior studies utilizing this type of pulley system,<sup>6</sup> the application of weight loads by pulling distally on the vaginal cuff is only a model for acute intraabdominal pressures applied onto

**TABLE**

#### Mean distance ( $\pm$ SEM) from each respective USLS suture to each ipsilateral sacral nerve (S1, S2, S3) and 3 discrete points along each nerve

Sacral nerve	Point	Suture 3 (cranial)		Suture 2		Suture 1 (caudal)	
		Right	Left	Right	Left	Right	Left
S1	a	4.1 $\pm$ 0.6	3.7 $\pm$ 0.5	4.7 $\pm$ 0.7 <sup>a</sup>	4.4 $\pm$ 0.6 <sup>a</sup>	5.1 $\pm$ 0.6 <sup>b</sup>	4.8 $\pm$ 0.6 <sup>b</sup>
	b	3.6 $\pm$ 0.5	3.7 $\pm$ 0.5	4.1 $\pm$ 0.5 <sup>a</sup>	4.2 $\pm$ 0.6 <sup>a</sup>	4.6 $\pm$ 0.5 <sup>b</sup>	4.6 $\pm$ 0.6 <sup>b</sup>
	c	3.6 $\pm$ 0.5	3.5 $\pm$ 0.6	4.1 $\pm$ 0.6 <sup>a</sup>	3.8 $\pm$ 0.7 <sup>a</sup>	4.5 $\pm$ 0.5 <sup>b</sup>	4.1 $\pm$ 0.6 <sup>b</sup>
S2	a	3.2 $\pm$ 0.6	3.4 $\pm$ 0.4	3.7 $\pm$ 0.6 <sup>a</sup>	4.1 $\pm$ 0.5 <sup>a</sup>	3.8 $\pm$ 0.5 <sup>b</sup>	4.2 $\pm$ 0.6 <sup>b</sup>
	b	2.9 $\pm$ 0.5	3.2 $\pm$ 0.5	3.3 $\pm$ 0.5 <sup>a</sup>	3.7 $\pm$ 0.5 <sup>a</sup>	3.6 $\pm$ 0.4 <sup>b</sup>	3.9 $\pm$ 0.6 <sup>b</sup>
	c	2.6 $\pm$ 0.3	2.9 $\pm$ 0.6	3.1 $\pm$ 0.4 <sup>a</sup>	3.5 $\pm$ 0.5 <sup>a</sup>	3.4 $\pm$ 0.3 <sup>b</sup>	3.8 $\pm$ 0.6 <sup>b</sup>
S3	a	2.1 $\pm$ 0.2	3.0 $\pm$ 0.3	2.9 $\pm$ 0.3 <sup>a</sup>	3.4 $\pm$ 0.4 <sup>a</sup>	3.3 $\pm$ 0.2 <sup>b</sup>	3.7 $\pm$ 0.4 <sup>b</sup>
	b	2.4 $\pm$ 0.4	2.7 $\pm$ 0.3	3.1 $\pm$ 0.3 <sup>a</sup>	3.3 $\pm$ 0.4 <sup>a</sup>	3.6 $\pm$ 0.3 <sup>b</sup>	3.8 $\pm$ 0.4 <sup>b</sup>
	c	2.4 $\pm$ 0.3	2.6 $\pm$ 0.3	3.0 $\pm$ 0.3 <sup>a</sup>	3.0 $\pm$ 0.3 <sup>a</sup>	3.5 $\pm$ 0.2 <sup>b</sup>	3.5 $\pm$ 0.4 <sup>b</sup>

<sup>a</sup>  $P < .05$ , compared with distances from the most cranial suture (suture 3); <sup>b</sup>  $P \leq .01$ , compared with distances from the most cranial suture (suture 3).

Montoya. Two vs 3 suture comparison in transvaginal uterosacral ligament suspension. *Am J Obstet Gynecol* 2013.

the pelvic floor in vivo. Each cadaver was used as its own control in an attempt to minimize the effect of confounding variables inherent in cadaveric studies.

One may argue that by utilizing the same specimen for testing 2 sequential weight loads, with a different number of suspension sutures for each, the tissues may weaken or be compromised with initial testing and result in less support with subsequent testing. However, the converse was observed with stronger support seen with the second application of weights utilizing 3 sutures per side.

It is noted that the BMI of the cadavers were uniformly low, the effect of which is unpredictable. Although having a cadaver specimen with a low BMI may allow better visualization of pelvic anatomy, one with a large BMI may potentially provide additional padding and distance from other anatomic structures. We acknowledge that the low BMI of the specimens may limit the ability to generalize our results to other study populations and is beyond the scope of this study.

Other limitations associated with the use of cadaveric specimens include lack of muscular tone and deterioration of tissue since time of death. We tried to limit these variants by utilizing fresh, unembalmed specimens with tissue

dissections performed soon after time of death. Finally, we are unable to make conclusions regarding long-term effects of using 2 or 3 USL suspension sutures using this model.

Taken together, the findings from this study suggest that using 3 USLS sutures per side is associated with stronger vaginal apical support than using only 2 sutures. Although the addition of a third, most cranial USL suspension suture does not seem to increase risk for ureteral injury, it is associated with a smaller distance to the sacral nerve structures, particularly S3. From our study, it is unclear whether this small but statistically significant distance translates to additional risk for sacral nerve injury, given that there is still an absolute distance of 2 cm away from the suture.

Future studies are needed to assess the long-term efficacy associated with different numbers of USL suspension sutures. Although the study findings support the use of 3 USL suspension sutures per side, the pelvic surgeon should continue to rely on personal comfort level, judgment, and technical expertise, as well as knowledge of pelvic anatomy, when deciding on the number of suspension sutures placed during transvaginal USLS. ■

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