

Mid-urethral slings in female incontinence: Current status

Ryan M. Krilin, Alana M. Murphy, Michael S. Ingber¹, Sandip P. Vasavada

Cleveland Clinic, Glickman Urological and Kidney Institute, Section of Female Pelvic Medicine and Reconstructive Surgery Cleveland, OH, ¹Department of Urology and Urogynecology, Saint Claire's Hospital, Denville, NJ, USA

ABSTRACT

The advent of the mid-urethral sling (MUS) 15 years ago has drastically changed the surgical management of stress urinary incontinence (SUI). Both retropubic and transobturator MUS can be placed in the ambulatory setting with excellent results. The tension-free vaginal tape (TVT) sling has the most robust and long-term data, but more recent literature suggests that the transobturator tape sling may offer comparable efficacy in appropriately selected patients. Single incision sling (SIS) is the newest addition to the MUS group and was developed in an attempt to minimize morbidity and create an anti-incontinence procedure that could be performed in the office. The efficacy of SIS remains unknown as the current literature regarding SIS lacks long-term results and comparative trials. The suprapubic arc sling appears to have equally effective outcomes in at least the short-term when compared with TVT. Although evolution of the SIS has led to a less invasive procedure with decreased post-op pain and reduced recovery time, durability of efficacy could be the endpoint we are sacrificing. Until longer-term data and more quality comparison trials are available, tailoring one's choice of MUS to the individual patient and her unique clinical parameters remains the best option.

Key words: Incontinence surgery, mid-urethral sling, stress urinary incontinence, tension-free vaginal tape, transobturator tape

INTRODUCTION

Significant changes in the treatment of stress urinary incontinence (SUI) have been made over the last 15–20 years, most notably in 1996 with the development of the tension-free vaginal tape (TVT) (Gynecare, Somerville, NJ, USA).^[1] This treatment was based on the Integral Theory, which suggests that continence depends on urethral closure related to interplay between the pubourethral ligaments, a suburethral vaginal hammock and the pubococcygeous muscles. This innovation armed the surgeon with a minimally invasive approach to treat SUI utilizing a synthetic

polypropylene mesh and was readily adopted, fostering an evolution from the accepted gold-standards of the Burch urethropexy and autologous fascial sling to the present day mid-urethral sling (MUS).

Current slings can be placed in the ambulatory setting through a small vaginal incision. Following minimal dissection, an MUS is placed using a retropubic (RP) approach, either in a “bottom to top” or in a “top to bottom” fashion, or a transobturator (TO) approach, either in an “in to out” or an “out to in” fashion. To further decrease the invasiveness of the procedure, the single-incision approach has been developed, avoiding the RP space, obturator fossa, and their associated incisions. To our knowledge, all commercially available MUS are now made from type 1 uncoated mesh [macroporous (>75 μm) and monofilament].^[2]

For correspondence: Dr. Sandip P. Vasavada, Cleveland Clinic, Glickman Urological and Kidney Institute, 9500 Euclid Ave, Q10-1, Cleveland, OH 44195, USA. E-mail: vasavas@ccf.org

Access this article online	
Quick Response Code:	Website: www.indianjurol.com
	DOI: 10.4103/0970-1591.85424

RP SLINGS

TVT

With respect to the RP approach, the TVT has the most prospective data in the literature, but the suprapubic arc (SPARC) sling appears to have equal cure and complication rates in shorter-term studies. Other RP slings have a paucity of data and long-term equivalency studies have yet to be reported. The TVT has long-term efficacy data in both

the urologic and gynecologic literature. This is nicely highlighted by Nilsson *et al.* in the Nordic multi-centered prospective study, which demonstrates the efficacy with this RP approach. They report on an original cohort of 90 women who had a TVT for treatment of SUI. A total of sixty-nine women (77%) were available for follow-up, which included a cough-stress test, 24-hour pad test and post-void residual urine volume. This study defined cure as < 8g of leakage on the 24-hour pad test and absence of leakage on an office cough-stress test. Fifty-five women (90.2%) were deemed objectively cured at a mean follow-up of 11.5 years. Subjectively, 53/69 (77%) women considered themselves cured based on the Patient Global Impression scale.^[3]

In 2008, Nilsson's results were confirmed in 2008 by Liapis and colleagues. Seventy women who underwent TVT were assessed with physical examination, urodynamics, and 1-hour pad testing at 5 years. These patients then had repeat urodynamics and completed a satisfaction questionnaire at 7 years. Patients were considered cured based on a urodynamic stress test and a pad test. The objective cure was 83% at 5 years and 80% at 7 years.^[4] Ward and Hilton reported their 5-year randomized trial outcome data on 344 women in 2007, which compared TVT with Burch colposuspension. The primary outcome measure was a one-hour pad test with cure defined as a pad weight of < 1g. Rates of objective cure were similar between the two groups, with 58/72 (81%) women in the TVT group and 44/49 (90%) in the colposuspension group having pad weights less than 1 gm ($P=0.21$).^[5] These studies further support the body of quality data on the retropubic TVT. Overall, there is a preponderance of good quality data to support the use of the RP TVT.

SPARC sling

The suprapubic arc (SPARC) sling was developed as a modification of the TVT with the use of antegrade trocar placement in contrast to retrograde trocars. The SPARC literature is more limited compared to the TVT literature, but there are several studies with at least one-year follow-up. Andonian *et al.* randomized 84 women to either TVT ($n=43$) or SPARC ($n=41$). Follow-up at 1, 6 and 12 months assessed complications and cure rates, where objective cure was defined as 1-hour pad weights of < 2 g. At 12 months, no difference in objective cure was seen between the two groups, with cure rates of 95% in the TVT group and 83% in the SPARC group ($P=0.1$).^[6]

In a 2008 retrospective chart review over a 5-year period, Nazemi *et al.* reported on 307 patients who underwent a SPARC sling for SUI. One hundred fifty-four women (55%) responded to questionnaires at a mean follow-up of 36 months. Complete resolution of SUI was seen in 52 women (33.8%) and 54 women (35.1%) had less than one weekly episode of SUI. Eleven (7.1%) patients had one or more episodes of leakage per week, but considered

themselves greater than 70% improved. With both of these groups considered a success the overall success rate of these patients was 76%.^[7]

A 2006 prospective trial by Primus evaluated patients undergoing SPARC for the indications of stress or mixed urinary incontinence, reporting 1-year follow-up on 64 patients. At 12 months 54 women had a negative cough-stress test and pad-test, yielding an objective cure rate of 84.4%. The subjective cure rate was 75%, as 48 women had no leakage during daily activities and no pad use.^[8] From these shorter-term studies, outcomes with the SPARC appear equally effective compared with TVT.

Other RP approaches that obviate the need for a commercial kit have been described. From a cost standpoint, there is a significant savings on materials by cutting one's sling mesh and passing it with reusable Raz or Stamey needles. Raz describes a self-fashioned distal polypropylene sling passed in this manner with a cost of about \$15 for the mesh, which they highlight is not as cost prohibitive as kits.^[9] Outcomes were good with objective and subjective cure rates of 92% and 89%, respectively. Although this distal placement has not been generalized across urology, Kapoor *et al.* describe a mid-urethral modification of the Raz technique with 85% of their patients completely dry.^[10] These approaches remain a viable and cost-effective method for the treatment of SUI.

TO SLINGS

Delorme introduced the TO approach in 2001. The TO technique avoids the RP space and addresses clinicians' concerns regarding potential bladder, intestinal and vascular injuries, as well as attempts to minimize voiding dysfunction after TVT.^[11] The described transobturator tape (TOT) technique is an "out to in" approach from the thigh to the vaginal incision. In Delorme's study, at a mean follow up of 17 months, 29/32 patients (90.6%) were cured and 3/32 (9.4%) improved. Cure was defined as wearing no protection, no report of SUI and no leakage during cough stress test with a full bladder. Modifications were later made to this procedure by de Leval in 2003, who changed the approach to an "in to out" technique with the TVT-Obturator (TVT-O, Ethicon).^[12] At 12 months, the cure rate of 102 patients, as defined by the absence of subjective SUI reported on a symptom scale and a negative cough stress test, was reported as 91% with no erosions or extrusions. Medium-term results at 3 years were available for 91 patients and cure rates remained similar at 88.4% via questionnaire. Additionally, frequency and urgency symptoms were significantly improved.^[13] Several iterations of the "out to in" technique now exist on the market [Table 1]. Direct comparisons of efficacy between TO slings have been demonstrated in at least three randomized studies. These studies report similar objective cure rates of 83–98% for the "out to in" approach and 87–98% for the "in to out" approach. When looking at

Table 1: Commonly used commercially available mid-urethral slings (adapted from Rapp and Kobashi^[2])

Name	Type	Manufacturer
TVT™	RP “bottom to top”	Ethicon
Advantage®	RP “bottom to top”	Boston Scientific
SPARC™	RP “top to bottom”	AMS
Lynx®	RP “top to bottom”	Boston Scientific
Prefyx PPS™	Pre-pubic “bottom to top”	Boston Scientific
Monarc™	TO “out to in”	AMS
ObTryx®	TO “out to in”	Boston Scientific
Aris®	TO “out to in”	Coloplast
TVT™-O	TO “in to out”	Ethicon
MiniArc™	Single incision	AMS
TVT Secur™	Single incision	Ethicon
Ajust™	Single incision	Bard
Solyx™	Single incision	Boston Scientific

Ethicon Inc., Somerville, NJ, USA; Boston Scientific Inc., Maple Grove, MN, USA; AMS, American Medical Systems, Minnetonka, MN, USA; Coloplast A/S, Copenhagen, Denmark; CR Bard Inc., Covington, GA, USA

subjective cure rates, the cure rate was 77–89% for the “out to in” approach and 80–91% for the “in to out” approach.^[14-16]

SINGLE INCISION SLING

In an attempt to further decrease the invasiveness of the RP and TO MUS, the single incision sling (SIS) has been developed. The theoretical advantage of the SIS is the avoidance of the RP space and obturator fossa, and the lack of necessary thigh or suprapubic incisions. There are presently three SISs available on the market [Table 1]. At this time, however, there is a paucity of medium- to long-term data pertaining to the SIS. Kennelly *et al.* published their 12-month outcomes with the MiniArc in 157 patients. A negative cough stress test was found in 90.6%, and 84.5% had a 1-hour pad weight test less than 1 g.^[17] In 2011, Pickens reported on 108 patients undergoing the MiniArc with a 94% cure rate at 12 months, where cure was a negative response to direct questioning about stress-related leakage or a “not at all” response to question three on the UDI-6.^[18] Both studies also showed statistically significant improvements in the UDI-6 and IIQ-7 scores. In a recent European study, the TVT Secur was compared to the TVT-O in a multicenter, prospective, randomized, control trial.^[19] One-year follow-up for 75 TVT Secur and 85 TVT-O patients showed objective post-op SUI of 16.4% with TVT Secur versus 2.4% with TVT-O ($P = 0.002$). Subjectively, 24% of TVT Secur patients reported SUI versus 8.3% with a TVT-O ($P = 0.008$). Up to the 2-week post-op period, significantly less pain was noted with the TVT Secur. Although this evolution has led to a less invasive procedure with decreased post-op pain and reduced recovery time, durability of efficacy could be the endpoint we are sacrificing. Additional medium- to long-term data are needed to answer this question.

OUTCOMES

In a 2011 Cochrane review of 62 trials involving 7101 women undergoing RP and TO slings, minimally invasive synthetic suburethral sling operations appeared to be as effective as traditional suburethral slings, but with less postoperative voiding dysfunction and less *de novo* urgency symptoms.^[20] When compared to open RP colposuspension, MUS appeared to be as effective and had fewer postoperative complications and less postoperative voiding dysfunction. When a subanalysis was performed based on the technique utilized with the RP approach, the “bottom to top” route was more effective than the “top to bottom” and had significantly less voiding dysfunction, bladder perforations and erosions. In comparisons between the RP and TO approaches, the TO approach was less successful than RP with respect to objective cure (84% vs. 88%; RR 0.96, 95% CI 0.93–0.99); however, there was no difference in subjective cure rates. The TO approach had less voiding dysfunction, blood loss, bladder perforations and shorter operative times.

SPECIAL SITUATIONS

The use of MUS in the treatment of SUI with demonstrable urethral hypermobility and pure urodynamic SUI is well established. However, the indications for MUS have been expanded to include other special situations. These special situations deserve mention as they may require additional patient counseling to manage expectations, as well as special skill sets to achieve the desired outcomes. Such conditions are mixed urinary incontinence, low leak-point pressures, minimal urethral hypermobility, recurrent SUI, concomitant prolapse surgery, obesity and advanced age.

Mixed urinary incontinence

Women with both stress and urgency urinary incontinence can be challenging to manage. It is important to determine which component is more bothersome as it will help in directing treatment. Urodynamic studies are frequently advocated prior to surgery in patients with mixed incontinence (MUI), as leakage with stress and urgency often coexists. In patients without detrusor overactivity there is some limited data suggesting they have a higher chance of resolution of their urgency symptoms after a sling than those with urodynamic detrusor overactivity. In patients with a predominant stress component, the MUS has been shown to improve urgency and urgency incontinence (UUI).

Cure with MUI was addressed when Paick *et al.* retrospectively looked at 144 patients undergoing TVT, SPARC, or TVT-O and evaluated them for cure of stress and urgency incontinence. They defined cure of SUI as absence of leakage during cough stress test and by self-reported. UUI cure was defined by the absence of a subjective complaint of urgency leakage. Mean follow-up was 10.9 months, and

cure rates for UUI for the TVT, SPARC, and TVT-O were 81.9%, 86.4%, and 82.0%, respectively ($P=0.965$). Cure rates for the SUI were 95.8%, 90.9%, and 94.0%, respectively ($P=0.625$). Overall cure rates were 81.9%, 77.3%, and 78.0% ($P=0.579$). In these patients with MUI, multivariate analysis showed that failure to cure UUI was predicted by low maximum urethral closure pressures (MUCP) and presence of uninhibited detrusor overactivity (DO).^[21]

Urodynamic findings pre- and postoperatively were addressed in a smaller retrospective study by Panayi *et al.* who reported their experience with mixed incontinence and TVT. Thirty-five of the 46 women with follow-up in their series agreed to repeat urodynamic testing postoperatively of whom 17 reported OAB symptoms postoperatively. On urodynamics 19/35 women (54%) had DO during filling but only 11 of these 19 women (58%) reported OAB symptoms at the beginning of the study. Women reporting symptoms of OAB postoperatively had a higher preoperative opening detrusor pressure than those without OAB symptoms (33.0 cmH₂O vs. 16.0 cmH₂O, respectively ($P < 0.05$)).^[22]

In yet another study Botros *et al.* focused on the resolution of DO and UUI in 276 women undergoing TVT, SPARC or Monarc slings for stress or mixed incontinence. Patients were evaluated with a physical exam, urgency incontinence questionnaire and urodynamics. One hundred eighty-one patients were available to have repeat urodynamics at three months. Interestingly, DO was improved in each group, 40%, 32% and 48% improved in the TVT, SPARC and Monarc groups, respectively ($P=0.39$). Urgency symptoms worsened in 14-16% of patients with preoperative UUI in the retropubic groups versus 6% of patients in the Monarc group ($P = 0.02$). High rates of de novo urgency were seen in 32% of the TVT group and 22% of the SPARC and Monarc groups. It should be noted that not all patients underwent solitary sling procedures, as there were concomitant prolapse repairs which may be a potential confounder.^[23]

Intrinsic sphincter deficiency

ISD is defined urodynamically as a valsalva leak point pressure (VLPP) < 60 cm H₂O or a MUCP < 20 cm H₂O. It creates a subset of incontinent patients that can be challenging to treat, as their SUI is more severe. Traditionally periurethral bulking agents were utilized as a mainstay of treatment of this pathology, requiring subsequent injections. However, the MUS has emerged as a treatment option for this more problematic group.

In comparing TVT with Monarc for the treatment of ISD, Schierlitz *et al.* published short-term results of their randomized controlled trial of 164 women with ISD. Urodynamic SUI at six months was used to define postoperative failure. This was seen in 14/67 (21%) of women who underwent TVT vs 32/71 (45%) of women who

had an obturator sling, with nine of those patients requiring repeat SUI surgery versus none who had TVT.^[24]

A retrospective study by Jeon *et al.* looked at treatment of ISD with an autologous fascial sling (AFS), TVT or TOT in 253 patients. The definition of cure for this study included absence of leakage on subjective questionnaire and a negative cough stress test on physical exam. Median follow-up in the AFS, TVT, and TOT groups were 36, 24, and 12 months, respectively. The groups were not statistically different with respect to baseline characteristics or complication rates. At two years, AFS had the highest cure rate at 87.3%, followed by the TVT at 86.9% and the TOT at 34.9% ($P < 0.0001$). Long-term cure rates in the limited number of women with 7-year follow-up were low in the TVT and AFS group, at 55.1% and 59.1%, respectively.^[25]

A randomized trial of TVT versus TVT-O for the treatment of SUI by Araco *et al.* stratified 208 patients based on their preoperative urodynamic VLPP. They defined cure as 1-hour pad tests < 2 gm at 6 months and absence of urodynamic SUI at 1 year. In those with mild incontinence cure rates were similar, but patients with severe incontinence (VLPP < 60 cm H₂O) had a higher cure rate was seen in the group treated with a TVT [100% versus 66% with TVT-O ($P < 0.001$)].^[26] In contrast to the Araco study, Costantini *et al.* demonstrated in a randomized trial of 145 patients that cure for ISD was equal between TVT and TOT. 50 women (34.5%) in this cohort had a VLPP < 60 cm H₂O. Cure was achieved when patients reported being completely dry upon interview and had a negative cough stress test. The overall cure rate in patients with ISD was 72%. Although the numbers are small, when subanalysis was performed there was no difference in cure rates between TVT and TOT [76% vs 68%, respectively ($P=0.528$)].^[27] On the contrary, another randomized study demonstrated equal efficacy between TVT and TOT in 145 patients with ISD. Of the entire cohort, 50 women (34.5%) had a VLPP < 60 cm H₂O. A patient was cured if they were completely dry based on patient interview and cough stress test on exam. The overall cure rate in patients with ISD was 72%. A subanalysis demonstrated no difference in cure rates in patients who had a TVT or TOT [76% vs. 68%, respectively ($P = 0.528$)]. This study is limited by its small numbers, although the mean follow-up was over 30 months.^[27]

TOMUS is the largest, multicenter equivalence trial comparing the 12-month efficacy and safety of the TO and RP MUS. Five hundred sixty-five randomized women completed the 12-month assessment with objective success rates of 80.8% in the RP sling group and 77.7% in the TO sling group.^[28] Objective success was a negative provocative stress test, a negative 24-hour pad test and no retreatment for SUI. The data suggest that patients with more severe urethral dysfunction (VLPP ≤ 60 cm H₂O or MUCP ≤ 20 cm H₂O) were no more likely to have treatment failure with the TO

MUS than with the RP MUS. It should be noted, however, that the number of women with severe urethral dysfunction in this study was small and that women who underwent an RP approach had lower baseline VLPP.

The authors use the degree of urethral mobility to help determine what type of sling is used. Patients with significant hypermobility do well with both RP and TO slings. However, based on some of the aforementioned studies and the author's experience, we prefer an RP sling when there is limited mobility (as determined by a Q-tip test). When urodynamics are performed, many women with limited urethral mobility will be found to have low VLPPs.

Recurrent SUI

Managing the outlet after failed retropubic, transobturator or single incision sling in cases of recurrent SUI can prove difficult and has been addressed in the literature. In 2009, Liapis *et al.* looked at 31 patients undergoing repeat MUS and found that the cure rate following TVT for recurrent SUI was 74%.^[29] There was a better response, however, in those with more urethral hypermobility. Success is not limited to the TVT, however. Biggs *et al.* demonstrated success with the TO sling in women with failed anti-incontinence procedures.^[30] In this series, 27 women with urethral hypermobility underwent TVT-O. The subjective success as defined by the Patient Global Impression of Improvement (PGI-I) responses of "much better" or "very much better" was 80% at a mean follow-up of 25.7 months. To assist with deciding between an RP and a TO approach, a study by Stav *et al.* showed that although repeat MUS yielded lower subjective success than initial placement (62% vs. 86%), repeat RP slings were more successful than repeat TO slings (71% vs. 48%).^[31] In our practice, we routinely perform MUS procedures on adequately informed patients with recurrent SUI when urethral hypermobility can be demonstrated; otherwise limited urethrolysis may be performed concomitantly.

Concomitant prolapse surgery

The decision to perform an anti-incontinence procedure at the time of prolapse remains a topic of some controversy when clinical, occult or urodynamic SUI cannot be demonstrated. In a 2004 non-randomized study by Groutz *et al.*, 100 clinically continent women with occult SUI underwent prolapse repair with concomitant anti-incontinence procedure. During the follow-up period, only two patients had symptomatic SUI.^[32] In another trial, Liang *et al.* randomized 79 patients with positive pessary tests who were undergoing hysterectomy and prolapse repair to TVT versus no TVT.^[33] The TVT group demonstrated a significantly lower rate of postoperative subjective SUI than the group that did not undergo TVT placement (10% vs. 65%). Interestingly, patients with a negative pessary test and no MUS also had no postoperative SUI. The OPUS trial is presently underway to evaluate prophylactic sling

placement.^[34] In our practice, the MUS is utilized with a concomitant prolapse repair in patients with clinical, occult or urodynamic SUI.

Obesity and advanced age

Obesity as a predictor of success after MUS placement has not been directly examined as a variable in a prospective randomized trial. Numerous studies have shown, however, that TVT cure rates are not affected by obesity. Killingsworth *et al.* retrospectively reviewed subjective outcomes, 1 year after TVT placement, with validated questionnaires and found no differences in satisfaction, improvement or complications rates when patients were stratified by body mass index.^[35] Age as a predictor of MUS outcome remains largely undefined. There is a discrepancy in the literature as to the definition of advanced age. The evidence that favors an RP approach is confounded by higher rates of detrusor overactivity and ISD, and no TO studies address this specific elderly population. Clinical judgment should be applied to each patient and their unique situation.

CONCLUSIONS

Advancements in the treatment of SUI have led to progressively less invasive procedures with high success rates, durable outcomes and minimal complications. Long-term data are lacking on newer techniques, which may or may not prove to be equal. Until longer-term data and more quality comparison trials are available, tailoring one's choice of MUS to the individual patient and her unique clinical parameters remains the best option.

REFERENCES

1. Ulmsten U, Henriksson L, Johnson P, Varhos G. An ambulatory surgical procedure under local anesthesia for treatment of female urinary incontinence. *Int Urogynecol J* 1996;7:81-6.
2. Rapp DE, Kobashi KC. The evolution of midurethral slings. *Nat Clin Pract Urol* 2008;5:194-201.
3. Nilsson CG, Palva K, Rezapour M, Falconer C. Eleven years prospective follow-up of the tension-free vaginal tape procedure for treatment of stress urinary incontinence. *Int Urogynecol J* 2008;19:1043-7.
4. Liapis A, Bakas P, Creatsas G. Long-term efficacy of tension-free vaginal tape in the management of stress urinary incontinence in women: Efficacy at 5- and 7-year follow-up. *Int Urogynecol J* 2008;19:1509-12.
5. Ward K, Hilton P. On behalf of the UK and Ireland TVT Trial Group. Tension-free vaginal tape versus colposuspension for primary urodynamic stress incontinence: 5-year follow up. *BJOG* 2008;115:226-33.
6. Andonian S, Chen T, St-Denis B, Corcos J. Randomized clinical trial comparing suprapubic arch sling (SPARC) and tension-free vaginal tape (TVT): One-year results. *Eur Urol* 2005;47:537-41.
7. Nazemi TM, Yamada B, Govier FE. Minimum 24-month followup of the sling for the treatment of stress urinary incontinence. *J Urol* 2008;179:596-9.
8. Primus G. One year follow-up on the SPARC sling system for the treatment of female urodynamic stress incontinence. *Int J Urol* 2006;13:1410-4.
9. Rodriguez LV, Raz S. Prospective analysis of patients treated with a

- distal urethral polypropylene sling for symptoms of stress urinary incontinence: Surgical outcome and satisfaction determined by patient driven questionnaires. *J Urol* 2003;170:857-63.
10. Kapoor R, Maheshwari R, Kapoor D, Singh UP, Upadhyay R. Is the modified Raz technique of midurethral sling a reliable and cost-effective method of treating stress urinary incontinence?. *Indian J Urol* 2011;27:34-8.
 11. Delorme E, Droupy S, de Tayrac R, Delmas V. Transobturator tape (Uratape): A new minimally-invasive method in the treatment of urinary incontinence in women. *Prog Urol* 2003;13:656-9.
 12. de Leval J. Novel surgical technique for the treatment of female stress urinary incontinence: Transobturator vaginal tape inside-out. *Eur Urol* 2003;44:742-30.
 13. Waltregny D, Gaspar Y, Reul O, Hamida W, Bonnet P, de Leval J. TVT-O for the treatment of female stress urinary incontinence: results of a prospective study after a 3-year minimum follow-up. *Eur Urol* 2008;53:401-8.
 14. Liapis A, Bakas P, Creatsas G. Monarc vs TVT-O for the treatment of primary stress incontinence: A randomized study. *Int Urogynecol J Pelvic Floor Dysfunct* 2008;19:185-90.
 15. Abdel-fattah M, Ramsay I, Pringle S, Hardwick C, Ali H. Evaluation of transobturator tapes (E-TOT) study: Randomised prospective single-blinded study comparing inside-out vs, outside-in transobturator tapes in management of urodynamic stress incontinence: Short term outcomes. *Eur J Obstet Gynecol Reprod Biol* 2010;149:106-11.
 16. But I, Faganelj M. Complications and short-term results of two different transobturator techniques for surgical treatment of women with urinary incontinence: A randomized study. *Int Urogynecol J Pelvic Floor Dysfunct* 2008;19:857-61.
 17. Kennelly MJ, Moore R, Nguyen JN, Lukban JC, Siegel S. Prospective evaluation of a single incision sling for stress urinary incontinence. *J Urol* 2010;184:604-9.
 18. Pickens RB, Klein FA, Mobley JD 3rd, White WM. Single incision mid-urethral sling treatment of female stress urinary incontinence. *Urology* 2011;77:321-4.
 19. Hinoul P, Vervest HA, den Boon J, Venema PL, Lakeman MM, Milani AL, *et al.* A randomized, controlled trial comparing an innovative single incision sling with an established transobturator sling to treat female stress urinary incontinence. *J Urol* 2011;185:1356-62.
 20. Ogah J, Cody D, Rogerson L. Minimally invasive synthetic suburethral sling operations for stress urinary incontinence in women: A short version Cochrane review. *Neurourol Urodyn* 2011;30:284-91.
 21. Paick JS, Oh SJ, Kim SW, Ku JH. Tension-free vaginal tape, suprapubic arc sling, and transobturator tape in the treatment of mixed urinary incontinence in women. *Int Urogynecol J Pelvic Floor Dysfunct* 2008;19:123-9.
 22. Panayi DC, Duckett J, Digesu GA, Camarata M, Basu M, Khullar V. Pre-operative opening detrusor pressure is predictive of detrusor overactivity following TVT in patients with pre-operative mixed urinary incontinence. *Neurourol Urodyn* 2009;28:82-5.
 23. Botros SM, Miller JJ, Goldberg RP, Gandhi S, Akl M, Beaumont JL, *et al.* detrusor overactivity and urge urinary incontinence following trans obturator versus midurethral slings. *Neurourol Urodyn* 2007;26:42-5.
 24. Schierlitz L, Dwyer PL, Rosamilia A, Murray C, Thomas E, De Souza A, *et al.* Effectiveness of tension-free vaginal tape compared with transobturator tape in women with stress urinary incontinence and intrinsic sphincter deficiency. *Obstet Gynecol* 2008;112:1253-61.
 25. Jeon MJ, Jung HJ, Chung SM, Kim SK, Bai SW. Comparison of the treatment outcome of pubovaginal sling, tension-free vaginal tape, and transobturator tape for stress urinary incontinence with intrinsic sphincter deficiency. *Am J Obstet Gynecol* 2008;199:76.e1-4.
 26. Araco F, Gravante G, Sorge R, Overton J, De Vita D, Sesti F, *et al.* TVT-O vs TVT: A randomized trial in patients with different degrees of urinary stress incontinence. *Int Urogynecol J Pelvic Floor Dysfunct* 2008;19:917-26.
 27. Costantini E, Lazzeri M, Giannantoni A, Bini V, Vianello A, Kocjancic E, *et al.* Preoperative valsalva leak point pressure may not predict outcome of mid-urethral slings. Analysis from a randomized controlled trial of retropubic versus transobturator mid-urethral slings. *Int Braz J Urol* 2008;34:73-83.
 28. Richter HE, Albo ME, Zyczynski HM, Kenton K, Norton PA, Sirls LT, *et al.* Retropubic versus transobturator midurethral slings for stress incontinence. *N Engl J Med* 2010;362:2066-76.
 29. Liapis A, Bakas P, Creatsas G. Tension-free vaginal tape in the management of recurrent urodynamic stress incontinence after previous failed midurethral tape. *Eur Urol* 2009;55:1450-5.
 30. Biggs GY, Ballert KN, Rosenblum N, Nitti V. Patient-reported outcomes for tension-free vaginal tape-obturator women treated with a previous anti-incontinence procedure. *Int Urogynecol J Pelvic Floor Dysfunct* 2009;20:331-5.
 31. Stav K, Dwyer PL, Rosamilia A, Schierlitz L, Lim YN, Chao F, *et al.* Repeat synthetic mid urethral sling procedure for women with recurrent stress urinary incontinence. *J Urol* 2010;183:241-6.
 32. Groutz A, Gold R, Puzner D, Lessing JB, Gordon D. Tension-free vaginal tape (TVT) for the treatment of occult stress urinary incontinence in women undergoing prolapse repair: A prospective study of 100 consecutive cases. *Neurourol Urodyn* 2004;23:632-5.
 33. Liang CC, Chang YL, Chang SD, Lo TS, Soong YK. Pessary test to predict postoperative urinary incontinence in women undergoing hysterectomy for prolapse. *Obstet Gynecol* 2004;104:795-800.
 34. Wei J, Nygaard I, Richter H, Brown M, Barber M, Xiao Xu, *et al.* Outcomes following vaginal prolapse repair and mid urethral sling (OPUS) trial-design and methods. *Clin Trials* 2009;6:162-71.
 35. Killingsworth LB, Wheeler TL II, Burgio KL, Martirosian TE, Redden DT, Richter HE. One-year outcomes of tension-free vaginal tape (TVT) mid-urethral slings in overweight and obese women. *Int Urogynecol J Pelvic Floor Dysfunct* 2009;20:1103-8.

How to cite this article: Krlin RM, Murphy AM, Ingber MS, Vasavada SP. Mid-urethral slings in female incontinence: Current status. *Indian J Urol* 2011;27:320-5.

Source of Support: Nil, **Conflict of Interest:** None declared.