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Original Research

The Role of Pelvic Ultrasound in Evaluating the Success of Tension-free Vaginal Tape (TVT)

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Abstract

Objectives: This study aims to assess the lack of response to treatment in individuals undergoing mid-urethral sling surgery for stress urinary incontinence (SUI) using ultrasound findings of the pelvic floor.

Methods: The study included patients who underwent the tension-free vaginal tape (TVT) procedure for stress urinary incontinence within the period spanning from January 2016 to January 2021. The physical examination involved maintaining bladder filling at an average volume of 200–400 mL, and treatment failure was determined by the presence of SUI during the Valsalva maneuver.

Results: The study comprised a total of 214 patients, where it was observed during the stress test that 32 patients (25.8%) had an unsuccessful outcome following mid-urethral sling surgery. In the unsuccessful group, the distance of the mesh-posterior urethra was lower (4.09±0.39 vs. 4.91±0.51; p<0.001), the posterior urethrovesical angle was lower when at rest, but the angle increased more significantly during the Valsalva maneuver, and the bladder neck angle was narrower (p<0.001).

Conclusion: We obtained lower mean values of mesh-posterior urethral distance in unsuccessful patients compared to those found in the group of cured patients. Pelvic floor ultrasound can predict the success of TVT surgeries but there is as yet little data and there is a need to find in the near future more standard and objective parameters for the diagnosis of urinary incontinence.

Keywords: Failure, pelvic ultrasound, stress urinary incontinence, tension-free vaginal tape

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Stress urinary incontinence (SUI) is characterized by the unintentional release of urine triggered by a sudden elevation in intra-abdominal pressure, such as coughing or sneezing.[1,2] SUI significantly affects the physical and mental health as well as the quality of life of patients.[3] Incontinence occurs due to inadequate coaptation of the urethra caused by the loss of connective tissue and muscle support. The primary surgical technique recognized for treating SUI involves the insertion of a mid-urethral sling (MUS) in either the retropubic or transobturator position. In the post-surgical analysis of patients who have undergone MUS, ultrasound plays a crucial role in assessing the anatomical position of the sling, both statically and dynamically.[4] The significance of ultrasound in evaluating MUS lies in its ability to correlate the position, behavior, and symptoms during the Valsalva maneuver and post-operative complications.[5,6]

Perineal ultrasound is considered the most useful imaging technique for assessing various aspects such as the

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localization of meshes, compression applied by the mesh on the urethra, the angle between mesh arms, bladder hypermobility, and the position of the mesh on the urethra.[7] It provides a good correlation with surgical exploration as it allows for easy observation of tapes and materials that create hyperechoic images, facilitating the assessment of post-operative complications. Pelvic floor ultrasound is utilized to visualize slings and assess urethral passage, urethral hypermobility, and changes following anti-incontinence surgeries.[8,9] Although pelvic floor ultrasound is widely used, definitive values for treatment failure have not been obtained.[10] There are inconsistencies among studies, and the limited literature on the subject acts as a barrier to establishing a clear consensus.

The objective of this study is to assess the therapeutic outcome of patients who received retropubic tension-free vaginal tape (TVT) for SUI by analyzing the pelvic floor ultrasound results.

Methods

Patients who underwent TVT for SUI between January 2016 and January 2021 were included in the study. The research obtained ethical committee endorsement, and written assent was acquired from every participant. The ethical approval was taken from the Ethics Committee of Prof. Dr. Cemil Tascioglu City Hospital (Date: January 23, 2023, Number: 27). The research design was executed in compliance with the Helsinki Declaration.

The study excluded patients who did not attend regular post-operative follow-up visits, individuals who became pregnant after the operation, those who underwent pelvic surgery or received radiotherapy following the operation, and patients who underwent procedures other than synthetic mesh (autologous sling), transobturator tape (TOT), and mini sling for SUI.

During regular post-operative follow-up visits, demographic data of the patients were collected. The medical condition of the patients was assessed through a comprehensive physical examination and pelvic ultrasound. After recording the demographic information, parity, birth history, presence of groin pain, history of mesh erosion, dyspareunia, and other relevant medical documents, the patients' data were documented on the case report form. The physical examination included the evaluation of urinary leakage, assessment of urethral hypermobility, and examination of the position and functionality of the tape at rest. A perineal ultrasound examination was performed using an abdominal probe commonly used in routine practice with the Siemens ACUSON NX3 Ultrasound system. Patients underwent examination in a semi-recumbent position following bladder emptying, with the ultrasound probe positioned sagittally on the labia minora. Median sagittal plane images were captured, encompassing the pubic symphysis, bladder, and urethra. The suburethral tape, visualized as a hyperechoic structure, was assessed in terms of its position relative to the urethra and pubic symphysis, both at rest and during the Valsalva maneuver. The distance from the closest, proximal edge of the tape to the posterior aspect of the urethra at the bladder neck (urethrovesical junction) level was defined as the "bladder neck to tape length." The "craniocaudal tape length" denoted the measurement of the tape's position in relation to the lower portion of the pubic symphysis. It was determined by measuring from the proximal edge of the tape at a right angle, along a horizontal line following the posterior lower edge. The position of the tape along the urethra was assessed as a percentage of the total urethral length, described as the "tape percentage." This measurement was obtained by dividing the proximal urethral length (distance from the urethrovesical angle to the proximal point of the tape) by the total urethral length (distance from the urethrovesical angle to the external urethral meatus) in the sagittal plane. The urethrovesical angle and external urethral meatus corresponded to 0% and 100% of the urethral distance, respectively. In addition, the tape-urethra gap (TUG) was defined as the shortest length between the tape and the hypoechoic formation of the urethra, as illustrated in Figure 1. Urethral measurement, the angle of the ureterovesical junction at rest and during the Valsalva maneuver, the configuration of the sling at rest, the shortest distance from the sling to the posterior urethral wall, the evenness of the sling, the placement of the sling, and the suitability of the sling with Valsalva maneuver were assessed (Fig. 2).

During the physical examination, if SUI was observed during the Valsalva maneuver while the bladder was filled to an average volume of 200–400 mL, it was categorized as treatment failure.[11] Based on this criterion, the patients were

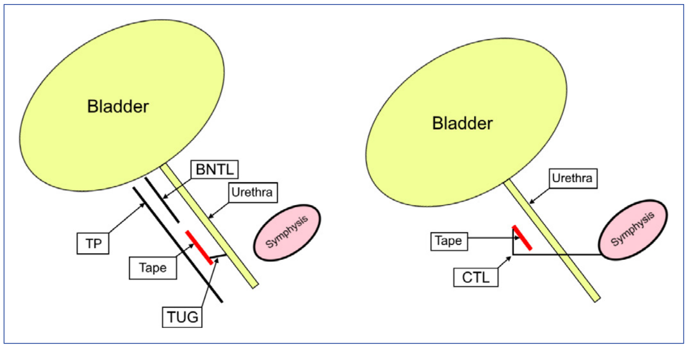

Figure 1. Tape-urethra gap.

BNTL: Bladder neck to tape length; TUG: Tape-urethra gap; CTL: Craniocaudal tape length; TP: Tape percentage.

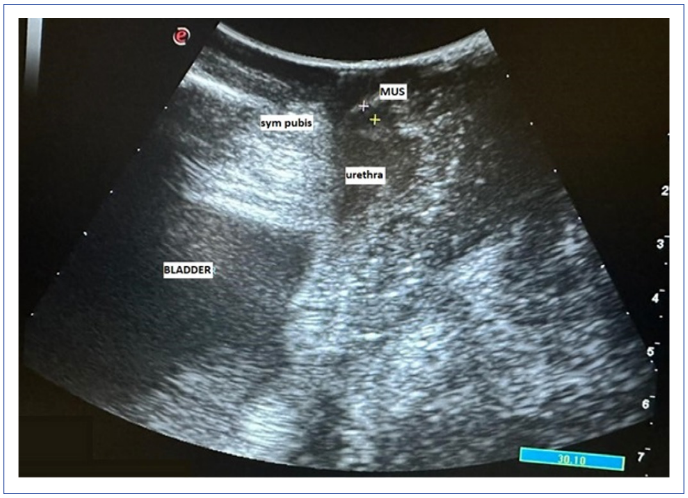

Figure 2. Ultrasound parameters.

MUS: Mid-urethral sling, mesh urethra length.

divided into two groups: The treatment success group and the treatment failure group.

Ultrasound was utilized to evaluate urethral hypermobility in the medio-sagittal plane by measuring the urethral length from the bladder neck to the symphysis pubis. The assessment involved observing any reduction in this distance during the Valsalva maneuver, indicating urethral mobility.

The form of the sling (during periods of inactivity and when performing the Valsalva maneuver) was assessed. While at rest, the slings generally possess a linear structure, running parallel to the urethral passage. Nevertheless, during the Valsalva maneuver, they undergo deformation into a curved shape resembling the letter "C" due to the tension induced by heightened intra-abdominal pressure. The synchronization between urethral motion and sling movement, the balance of the sling and its branches in the cross-sectional or frontal view during the Valsalva maneuver (urethral flexing), and the examination of extrusion or twisting of the sling branches were also conducted employing pelvic ultrasound.

Statistical Analysis

The patients' data were analyzed using SPSS 25.0 (IBM, NY, USA) software. The distribution of the data was assessed using the Kolmogorov–Smirnov test. Comparisons of pelvic ultrasound data between the two groups were conducted utilizing an independent sample t-test, Mann–Whitney U-test, and t-test, based on the data distribution. Factors that influenced treatment success were evaluated through univariate and multivariate regression analysis. A significance level of p<0.05 was determined for statistical significance.

Results

The study enrolled a total of 214 patients, having an average age of 53.92±6.66 years and a mean body mass index (BMI) of 25.89±2.03. The average duration from surgery to the last follow-up date was 23.57±8.52 months. Among the patients included, 98 (79%) had a history of previous normal vaginal delivery, whereas 21% had a history of previous cesarean section. The population profile of the patients is documented in Table 1.

When patients were evaluated with a stress test, it was observed that 32 patients (25.8%) had failed mid-urethral sling surgery. When comparing the successful and unsuccessful groups, it was found that the average BMI of patients in the unsuccessful group was higher (p<0.001). When comparing the pelvic ultrasound findings of the patients, it was observed that the mesh-posterior urethral wall length was shorter in the unsuccessful group (4.09±0.39 vs. 4.91±0.51; p<0.001), the posterior urethrovesical angle was smaller at rest but had a greater increase with the Valsalva maneuver, and the angle of the bladder neck with the mesh was narrower (p<0.001). Furthermore, mesh asymmetry was more prominent in the unsuccessful group (p<0.001) (Table 2).

When examining the factors affecting the success of synthetic mesh surgery using univariate and multivariate analysis, it was determined that BMI (odds ratio [OR]: 2.472), mesh-posterior urethral wall distance (OR: 12.21), the difference between the posterior urethrovesical angle at rest and during Valsalva maneuver (OR: 0.804), and mesh to bladder neck angle (OR: 1.636) were significant factors influencing failure (Table 3).

Discussion

In our study, we observed that the distance between the mesh and the posterior urethra in successful TVT operations was measured as 4.91±0.51 mm. While there is no definitive consensus in studies regarding perineal ultrasound, which has become a routine practice in urogynecological surgeries in recent years, a similar study focusing on MUS procedures found a correlation between successful surgical outcomes and a minimum distance of 3 mm from the urethral lumen, along with dynamic changes in the tape during the Valsalva maneuver.[5] Another study has reported that a distance greater than 15 mm between the bladder neck descent and a posterior retrovesical angle exceeding 120° is indicative of weak support for the bladder neck in patients who have SUI. The study found 96% and 53% sensitivities and specificities of 85% and 100% for these measurements, respectively.[12] However, it should be noted that a recent study has confirmed that the distance of bladder neck descent alone is not

Table 1. Demographic characteristics of patients and pelvic ultrasound findings

	Mean	SD	Min	Max	n	%
Age	53.92	6.66	39	70		
BMI	25.89	2.03	22	36		
Time from operation to final control	23.57	8.52	8	48		
Delivery method						
NVD					98	79
C/S					26	21
Incontinence type						
Stress					122	98.4
Mixed					2	1.6
Success						
Successful					92	74.2
Unsuccessful					32	25.8
Mesh-posterior urethral wall length	4.7	0.60	3.7	5.9		
Posterior urethrovesical angle (at rest)	121.79	3.48	116	130		
Posterior urethrovesical angle (Valsalva)	141.00	7.06	128	156		
Form at rest						
Flat					122	98.4
C shape					2	1.6
Form at Valsalva						
Flat					2	1.6
C shape					122	98.4
Symmetry						
Symmetrical					96	77.4
Asymmetrical					28	22.6
Angle difference						
<15					30	24.2
>15					94	75.8
Mesh to urethrovesical angle	22.98	3.34	16	30		

BMI: Body mass index; NVD: Normal vaginal delivery; C/S: Cesarean delivery.

sufficient to evaluate SUI.[13] In line with these findings, our study also reveals that the angle between the mesh and the posterior urethrovesical region has an impact on treatment success. Differences in angles observed during rest and the Valsalva maneuver hold significance in post-operative evaluations, particularly in relation to urethral hypermobility.[14] Our study revealed that angles exceeding 15° are associated with treatment failure (OR: 0.804). Furthermore, an increased angle between the mesh and bladder neck was also found to be linked to failure in the multivariate analysis (OR: 1.636). An alternate study revealed that the effectiveness of the sling relies on the mechanical interplay between the tape and the urethra. They observed that the lack of urethral intrusion (bending) during periods of inactivity, narrowing of the bladder neck, positioning of the urethra below the median percentile, and resting angle of the tape measuring <165° are associated with sling malfunction. Furthermore, they noted a greater occurrence of bending within the triumphantly treated group compared to the group that experienced treatment failure (62% vs. 15%).[15] The symmetric appearance of the mesh on ultrasound has been suggested as a criterion for treatment success. Studies have found that asymmetric mesh placement is more prevalent in patients who experience persistent urinary incontinence after treatment.[16,17] Our study observed mesh asymmetry in 77% of patients with failed mid-urethral sling surgery. Ensuring the symmetric placement of both arms of the mesh during the procedure is an important step for achieving treatment success.

Once again, our study underscores the importance of perineal ultrasound in evaluating cases of treatment failure following MUS surgery. The strengths of our study include strict adherence to follow-up schedules by patients and the uniformity of surgical procedures performed by the same surgical team. However, it is important to acknowledge the

Table 2. Comparison of successful and unsuccessful patients

	Unsuccessful (n=32)	Successful (n=92)	p
Age	55.19±2.60	53.48±7.54	0.212
BMI	26.26±2.23	24.81±0.39	<0.001
Time from operation to final control	25.25±4.64	22.95±9.50	0.193
Delivery method			
NVD	32 (32.7%)	66 (67.3%)	<0.001
C/S	0	24 (100)	
Mesh-posterior urethral wall length	4.09±0.39	4.91±0.51	0.001
Posterior urethrovesical angle (at rest)	120.25±1.70	122.33±3.77	0.003
Posterior urethrovesical angle (Valsalva)	145.63±7.19	139.39±6.30	<0.001
Symmetry			
Symmetrical	12 (12.5)	84 (87.5%)	<0.001
Asymmetrical	20 (76.9%)	6 (23.1%)	
Angle difference			
<15	0	30 (100%)	<0.001
>15	32 (34%)	62 (66%)	
Mesh to urethrovesical angle	21.38±2.03	23.54±3.52	0.001

BMI: Body mass index; NVD: Normal vaginal delivery; C/S: Cesarean delivery.

Table 3. Univariate and multivariate analysis - factors affecting success

	p	OR	CI (95%)	p	OR	CI (95%)
Age	0.133	2.260	0.450–2.550			
BMI	0.001	11.624	0.001–15.604	0.033	2.472	1.076–5.676
Time from operation to final control	0.144	2.136	0.045–3.456			
Delivery method	0.001	11.528	0.001–15.001	0.997	1.000	1.000–1.000
Mesh-posterior urethral wall length	<0.001	5.208	0.001–6.678	0.008	12.208	1.896–18.607
Posterior urethrovesical angle (at rest)	0.06	8.598	0.001–10.000			
Posterior urethrovesical angle (Valsalva)	0.08	15.509	0.001–22.123			
Symmetry	<0.001	4.707	0.001–6.665	0.626	0.982	0.528–0.992
Angle difference	<0.001	2.191	0.001–3.001	0.008	0.804	0.684–0.946
Mesh to urethrovesical angle	0.001	1.081	0.001–2.689	0.002	1.636	1.191–2.247

limitations of our study, such as its retrospective nature and the relatively small sample size. Given the increasing prevalence of urogynecological surgeries and the growing use of minimally invasive techniques, there is a need for more frequent utilization of pelvic floor ultrasound. Larger cohorts and prospective urodynamic studies can provide valuable insights and generate more robust and conclusive results regarding the relationship between SUI and the pelvic floor.

Conclusion

We obtained lower mean values of mesh-posterior urethral distance in unsuccessful patients compared to those found in the group of cured patients. The use of intraoperative ultrasound for TVT placement allows us to position them optimally and avoid erroneous placements (e.g., mesh asymmetry). We believe to have obtained interesting results which should be pursued further to gain a better insight into the pathophysiology of urinary incontinence as well as gain a new parameter in the assessment of female incontinence. Perineal ultrasonography is becoming increasingly common in the evaluation of the pelvic floor. We think that pelvic ultrasound can be used to predict the success of urinary incontinence surgeries. According to the results of our study, pelvic floor ultrasound can predict the success of TVT surgeries. We believe to have obtained interesting results which should be pursued further to gain a better insight into the pathophysiology of urinary incontinence as well as gain a new parameter in the assessment of female incontinence. Perineal ultrasonography is becoming increasingly common in the evaluation of the pelvic floor.

We think that pelvic ultrasound can be used to predict the success of urinary incontinence surgeries. According to the results of our study, pelvic floor ultrasound can predict the success of TVT surgeries.

Disclosures

Ethics Committee Approval: The ethical approval was taken from the Ethics Committee of Prof. Dr. Cemil Tascioglu City Hospital (Date: January 23, 2023, Number: 27). The research design was executed in compliance with the Helsinki Declaration.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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