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ORIGINAL ARTICLE

Ultrasound appearances after mesh implantation—evidence of mesh contraction or folding?

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Abstract
Introduction and hypothesis Polypropylene meshes are frequently used in abdominal and vaginal reconstructive surgery. Recently, several authors have claimed that mesh-associated complications may be linked to mesh shrinkage. We have performed a prospective study with postoperative follow-up by ultrasound examination at two time points after Prolift anterior implantation to assess changes in the ultrasound appearance of mesh implants over time.
Methods We assessed 36 patients who had undergone mesh implantation with Prolift anterior™ mesh for the correction of symptomatic anterior vaginal wall prolapse. During the surgery, we measured the actual midline length of the mesh (initial length). On the fourth postoperative day, we performed a vaginal ultrasound examination (US) to measure mesh length in the midsagittal plane. A second US was performed 3–5 months after surgery to repeat this measurement.
Results There was a significant difference in mesh length determined before and 4 days after surgery (90.3 vs. 57.1 mm, P=<0.0001) indicating intraoperative folding. On comparing early and late postoperative ultrasound measurements, there was a reduction in length from 57.1 to 48.3 mm (P<0.0001), indicating possible shrinkage or retraction.
Conclusions Intraoperative folding seems to be responsible for a large part of the difference between preoperative (in vitro) and postoperative (US) measurements of mesh dimensions, suggesting that surgical techniques may require adjustment.

Keywords Prolift anterior · Mesh shrinking · Mesh retraction · Vaginal ultrasound · Vaginal surgery

Abbreviations

POP-Q	Pelvic organ prolapse quantification system
US	Ultrasound
ICC	Intraclass correlation
CT	Computer tomography
MR	Magnetic resonance

Introduction

Polypropylene meshes are frequently used in abdominal and vaginal reconstructive surgery. Its use in vaginal surgery is in the process of becoming routine, but we are still lacking good quality studies [1]. It is often assumed that mesh contraction or retraction/shrinkage is a possible cause of complications such as mesh erosion [2–4].

We know from animal studies that polypropylene mesh can cause a strong inflammatory reaction that is associated with retraction or shrinkage of the area occupied with mesh. The majority of published studies on mesh retraction were performed on animal abdominal wall [5]. Shrinking of macroporous polypropylene mesh in such animal models is described at around 16% for diameters or 28% for mesh area. The degree of shrinkage seems to depend on type of mesh, pore size, and on the presence of wound infection

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[5–8]. According to those animal studies, the dimensions of macroporous polypropylene mesh reach stability after 3 months [5, 9], although, for obvious reasons, long-term studies are lacking. To date (April 2010), there is no published data confirming mesh shrinkage or retraction in humans.

There have been several attempts at describing retraction of anterior vaginal wall mesh after implantation using ultrasound. Tunn et al. used introital ultrasound to study mesh dimensions and reported a reduction of as much as 60% compared to preimplantation length [10]. Velemir et al. showed an association between clinical prolapse recurrence and the degree of mesh retraction 1 year after mesh implantation. Both these studies used only one postoperative time point, comparing these ultrasound measurements with preimplantation mesh dimensions; however, there are at least two mechanisms that could explain shortening of the mesh after implantation.

Firstly, insufficient spreading of the mesh at the time of implantation or folding at or shortly after the surgery may cause an apparent reduction in dimensions. This effect would be independent of the mesh type and is determined mainly by dissection and insertion, i.e., surgical technique. Secondly, inflammatory processes could cause a reduction in diameters due to collagen deposition and possibly chemical alteration or degradation of the mesh material. To distinguish those two mechanisms, one would need at least two time points for ultrasound measurements. To this purpose, we undertook a prospective study with postoperative follow-up by vaginal ultrasound at two time points after Prolift anterior implantation.

Materials and methods

For a prospective observational study, we enrolled 36 patients who underwent a Prolift anterior procedure (Prolift Anterior™, Gynecare, Ethicon, Sommerville, NJ, USA) for symptomatic prolapse of the anterior vaginal wall [stage 2 or higher on pelvic organ prolapse quantification system (POP-Q)].

All patients underwent a preoperative clinical (POP-Q) and ultrasound examination with GE Voluson 730 Expert system (GE Medical Systems, Zipf, Austria) equipped with 8–4 MHz curved array volume transducer and 9–5 MHz vaginal volume transducer with an acquisition angle of 146°×120°. Ultrasound is the method of choice for imaging polypropylene mesh implants [11, 12] since these implants are radiolucent and impossible to image using plain X-ray, CT, or MR.

The Prolift procedure was performed according to the original technique [13]. At the time of insertion, the original mesh length was measured with the ruler before its placement. This time point was defined as time point 0, and the mesh length at this time is the "initial length." The mesh was fixed in position with Vicryl Rapid® (Ethicon, Sommerville, NJ, USA) to prevent peri and early postoperative slipping (see Fig. 1).

Transvaginal ultrasound was performed on the fourth day after surgery (time point 1, "early US length") and at 3–5 months after surgery to measure the mesh length in the midsagittal plane (time point 2, "late US length"). The ultrasound operator (KS) was blinded against all earlier measurements. After introducing the vaginal probe into the vagina, the proximal and distal ends of the mesh were localized in the midsagittal plane, and the mesh was traced and measured. A two-screen mode was used to view those cases where the entire mesh length could not be accommodated on one screen. The viewing needs never exceeded two screens. Then, the distances from the proximal and the distal ends of the mesh to the designated corresponding landmark—either the urethrovesical junction or the ureteral ridge in case of need for distal corresponding point visible on both screens—were measured and summated (see Fig. 2). We had to used the urinary bladder wall landmarks only due to lack of unmistakable points on the mesh. Additionally, a 4D volume-rendered cine loop of the entire mesh length was stored.

All measurements were taken three times—once at the time of examination and twice from saved 4D volumes using the proprietary software GE Kretz 4D View v. 7.0 (GE Medical Systems). We used the mean value of all three measurements for further analysis and we performed intra-observer reliability correlation (Table 1). The vaginal approach was chosen to approximate the transducer as

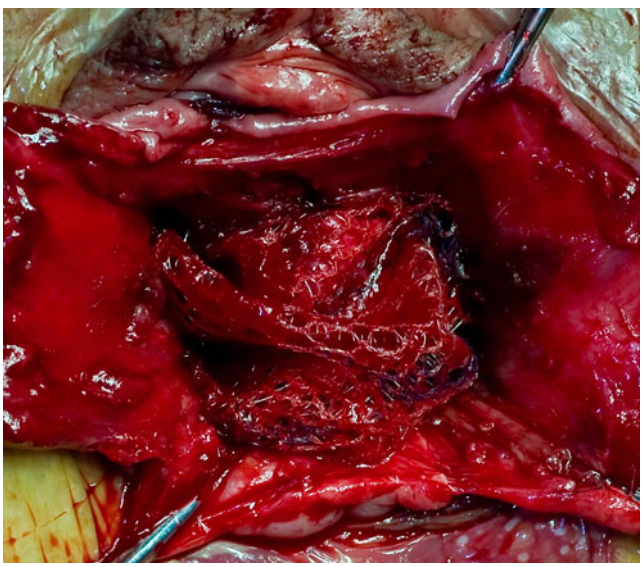

Fig. 1 Prolift anterior mesh folds—at site—before closing the vaginal skin and stretching of the mesh

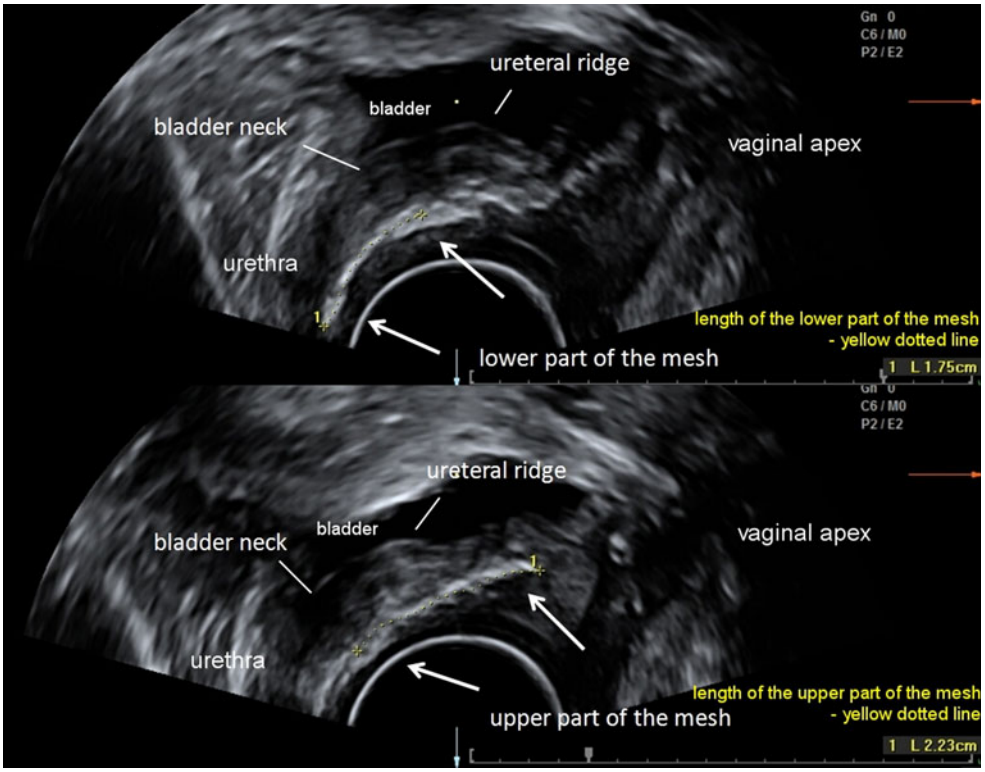

Fig. 2 Vaginal ultrasound mesh length measurement in two-screen mode

closely to the mesh for better visualization and to allow complete unfolding of the vaginal skin. The visualization on vaginal ultrasound seemed clearer compared to introital imaging. This method was evaluated in our pilot series with different mesh sizes [14].

To check for the consistency of measurements an interobserver reliability series for each value was performed on 30 patients by AM from saved volumes with the results given in Table 1.

The typical measurement error is 3.6% in late US measurements and 7.7% for the early US scan (see Table 2).

All data were analyzed using the software "statistical environment R," version 2.9.1. Continuous data were summarized as mean with standard deviation or as median and interquartile range (IQR; for comparisons of different measurements we used the paired *t* test. The reliability was assessed via intraclass correlation coefficient computed on the basis of analysis of variance model (library IRR). All tests were performed at 5% level of significance.

This study was approved by the local ethics committee and all participated patients gave written informed consent.

Table 1 Reliability

	ICC	CI		*P* value
Intraobserver				
Early US length	0.90	0.76	0.95	<0.0001
Late US length	0.97	0.94	0.98	<0.0001
Interobserver				
Early US length	0.74	0.51	0.86	<0.0001
Late US length	0.82	0.63	0.91	<0.0001

ICC intraclass correlation; *CI* confidence interval

Results

We included 36 patients with Prolift anterior with a mean age of 60.4 years (SD, 10.6); mean height of 163.3 cm (SD, 5.9); mean weight of 76.2 kg (SD, 11.0); mean body mass index of 28.6 (SD, 3.8); and parity of 2.0 (QR, 1.0). Six patients with an uneventful postoperative course were not seen by KS for the early US assessment, and two of them missed the late US assessment. The initial length of the Prolift anterior group was measured at 90 mm (range, 90–100 mm). The first ultrasound was performed on the fourth postoperative day in all patients, the second ultrasound 119 days after the procedure (median, 119 days; IQR, 94–139 days).

On comparing the intraoperative mesh length with the ultrasound measurement obtained on the fourth postoperative day (n=30), there was a marked reduction in midsagittal

Table 2 Measurement errors

Measurement errors	Typical error (mm)	Typical error (%)
Early US length	3.9	7.7
Late US length	1.9	3.6

mesh length 90.3 mm (SD, 1.8) vs. 57.1 mm (SD, 10.0), $P<0.001$ (38% initial length reduction). When early and late ultrasound measurements were compared ($n=30$, time point 1 and 2), we observed a further reduction of about 15% in the midsagittal dimensions [57.1 mm (SD, 10.0) vs. 48.3 mm (SD, 10.2), $P<0.001$] (Table 3).

Discussion

Ultrasound imaging has been widely used in the follow-up of tension-free vaginal tapes and has yielded detailed information on the position and tightness of the tape [11, 12]. Ultrasound is the method of choice for imaging such implants as macroporous polypropylene meshes are highly echogenic and cannot be imaged with X-ray, CT, or MR [15]. It is therefore only plausible to use ultrasound imaging for follow-up after mesh implantation to gain information about placement and extent of the mesh and, ultimately, to correlate such findings with clinical success and failure.

In this paper, we present the first clinical imaging study applying two time points to allow assessment of changes in mesh dimensions occurring within the first months after implantation of macroporous polypropylene mesh. The degree of shrinkage observed by us (approximately 15%) agrees with data from experimental animal studies using a similar type of mesh, where shrinkage of between 15% and 28% of the original area was described [5, 7, 16].

It is assumed that macroporous polypropylene mesh should achieve biological stability after about 3 months, once the healing process is complete [5, 9]; however, Letuzey et al. have recently presented long-term ultrasound data suggesting a linear decrease in mesh dimensions, implying ongoing contraction/retraction of mesh. Contrary to our study, however, Letouzey et al. used only a single time point. In view of the marked effect of surgical technique on mesh dimensions observed in our study, one wonders whether the marked difference between implantations performed over a period of 9 years may rather be due to changes in surgical technique.

Table 3 Mesh lengths in different time points

	Prolift		
	Number	Mean (SD)	95% CI for mean
Time point 0: initial length (mm)	36	90.3 (1.8)	(89.7; 91.0)
Time point 1: early US length (mm)	30	57.1 (10.0)	(53.6; 60.7)
Time point 2: late US length (mm)	34	48.3 (10.2)	(44.7; 52.0)

Tunn et al. used introital ultrasound to compare preimplantation mesh length with ultrasound measurements of mesh length after 6 weeks and showed a reduction in length of about 60% [10]. This corresponds with the 12% of length lost when one compares preimplantation length with measurements obtained at 3–5 months, and it is clear that most of this loss in length is due to intraoperative events (i.e., the surgeon) rather than postoperative processes (i.e., the patient).

Our data does not allow any conclusions as to whether intraoperative folding or postoperative mesh shrinkage is of clinical significance. Velemir et al. associated a higher degree of retraction with recurrence of prolapse [4]. It seems conceivable that a greater degree of intraoperative folding, i.e., insufficient spreading of the mesh, would result in a lesser degree of support of the vaginal wall, potentially leading to prolapse recurrence; however, given the much smaller degree or numerical change, this seems less likely for postoperative retraction or shrinkage, if such exists.

Based on the assumption of substantial mesh retraction or shrinkage over time, Feiner et al. conclude that there is a need for newer graft materials with diminished shrinkage properties [2]. Our data does not support this conclusion, and our clinical experience does not support the assumption of continuous shrinking. We have no prospective longitudinal data to assess symptoms over time; however, our data clearly suggests that the main means of improving mesh appearance and dimensions should be a change in surgical technique and mesh size in order to allow the mesh to be implanted flat and well spread out, anchored to underlying tissues in order to prevent immediate postoperative folding. Imaging techniques can serve to monitor and audit surgical results as a clinical standard. Together with investing in the development of new materials, we should focus as well on improving surgical technique and quality control.

We have to acknowledge several weaknesses of the current study. We were unable to accurately measure transverse mesh diameters and consequently have not attempted to calculate area due to the uneven shape and width of the mesh. This implies that we are unable to determine whether the reduction in midsagittal diameters observed by us may have been due to lateral stretching. Stretching would be expected once load bearing commences. Consequently, it seems possible that at least some of the observed changes in midsagittal diameters may be due to lateral stretching of the mesh, rather than retraction. Future studies into postoperative mesh appearances should include coronal or transverse measurements as well as those obtained in the midsagittal plane.

Secondly, our data are valid only for Prolift mesh implanted into the anterior vaginal wall, and our surgical technique may also have played a significant role; however, most of the

currently used implants used in pelvic reconstructive surgery are polypropylene macroporous meshes (amid type I) with similar pore sizes, and similar results may be expected from other meshes of the same type.

Conclusion

We observed a large and highly significant difference in pre- and postoperative dimensions of Prolift anterior mesh. Most of this difference seemed to be due to intraoperative folding rather than postoperative mesh retraction. This raises questions regarding the appropriate size of mesh implants and insertion technique.

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Conflicts of interest A. Martan provides consultation for Gynecare, Bard, and AMS.

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