The role of TVT position in relation to the pubic symphysis in eliminating the symptoms of stress urinary incontinence and urethral funneling

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Abstract

The introduction of suburethral sling was a breakthrough in the treatment of stress urinary incontinence in women. The method is highly effective. However, the mechanism of action of a sling and the reasons for surgical failures are not fully understood. **Aim:** The aim of the study was to assess the impact of sling-pubic symphysis distance on eliminating the symptoms of stress urinary incontinence and urethral funneling. **Materials and methods:** The analysis included 106 patients who reported 3 to 6 months after sling placement for a follow-up visit encompassing clinical examination and standard ultrasonography. We evaluated the position of sling in relation to the pubic symphysis, urethral length, as well as urethral funneling length and width. **Results:** Cure criteria were met by 91 patients. Elimination of urethral funneling was achieved in 76.9% (n = 70) of cured patients. Urethral funneling was still present, yet shorter by a mean of 10.2 mm (p = 0.02) than before surgery in the remaining cured patients. There was a 32.5% reduction in the mean relative length of urethral funneling (p = 0.002). No significant differences were found in the pre- and postoperative funneling width. The tape-pubic symphysis distance was lower in cured women: 23.2 mm vs. 26.1 mm in failed women (p = 0.04). Similar observations were made for cured patients with persistent urethral funneling vs. failed patients (22.47 mm vs. 26.0 mm, p = 0.027). There were no differences between cured patients without urethral funneling and cured patients with persistent postoperative funneling (23.5 mm; 22.5 mm; p = 0.417). **Conclusions:** Tape position in relation to the pubic symphysis is important for the elimination of stress urinary incontinence. Sling location closer to the pubic symphysis reduces the length of urethral funneling, but has no effects on its width in cured patients with persistent postoperative funneling.
**Introduction**

Stress urinary incontinence (SUI) is the most common type of urinary incontinence (UI) in women. However, its pathophysiology is not fully understood. The symptoms of SUI are assumed to be associated with urethral hypermobility and low maximum urethral closure pressure in most cases.

The introduction of tension-free vaginal tape (TVT) was a breakthrough in the surgical treatment of SUI. The method is highly effective, with cure rates up to 93% at 6 months after procedure. However, the exact mechanism of TVT and the causes of surgical failures remain unknown. Ultrasound findings indicate two possible mechanisms during increased intra-abdominal pressure: urethral compression against the pubic symphysis and urethral compression by the tape.

In addition to standard diagnostic methods, such as cough stress test, pad test, voiding diary or urodynamic testing, ultrasonography is also likely to play an important role in the diagnosis and assessment of patients with SUI. Pelvic floor ultrasound performed with transvaginal probe (PFS-TV) shows excellent and good repeatability of the obtained results. In addition to sonographic evaluation of urethral and bladder neck mobility, as well as postoperative sonographic localization of the tape, visualization of urethral funneling, which, according to different authors, may overlap with SUI in 18.6% to 100% women, is also possible. Sonographic assessment of urethral funneling may be an important diagnostic parameter in SUI and help monitor surgical outcomes in SUI patients in the future. However, the data published so far is too sparse.

Previous studies indicate that a tape positioned closer to the pubic symphysis increases the chances for successful elimination of SUI. So far, it has not been verified whether the distance between the tape and the pubic symphysis has any effects on the elimination of urethral funneling.

The aim of the study was to assess the impact of tape-pubic symphysis distance on the elimination of SUI symptoms and urethral funneling.

**Materials and methods**

A total of 121 patients were qualified for TVT procedure between 2006 and 2012 (Ethicon, Johnson&Johnson, USA). Of these, 115 women reported for the procedure. All patients gave their consent to participate in the study. Treatment outcomes of 106 patients who reported for a follow-up visit within 3 to 6 months of surgery were included in the analysis. The study was approved by the Ethics Committee of the Medical University of Lodz.

Preoperative SUI was confirmed during clinical and urodynamie examination, based on objective and subjective criteria described by Kociszewski et al. Clinical assessment of vaginal wall prolapse was performed using the POP-Q scale. PFS-TV was performed in all patients.

The planned hospital stay after the surgery was 2 days. Foley catheter was removed about 24 hours after the surgery. Micturition disorders were diagnosed if 100 mL of residual urine remained after voiding and persisted for more than 1 day after catheter removal. The results of medical observations during hospital stay and follow-up findings obtained 3 to 6 months after TVT procedure were included in the analysis. Postoperative diagnosis included clinical and ultrasonographic (PFS-TV) examination.

Standardized PFS-TV was performed using Philips EnVisorC, Hitachi EUB-525 and BK Pro Focus ultrasound systems, a 6.5 MHz transvaginal probe, 160° beam angle, as in accordance with a technique developed by Kociszewski in a patient in a semi-sitting position with a normalized bladder volume of 250–300 mL, which was calculated from 3 bladder dimensions: transverse, anteroposterior and superior-inferior.

The assessment of surgical outcomes included subjective symptoms, such as inguinal pain, urge and voiding dysfunction. The group of cured patients included women with negative cough test, negative 1-hour pad test (<2 g), and with Visual Analogue Scale (VAS) score of 0 to 1. If the patients failed to meet all these criteria, the treatment was considered unsuccessful and they were classified in the failed group.

PFS-TV was performed in patients after TVT procedure to assess tape position in relation to the pubic symphysis. The examination was started by positioning the probe in alignment with the patient’s axis. A single image was taken to visualize the pubic symphysis (which was the only fixed point of reference), the urethra and the bladder neck, as well as to assess the position of the tape in relation to the pubic symphysis (Fig. 1, Fig. 2).

The probe angle was changed in accordance with Kociszewski technique for precise pre- and postoperative visualization of the urethral funneling. During maximum straining, we verified the presence of urethral funneling, measured its geometry and verified whether urine flow was visible in the ultrasound examination. Using the previously described technique, we measured urethral length, the funneling length and width, as well as we calculated the relative funneling length (%). According to the previously published definition, long funneling was estimated at >50% of urethral length with sonographic evidence of urine flow. Short urethral funneling was diagnosed if no urine flow was seen in ultrasound and the funneling length was ≤50%.

The investigated variables showed normal distribution. The Shapiro-Wilk test was used for normality analysis. The T-test was used for independent variables to compare the groups of cured vs. failed patients. Statistical analysis of pre- and postoperative data was conducted using the T-test.
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On follow-up, 91 patients were considered to meet the cure

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months after the surgery. No significant peri- or postopera-
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On follow-up, 91 patients were considered to meet the cure criteria (group C), while 15 women were qualified as failed

A total of 106 patients were included in the analysis. The mean age of patients was 60.8 years (47 to 77 years). Mean BMI was 27.2 kg/m² (standard deviation 4.5 kg/m²). A mean number of 2 childbirths (0 to 6) was reported. Natural delivery and cesarean section were reported by 83% and 13.2% of patients, respectively. Operative delivery (forceps or a vacuum extractor) was reported by 7.5% of patients. Nulligravidas accounted for 7.5%. Patients after hysterectomy accounted for 13.2% (n = 14). A total of 19.8% (n = 21) of patients had a history of at least one urogynecological surgery, including Burch procedure in 2.8% (n = 3). There were no patients with a history of sling placement.

No significant disorders of genital statics other than sec-

ond-degree rectocele in 3 women (2.8%), who additionally underwent posterior wall repair, were found in the patients qualified for TVT procedure. Other patients underwent TVT placement only. Symptoms of dry overactive bladder were reported preoperatively by 40 women (37.7%). There were no cases of voiding abnormalities.

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On follow-up, 91 patients were considered to meet the cure criteria (group C), while 15 women were qualified as failed

A mean value of 23.2 mm in the C group, and 26.1 mm in

the distance between the tape and the pubic symphysis

were obtained for cured (C) vs. failed (F) patients. The

mean value was 22.47 mm, mean (UF+) = 22,47 mm, mean (F)

p = 0.027, mean (UF+) = 22,47 mm, mean (F) = 26.0 mm).

PFS-TV showed persistent long funneling in 15 failed

patients. TVT placement had no significant impact on

either length or width of the funneling.

Statistically significant differences (p = 0.04) were found

in the distance between the tape and the pubic symphysis

between cured (C) and failed (F) patients. Higher values

were obtained for cured (C) vs. failed (F) patients. The

mean value was 23.2 mm in the C group, and 26.1 mm in

the F group (Fig. 4).

The analysis of the distance between the tape and the pubic symphysis confirmed a statistically significant difference in this distance between cured patients with persistent post-TVT placement urethral funneling (UF+) and failed patients (p = 0.027, mean (UF+) = 22,47 mm, mean (F) = 26.0 mm).

Ultrasound measurements of the position of the TVT tape

in relation to the pubic symphysis showed no significant

(Fig. 2. Method for measuring the tape-pubic symphysis parameter (D’O) – a PFS-TV image. S – pubic symphysis, B – bladder, U – urethra, arrow – suburethral sling, 1 – a line drawn along the lower edge of the pubic symphysis, 2 – tape position in the Y axis in relation to the pubic symphysis, 3 – tape position in the X axis in relation to the pubic symphysis, 4 – tape-pubic symphysis distance

Fig. 1. Measurement scheme for the tape-pubic symphysis parameter (D’O). S – pubic symphysis, B – bladder, U – urethra, CI and CII – bladder urethral outlet, T – tape, D’O – tape-pubic symphysis parameter

for dependent variables. Mean values (with their ranges)

were specified for continuous variables.

Results

A total of 106 patients were included in the analysis. The

mean age of patients was 60.8 years (47 to 77 years). Mean BMI was 27.2 kg/m² (standard deviation 4.5 kg/m²). A mean number of 2 childbirths (0 to 6) was reported. Natural delivery and cesarean section were reported by 83% and 13.2% of patients, respectively. Operative delivery (forceps or a vacuum extractor) was reported by 7.5% of patients. Nulligravidas accounted for 7.5%. Patients after hysterectomy accounted for 13.2% (n = 14). A total of 19.8% (n = 21) of patients had a history of at least one urogynecological surgery, including Burch procedure in 2.8% (n = 3). There were no patients with a history of sling placement.

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tive complications were found in any of the patients. No cases of significant post-void urine retention were observed. None of the patients developed vaginal mucosal erosion. A total of 13 (12.3%) patients reported persistent symptoms of dry overactive bladder. Urge was reported by 2 patients (1.9%). None of the patients reported de novo urge without incontinence.

On follow-up, 91 patients were considered to meet the cure criteria (group C), while 15 women were qualified as failed

(group F). Figure 3 shows the number of patients qualified into different groups depending on the symptoms of SUI and urethral funneling.

Long urethral funneling was found preoperatively in all

(n = 106) patients with the symptoms of second and third stage SUI. The relative funneling length exceeded 50% in all patients (50.2–99.7%, mean 53.3%); the mean absolute length was 16.7 mm (9.7–32.8 mm). The mean funneling width was 5.5 mm (1.2–16.6 mm).

In the group of cured patients (n = 91), the procedure led to complete elimination of urethral funneling in 76.9% (n = 70). The funneling was still visible in the remaining 23.1% (n = 21) of the cured patients, but with no evident urine flow in ultrasound (short funneling). It was shorter in this group of patients compared to preoperative findings: mean 10.2 mm, (4.5–17.3 mm, p = 0.02). The mean relative length of funneling was smaller than before TVT implantation: 32.5% (11.8–48%, p = 0.002). There were no significant differences in pre- and postoperative funneling width (5.6 mm vs. 5.9 mm).

PFS-TV showed persistent long funneling in 15 failed

patients. TVT placement had no significant impact on

either length or width of the funneling.

Statistically significant differences (p = 0.04) were found

in the distance between the tape and the pubic symphysis

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Ultrasound measurements of the position of the TVT tape

in relation to the pubic symphysis showed no significant
differences between cured patients with eliminated funneling after the surgery (UF0) and cured patients with persistent postoperative funneling (UF+) (p = 0.417, mean (UF0) = 23.5 mm, mean (UF+) = 22.5 mm).

Discussion

The analyzed results confirmed that the position of the tape in relation to the pubic symphysis has an impact on treatment outcomes in patients with SUI. According to Dietz, the sling moves within the arch around the pubic symphysis, which reduces the distance between the sling and the pubic symphysis on straining\(^6\). Duckett et al. pointed out that the effect of continence is achieved by urethral compression against the pubic symphysis and therefore, in their opinion, the distance between the tape and the pubic symphysis plays an important role in the successful treatment of SUI by suburethral sling placement\(^{13,14}\).

According to Yang et al., sling tension is the only intraoperatively controllable factor. The authors used intraoperative ultrasonography for this purpose\(^{15}\).

Kociszewski et al. suggested that it is possible to modulate tape location in the longitudinal axis of the urethra by preoperative choice of the site for vaginal mucosal incision and pointed to the impact of the distance between the tape and the urethral lumen on the effectiveness of eliminating SUI after suburethral sling implantation\(^{5,10,11}\).

Dietz confirmed in his study using 4D ultrasound that the position of the tape in relation to the long and transverse urethral axis has an impact on the postoperative outcome\(^{6,16}\).

Our study did not compare the impact of sling location in relation to the pubic symphysis vs. urethra. Our findings confirm that the treatment outcome in patients with SUI depends on tape position in relation to the pubic symphysis. A tape inserted closer to the pubic symphysis offers a better chance of curing SUI. Unfortunately, surgical techniques allowing for an individually planned, optimal location in relation to the pubic symphysis are not known.

TVT positioned closer to the pubic symphysis allowed for eliminating SUI and funneling in 77% of cured patients. Our studies and analyses have never shown any significant effects of the tape-pubic symphysis distance and funneling width in cured patients with postoperatively persisting funneling or failed patients. A shorter tape-pubic symphysis distance was associated with reduced funneling length in SUI patients after TVT implantation, but had no effects in on this length in failed patients.

No analyses on the impact of surgical tape positioning in relation to the pubic symphysis on complete elimination of funneling or its size have been published in the available worldwide literature.

In our opinion, the probable causes of postoperatively persisting funneling include damaged internal urethral sphincter mechanism and periurethral structures. In the...
case of patients with efficient internal urethral sphincter mechanism, proper TVT placement may improve the effectiveness of extraspincteric mechanism, and thus allow for complete elimination of urethral funneling.

Falconer et al. conducted a study suggesting that SUI elimination after suburethral sling placement may also result from altered metabolism of the periurethral connective tissue. The authors suspect that the tape is likely to promote restoration of connective tissue supportive properties along the sling, which is another argument for midurethral placement of the tape instead of insertion in the bladder region, where the number of periurethral fibers is significantly lower.²³

Our findings again confirmed² that a short funneling is not a symptom of SUI.

Conclusions

1. TVT position in relation to the pubic symphysis important for the cure of stress urinary incontinence.
2. Reduced TVT-pubic symphysis distance translates into shorter urethral funneling, but has no effects on funneling width in cured patients with persistent postoperative funneling.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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