The Urethral Motion Profile Before and After Suburethral Sling Placement

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Abbreviations and Acronyms
SUI = stress urinary incontinence
UMP = urethral motion profile
USI = urodynamic stress incontinence

Purpose: We examined the effect of the Monarc™ suburethral sling on urethral mobility.

Materials and Methods: We retrospectively studied the records of 54 consecutive women who received a Monarc suburethral sling between July 2005 and November 2008. All patients were examined by volume ultrasound preoperatively and at followup (average 0.7 years). Volume data sets were analyzed using post-processing software. Urethral mobility was described by vectors of movement from rest to a maximum Valsalva maneuver of 6 equidistant points marked evenly along the urethra from bladder neck (point 1) to external urethral meatus (point 6), as identified in the mid sagittal view. Measurements were made of point coordinates relative to the pubic symphysis dorsocaudal margin at rest and during maximal Valsalva maneuver. To determine the urethral motion profile we calculated mobility vectors of the 6 points using the formula, square root \[ (x_{val} - x_{rest})^2 + (y_{val} - y_{rest})^2 \], where val represents the value during the Valsalva maneuver and rest represents the value at rest. We compared values before and after sling placement.

Results: The subjective cure rate for stress urinary incontinence was 78% (42 cases). There was a statistically significantly decreased mobility at points 2 to 4, corresponding to the urethral central aspect (p = 0.002 to 0.018). No significant change in mobility was noted at the bladder neck and distal urethra (p = 0.39 to 0.89).

Conclusions: Monarc suburethral sling placement decreases mid urethral mobility but does not seem to affect the bladder neck.

Key Words: urethra; urinary incontinence, stress; suburethral slings; ultrasonography; process assessment (health care)

The prevalence of urinary incontinence in community dwelling women is 20% to 40%1–3 with SUI the most common type.2,4 Despite its high prevalence the exact etiology of SUI remains elusive. SUI may develop when urethral support is defective, impairing pressure transmission during periods of increased intra-abdominal pressure.5 Burch colposuspension, the previous gold standard for SUI surgical treatment, aims to reposition the bladder neck in the abdominopelvic pressure zone to improve pressure transmission. While immobilizing and elevating the bladder neck is the primary aim of the procedure and successful colposuspension has been documented,6,7 postoperative complications are not uncommon, including voiding difficulties in 3% to 32% of patients and urge symptoms or de novo urge incontinence in 4% to 41%.8–11 The observation that voiding initiation is...
preceded by bladder neck descent suggests that the procedure may not be physiological.

The tension-free suburethral sling, a minimally invasive procedure with greater than 80% objective and subjective cure rates, and a low rate of de novo urge symptoms and voiding difficulty at 7-year followup,12 has now become the gold standard for surgical treatment for SUI. Previous groups examined the effect of such slings on bladder neck mobility13,14 and urethrovaginal junction position,15,16 and determined suburethral sling site and mobility17–19 but there is little information on changes in urethral mobility. Such information may enhance our understanding of the mechanism of action of suburethral slings and complications after such procedures. We examined the effect of Monarc suburethral sling placement on UMP, a recently developed method to study urethral mobility.19

METHODS

We retrospectively reviewed the records of 91 consecutive women who received a Monarc suburethral sling between July 2005 and November 2008 at a tertiary urogynecology unit. Preoperatively in all patients USI was diagnosed by multichannel urodynamic testing. The procedure was performed or supervised by one of us (HPD). The sling procedure was done using general anesthesia according to the manufacturer technique. All patients had undergone standardized interview, clinical examination, uroflowmetry and 4-dimensional transperineal ultrasound preoperatively and during followup a minimum of 4 weeks postoperatively. Voiding data obtained with a weight transducer flowmeter were converted to maximum flow rate centiles according to the Liverpool nomogram.20 Transperineal ultrasound was done with the patient supine after bladder emptying using a Voluson 730 Expert system (GE Medical Ultrasound Kretz, Zipf, Austria) equipped with an 8 to 4 MHz curved array volume transducer with an 85-degree acquisition angle, as previously described.21 Volume acquisition was done at rest and during the maximum Valsalva maneuver. At least 3 Valsalva maneuvers were done per patient. Data analysis was performed on a desktop personal computer using 4-dimensional SonoView™, version 5.0 several months after ultrasound data acquisition while blinded to clinical data.

Urethral mobility was described by vectors of movement from rest to a maximum Valsalva maneuver of 6 equidistant points marked along the length of the urethra from bladder neck (point 1) to external urethral meatus (point 6) in the mid sagittal plane, as previously described (fig. 1).19 Measurements of point coordinates relative to the dorsocaudal margin of the symphysis pubis were made at rest and during the maximal Valsalva maneuver. Mobility vectors of the 6 points were calculated using the formula, square root \((x_{val} - x_{rest})^2 + (y_{val} - y_{rest})^2\) to determine UMP, where val represents the value during the Valsalva maneuver and rest represents the value at rest. Our method of determining UMP has good to excellent repeatability.19

![Figure 1. Bladder and urethra at rest (Br) and during Valsalva maneuver (Bv) showing change in position of points 1 (bladder neck) to 6 (external urethral meatus) marked along urethra. SP, symphysis pubis.](image)

Since manually determining UMP coordinates is time-consuming, a semi-automated program was developed using an Excel® macro allowing automatic determination of x and y coordinates of the 6 points relative to the inferoposterior margin of the symphysis pubis on an image bitmap. Mobility vectors of the 6 points were calculated using the mentioned formula. Values before and after sling placement were compared to determine the change in UMP. A test-retest series of 20 UMPs (120 mobility vectors) was done to test correlations between manual measurement and the semi-automated program, and between observers (KLS and VC) using the semi-automated program. ICC was 0.93 (95% CI 0.90–0.96) and 0.95 (95% CI 0.92–0.96), respectively, suggesting excellent repeatability.

The study was done in the context of a human research ethics committee approved surgical audit (SWAHS HREC ref 09/03). The paired t and 2-sample t tests were used for statistical analysis with Minitab®, version 13 for personal computers. The paired t test was used to compare the change in UMP after sling placement. The 2-sample t test was used to compare UMP in the cured group vs the group with persistent SUI and in women with vs without de novo voiding difficulty with p < 0.05 considered statistically significant.

RESULTS

Of the 91 patients 31 were excluded from analysis due to previous or concomitant surgery that may interfere with urethral mobility, including a previously implanted sling in 5, anterior compartment Perigee™ mesh in 4, previous colposuspension in 8, of whom 1 also had a history of sling placement, and concomitant anterior compartment Perigee mesh implantation in 15. Six volumes could not be assessed due to corrupted files or incomplete data acquisition. All subsequent data refer to the remaining 54 data sets. Mean patient age was 55 years (range 33 to 87), median parity was 3 (range 1 to 8) and
The median followup was 0.7 years (IQR 0.38–1.31). At the preoperative assessment 52 (96%), 36 (67%) and 13 (24%) of the 54 patients complained of stress incontinence, urge incontinence and prolapse symptoms, respectively. Significant prolapse (International Continence Society Pelvic Organ Prolapse Quantification stage 2 or greater) noted in 31 patients was a stage 2 or greater cystocele in 16. All 54 patients had USI preoperatively and 11 (20%) also had detrusor overactivity. Concomitant prolapse repair was done in 22 patients (41%), including posterior repair in 16, anterior repair in 4 and sacrospinous colpopexy in 3.

The subjective cure rate for SUI was 78% (42 of 54 patients). Five patients (9%) noted improvement, 5 remained the same and 2 felt worse after the sling procedure. Nine patients (17%) complained of de novo voiding dysfunction symptoms. Of 36 women with urge urinary incontinence preoperatively 31 (86%) noticed urge incontinence improvement/cure after sling placement. No sling erosion was identified.

Before suburethral sling placement the mean mobility vector distances from points 1 (bladder neck) to 6 (external urethral meatus) were 2.92, 2.61, 2.31, 2.06, 1.88 and 1.80 cm, respectively. There was a decrease in mean mobility vector distance throughout the entire urethral length after sling placement. Corresponding values from points 1 to 6 were 2.86, 2.37, 1.99, 1.82, 1.8 and 1.81 cm (p = 0.67, 0.039, 0.002, 0.018, 0.39 and 0.89), respectively. There was statistically significantly decreased mobility at points 2 to 4, corresponding to the central urethral aspect. No significant change in mobility was observed at the bladder neck or the external urethral meatus (see table and fig. 2).

Comparing UMP in 12 women with persistent SUI and in 42 who were cured showed no significant difference in the change in mobility vectors of points 1 to 6 after sling placement (p = 0.13 to 0.8). Maximum urethral closure pressure in the 2 groups was 28.22 and 36.9 cm H₂O, respectively (p = 0.036), suggesting poorer urethral sphincter function in those with persistent SUI. There was a trend toward a greater decrease in mobility vectors of all 6 points in 9 patients with de novo symptoms of voiding dysfunction but it did not attain statistical significance (p = 0.067 to 0.781). The maximum flow rate centile (35th vs 34th, p = 0.94), post-void residual volume (15 vs 35 ml, p = 0.23) and detrusor pressure at maximum flow on urodynamic testing before sling placement (25 vs 24 cm H₂O, p = 0.78) were not significantly different in women with vs without de novo voiding dysfunction. Similarly the maximum flow rate centile (28th vs 21st, p = 0.51), change in maximum flow rate centile (−4 vs −13, p = 0.56) and post-void residual volume (11 vs 22 ml, p = 0.052) after sling placement were also not significantly different between the 2 groups. There was no significant association between the mobility vector change and improvement/cure of urge urinary incontinence (p = 0.16 to 0.29). Figure 3 shows ultrasound images in the mid sagittal plane before and after sling placement in a patient cured of SUI.

### DISCUSSION

Urethral hypermobility is considered an important factor in USI pathophysiology. However, information on urethral mobility after incontinence surgery is lacking in the literature unless one considers bladder neck mobility, cotton swab angles, urethrovesical angle or bladder neck descent to indicate urethral mobility. These parameters at best focus on bladder neck mobility and give no information on the rest of the urethra. One could argue that the cotton swab test describes nothing more than an artifact since the urethra does not usually remain a straight tube upon the Valsalva maneuver.
Masata et al recently described an ultrasound method to assess changes in urethral mobility after a successful TVT™ procedure. They assessed the urethrovesical junction and fixed urethral points 7, 17 and 27 mm below, representing different parts of the urethra in different individuals since urethral length can vary markedly among patients. We measured urethral length as a mean of 30.8 mm (range 22.9 to 40.1). Thus, the method of Masata et al may not be exact enough to serve as a research tool to study urethral support and mobility. In that study mobility was significantly decreased in all parts of the urethra upon the Valsalva maneuver after TVT placement. In contrast, we found significantly decreased urethral mobility only at the proximal and mid urethra (points 2 to 4). No significant change in mobility was noted at the bladder neck or the distal urethra. Differences in methodology may partly explain the discrepancies in findings and a transobturator tape cannot be considered fully equivalent to a TVT.

We noted no significant changes in bladder neck mobility after suburethral sling placement. Other groups reported similar findings after TVT placement. Unlike colposuspension, which supposedly works by immobilizing the bladder neck, suburethral slings seem to exert a different effect. These procedures seem to be curative by limiting the mobility of the mid urethra rather than the internal meatus, likely leading to mid urethral compression. In a study of the correlation of UMP with SUI and USI an increased mobility vector distance of point 2 to 4, ie the proximal and mid urethra, significantly correlated with SUI and a USI diagnosis significantly correlated with the mobility vector distance of all 6 points with the correlation strongest for points 2 to 4. Central urethral mobility rather than bladder neck mobility seems to be most strongly affected in SUI cases, suggesting possibly impaired urethral support/fixation of this part of the urethra. Thus, suburethral slings may be more physiological in their action than colposuspension procedures, as supported by urodynamic studies after TVT and colposuspension. No significant change in urodynamic parameters except positive pressure transmission in the mid portion of the urethra of those cured or improved was noted after TVT. However, after colposuspension significantly increased voiding detrusor pressure and slowing of the maximum flow rate may suggest a degree of outlet obstruction as a result of bladder neck immobilization.

To our knowledge this is the first study using ultrasound to examine the effect of suburethral slings on mobility of the entire urethra. While currently available data mainly focus on bladder neck mobility after incontinence procedures, this parameter cannot be considered to signify urethral mobility. The methodology described is a clear improvement on previously used methods and it may be useful in future studies, eg to investigate urethral trajectory during cough or the Valsalva maneuver. With current ultrasound technology the UMP methodology may become useful for this purpose. Instead of focusing on movement amplitudes we also plan to study the timing and direction of urethral segmental movement along the lines of the pioneering series by Lovegrove et al.

CONCLUSIONS
There is a significant decrease in mobility of the central aspects of the urethra after Monarc suburethral sling placement. No significant changes in mobility were found for the bladder neck or the external meatus. Unlike colposuspension, this suburethral sling seems to limit central urethral rather than bladder neck mobility, a curative mechanism that may be more physiological.

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REFERENCES


