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**The Effect of Subsequent Pregnancy and Childbirth on Stress Urinary  
Incontinence Recurrence Following Mid-Urethral Sling procedure:  
A Meta-Analysis**

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**Tweetable Statement:** Pregnancy and childbirth following a mid-urethral sling procedure does not increase the risk for stress urinary incontinence recurrence or reoperation.

**Short title:** SUI Recurrence following a MUS and subsequent childbirth.

**AJOG at a glance:**

□ A. Why was this study conducted?

To assess the risk for stress urinary incontinence (SUI) recurrence following pregnancy and childbirth in women who had already undergone a mid-urethral sling procedure for SUI and to assess the effect of delivery mode on this risk.

□ B. What are the key findings?

Subsequent childbirth did not seem to carry an increased risk for SUI recurrence or reoperation. Furthermore, the mode of delivery (vaginal versus cesarean) did not seem to affect this risk.

□ C. What does this study add to what is already known?

This is the first study to integrate all published data regarding the effect of subsequent pregnancy and childbirth on the risk of SUI recurrence following a mid-urethral sling procedure.

## Abstract

**Objective:** To assess the risk for stress urinary incontinence (SUI) recurrence and reoperation following a midurethral sling (MUS) procedure in women with a subsequent childbirth and to assess the effect of delivery mode on this risk.

**Data sources:** We performed an electronic database search using MEDLINE with the OvidSP interface and PUBMED, Embase, Web of Science and Cochrane Library up to September 20<sup>th</sup>, 2023.

**Study eligibility criteria:** We included experimental and non-experimental studies, comprising of randomized controlled and observational (case-control, cohort, cross-sectional) studies assessing risk factors for SUI recurrence and reoperation following childbirth in women who had previously undergone a MUS procedure for SUI.

**Study appraisal and synthesis method:** Analysis was conducted using RevMan 5.3 (Cochrane Collaboration, Oxford, UK). Quantitative synthesis was utilized if the included studies were sufficient in numbers and homogeneity. The overall certainty of the evidence was assessed using criteria recommended by the Grading of Recommendations Assessment, Development and Evaluation Working Group (GRADE).

**Results:** A total of 2,001 studies were identified of which six were eligible for analysis, comprising 381 patients who had at least one childbirth following a MUS procedure (study group), and 860 patients who underwent a MUS without having a subsequent childbirth (control group). All included studies were observational, the patients' mean age at the time of the MUS procedure ranged from 34 to 36 years and the mean time from MUS procedure to delivery ranged from 21 to 31 months. No differences in SUI recurrence (RR 0.1.02 [95%CI 0.78-1.33]) or reoperation (RR 1.37 [95% CI 0.87-2.17]) were found between the study and control groups. The



average follow-up time among the included studies of this comparison was 9.8 years (range 2-18 years). Furthermore, the mode of delivery (vaginal versus cesarean) did not seem to affect the risk for SUI recurrence.

**Conclusions:** Subsequent pregnancy and childbirth do not seem to increase the risk for SUI recurrence or reoperation following a MUS procedure.

**Keywords:** childbirth; delivery; midurethral sling; pregnancy; recurrence; reoperation; Tension-free vaginal tape

## Introduction

Stress urinary incontinence (SUI) is a bothersome condition which adversely affects women's quality of life worldwide. The estimated prevalence of SUI in the general population is 20-25%, while in younger women the rates range from 4 to 23%<sup>1-3</sup>. The mid-urethral sling (MUS) procedure is considered to be the gold standard treatment for SUI with success rates of up to 85%<sup>4</sup>. A unique group of women who have not yet completed their family planning and seek surgical treatment for SUI, pose a clinical dilemma as for the potential determinantal effect of additional pregnancy and childbirth on their surgical outcome. Many clinicians recommend postponing surgical treatment for SUI until completion of childbearing due to concern regarding SUI recurrence following subsequent pregnancy and childbirth<sup>5,6</sup>. Furthermore, many advocate cesarean rather than vaginal delivery following a previous MUS procedure<sup>6</sup>. These policies are based upon the fact that pregnancy and childbirth have been shown to be major risk factors for SUI. Nonetheless, whether they affect the risk for recurrent SUI following a MUS procedure is yet unclear, as only few studies have addressed this question with conflicting results<sup>5,7-11</sup>. The primary goal of the current study was to perform a comprehensive meta-analysis based on currently available data regarding the effect of subsequent pregnancy and childbirth on the risk for SUI recurrence and reoperation following a MUS procedure. A secondary goal was to assess the effect of the mode of delivery (vaginal versus cesarean) on the risk for SUI recurrence and reoperation following a MUS procedure.

## Methods

### Search strategy and selection criteria

This meta-analysis was conducted by the Cochrane Handbook for Systematic Reviews of Interventions<sup>12</sup>. Study protocol can be assessed at PROSPERO International prospective register of systematic reviews (<http://www.crd.york.ac.uk/PROSPERO>, registration number CRD42022346236).

Searches were conducted by an experienced research librarian using the following databases: MEDLINE using the OvidSP interface and PUBMED, Embase, Web of Science and Cochrane Library up to September 20<sup>th</sup>, 2023. Search strategies are detailed in Supplementary Document 1. No restrictions were imposed regarding the year of publication. Only manuscripts in the English language were included. We included experimental and non-experimental studies, comprising of randomized controlled as well as observational (case-control, cohort, cross-sectional) studies assessing the effect of subsequent pregnancy and childbirth on the risk for SUI recurrence and reoperation following a MUS procedure, as compared to women who had undergone a MUS procedure without subsequent childbirth. We also included studies assessing the effect of delivery mode (vaginal versus cesarean) on this risk. Case reports, reviews, editorials, and non-human studies were excluded. Abstracts of studies were excluded if the entire article was not published as well. If two publications seemed identical (duplicate publication), only one of the studies was included. Screening of titles, abstracts and full texts was conducted independently by two reviewers; disagreements were resolved by discussion. If needed due to a disagreement, a third reviewer was added to the discussion. A detailed list of study characteristics related to patients' demographics, clinical data and study methodology was created for all studies included in this meta-analysis.

## Outcomes

Primary outcome:

1. SUI recurrence following childbirth.
2. Reoperation for SUI recurrence following childbirth.

Secondary outcome:

1. The effect of delivery mode (vaginal birth versus cesarean section) on SUI recurrence.
2. The effect of delivery mode (vaginal birth versus cesarean section) on reoperation rates for SUI.

## Strategy for data synthesis

Analysis was conducted using RevMan 5.3 (Cochrane Collaboration, Oxford, UK). We complied with the methods and techniques introduced and explained in chapter 10 of the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy<sup>12</sup>. The results were measured by risk ratio (RR), presenting the confidence interval (CI) and p-value and  $I^2$  for heterogeneity assessment. A two-tailed  $P < 0.05$  was considered statistically significant for all comparisons. Heterogeneity across studies was assessed using the  $I^2$  statistic tool. An  $I^2 < 25\%$  was considered to represent a low level of heterogeneity, while an  $I^2$  statistic of 25% to 50% a moderate level and  $I^2 > 50\%$  a high level of heterogeneity. Pooling of the results was performed using either the Mantel–Haenszel fixed effects model or the Der Simonian–Laird random-effects model. The random-effects model was used if the  $I^2$  test indicated significant heterogeneity between the studies. In contrast, the results were interpreted using the fixed-effects model in cases of low statistical heterogeneity. According to the *Cochrane Handbook for Systematic Reviews of Interventions*<sup>12</sup>, tests for funnel plot

asymmetry should be used only when at least ten studies are included in the meta-analysis since when there are fewer studies, the power of the tests is too low to distinguish the chance from real asymmetry. In our meta-analysis, only six studies were included. Therefore, publication bias was not assessed. Sensitivity analyses were conducted by omitting studies with the highest weight, removal of outliers, and by skipping one study at a time to evaluate whether the results could have been affected markedly by a single study. Quantitative synthesis was utilized if the included studies were sufficient in numbers and homogeneity.

#### **Risk of bias (quality) assessment**

Cochrane Collaboration's Risk of Bias tool would be used to evaluate the quality of randomized controlled trials. Methodological quality assessment of observational studies was conducted using the Newcastle-Ottawa Quality Assessment Scale <sup>13</sup>. The overall certainty of the evidence was assessed using criteria recommended by the Grading of Recommendations Assessment, Development and Evaluation Working Group (GRADE) <sup>14</sup>. This meta-analysis was reported according to the Meta-analysis of Observational Studies in Epidemiology (MOOSE) statement <sup>15</sup>.

## Results

### *Study selection and characteristics*

A total of 2,001 studies were identified through database searching, with 389 duplicates removed. Fig. 1 describes the data collection and selection process. Finally, we included six studies<sup>16–21</sup> comprising 381 patients who had at least one childbirth following a MUS procedure (study group) as well as 860 patients who had a MUS procedure without a subsequent childbirth (control group). Among patients in the study group 182 had a vaginal birth, 195 had a cesarean delivery and four patients had both vaginal and cesarean deliveries. No instrumental deliveries were recorded in any of the studies. Tables 1 and 2 summarize the studies' main characteristics. Three studies were population register-based and four were retrospective. SUI recurrence was defined subjectively in all studies. Patients' average age at the time of the MUS procedure ranged from 34 to 36 years. The average time from MUS procedure to delivery ranged from 21 to 31 months (Tables 1 and 2). The average follow-up time among the included studies of this comparison was 9.8 years (range 2–18 years).

The methodological quality assessment summary according to the Newcastle-Ottawa Quality Assessment Scale<sup>13</sup> is presented in Supplementary Table 2, studies ranged from low to medium quality.

### *Synthesis of results*

#### Primary outcome measure

The forest plots for the effect of childbirth on SUI recurrence and re-operation rates are presented in Fig. 2. No differences in the risk for SUI recurrence (17–24% vs. 15–22% respectively, RR 1.02 [95%CI 0.78–1.33], P=0.90, I<sup>2</sup>=46%) or re-operation (3–12% vs. 3–7% respectively, RR 1.37 [95% CI 0.87–2.17], P=0.17, I<sup>2</sup>=9%), were found

between patients with and without a childbirth following the MUS procedure.

#### Secondary outcome measures

The forest plots for the effect of delivery mode on SUI recurrence and re-operation rates are presented in Fig. 3. No differences in the risk for SUI recurrence (RR 1.81 [95%CI 0.48-6.80],  $P=0.38$ ,  $I^2=0\%$ ) or re-operation (RR 1.43 [95% CI 0.70-2.92],  $P=0.33$ ,  $I^2=0\%$ ), were found between patients who had a vaginal versus a cesarean delivery.

Sensitivity analyses showed that none of the results were significantly affected by a single study. Using the GRADE criteria <sup>14</sup>, the overall certainty of the existing evidence was determined as low considering data acquisition from observational studies. Due to low heterogeneity, high consistency between studies, and direct evidence, the final grading was not changed.

## Comment

### Principal Findings

The current meta-analysis found that subsequent labor and delivery were not associated with an increased risk for SUI recurrence or reoperation following a mean follow up period of 9.8 years from a MUS procedure. Furthermore, this risk was not affected by the mode of delivery (vaginal versus cesarean). Risk of SUI recurrence following a MUS procedure was found to range from 15% to 24%, with or without subsequent childbirth and risk for SUI reoperation following a MUS procedure was found to range from 3% to 12%.

### Comparison with Existing Literature

Stress urinary incontinence is a common disorder with an increasing incidence in postmenopausal and elderly women. A relatively small proportion of women are diagnosed with SUI at a younger age when future childbearing may still be desired. In cases where surgical treatment is considered the clinician may face questions regarding the potential effect of future childbearing on the surgical outcome of this procedure, as well as the potential effect of a MUS on future pregnancies and deliveries. Furthermore, the preferred mode of delivery following a MUS (vaginal versus cesarean) may also require patient consultation <sup>5,6</sup>.

Currently, there is paucity of evidenced-based data regarding the effect of subsequent pregnancy and delivery on the risk for SUI recurrence following a MUS procedure. Since both pregnancy and delivery are independent risk factors for pelvic floor disorders <sup>22</sup> many clinicians advocate postponing the MUS procedure until the completion of childbearing <sup>23,24</sup>. In a survey among members of the American Urogynecologic Society (AUGS) <sup>25</sup> nearly 15% of respondents stated they would not



perform an anti-incontinence surgery on patients who desire future pregnancy, and 40% said they would advocate a cesarean rather than a vaginal delivery for patients who had undergone surgery for SUI. Another survey from the United Kingdom found that although 78% of clinicians would perform an anti-incontinence procedure on patients who have not yet completed childbearing, 60% would advise a cesarean delivery in subsequent pregnancies <sup>6</sup>. Currently, AUGS states that existing data are insufficient to establish whether recurrent SUI rates differ between vaginal and cesarean delivery <sup>26</sup>. In view of the current meta-analysis it seems that subsequent childbearing does not increase the risk of SUI recurrence or re-operation following a MUS procedure. Thus, women may not need to wait until completion of childbearing before undergoing a MUS procedure. Furthermore, women may be advised that elective cesarean delivery may not be required as vaginal birth was not associated with an increased risk for SUI recurrence. Moreover, if a patient becomes incontinent following a MUS procedure and subsequent childbirth, a repeated MUS may be offered in the future. In accordance with our results, the reported reoperation rate for MUS has been reported to range between 3.5 and 14.5% <sup>27,28</sup>. Such a procedure has been found to be safe and efficient. A meta-analysis reported cure rates for recurrent SUI of 73% which is slightly lower than that for primary MUS <sup>29</sup>. Regarding pregnancy safety following a MUS procedure, studies have found that major perinatal complications due to a previous MUS procedure are extremely rare, such as complete urinary obstruction <sup>9,30</sup>. Minor complications included voiding difficulties, sling displacement, bladder irritations, and urinary tract infections <sup>9,30</sup>. Though rare, these complications need to be discussed with patients planning to perform a MUS procedure between or before planned pregnancies.

## **Strengths and Limitations**

This is the first published meta-analysis regarding the effect of subsequent childbirth on the risk for SUI recurrence and re-operation following a MUS procedure. We utilized major clinical literature databases from which data were extracted and analyzed using robust statistical methodologies. Limitations of this meta-analysis include lack of information on confounders that may influence the results as well as insufficient data regarding characteristics of the study participants such as the number of deliveries before and after the MUS procedure, birthweight, instrumental deliveries, patients BMI, the specific type of MUS performed for each woman and whether the sling was synthetic or biologic. The final number of studies included and analyzed in this meta-analysis was small (6 studies) as most studies screened were of low quality or did not comply with our inclusion criteria, and analyses included only three studies per comparison. In addition, the three population-based studies included in this meta-analysis are from a selected population in Scandinavia, thus generalization of the results to other countries may be inaccurate. Adjustments of the data presented to the local population should be taken into consideration. Last, the language restriction used in this meta-analysis might have introduced selection bias.

## **Conclusions and Implications**

This is the first meta-analysis to evaluate the effect of subsequent childbirth on the risk for recurrence and reoperation among women who had undergone a MUS procedure for SUI. The study results indicate that subsequent pregnancy and delivery do not necessarily increase the risk for SUI recurrence or reoperation following a MUS procedure. Furthermore, the mode of delivery did not seem to affect this risk. Nonetheless, due to the unavoidable confounding effect associated with

observational studies, these conclusions should be taken with a grain of salt. Well-designed prospective randomized studies are still needed in order to support or negate these findings.

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**Author's contribution:**

Chen Nahshon: Data collection, Statistical analysis, Writing - Original draft, Methodology, Investigation.

Yoram Abramov: Writing- Review and Editing, Validation, Review.

Nir Kugelman: Validation, Review.

Nadav Cohen: Validation, Review.

Ofer Lavie: Validation, Review.

Ariel Zilberlicht: Conceptualization, Writing- Review and Editing, Methodology, Investigation, Supervision.

## References

1. Nygaard IE, Heit M. Stress urinary incontinence. *Obstetrics and Gynecology*. 2004;104(3):607-620. doi:10.1097/01.AOG.0000137874.84862.94
2. Kurkijärvi K, Aaltonen R, Gissler M, Mäkinen J. Surgery for stress urinary incontinence in Finland 1987–2009. *Int Urogynecol J*. 2016;27(7):1021-1027. doi:10.1007/S00192-015-2926-Z/FIGURES/3
3. Sangsawang B, Sangsawang N. Stress urinary incontinence in pregnant women: A review of prevalence, pathophysiology, and treatment. *Int Urogynecol J*. 2013;24(6):901-912. doi:10.1007/S00192-013-2061-7/TABLES/2
4. Chmaj-Wierzchowska K, Raba G, Dykczynski P, et al. Clinical Outcomes of Mid-Urethral Sling (MUS) Procedures for the Treatment of Female Urinary Incontinence: A Multicenter Study. *Journal of Clinical Medicine* 2022, Vol 11, Page 6656. 2022;11(22):6656. doi:10.3390/JCM11226656
5. Tulokas SA, Rahkola-Soisalo P, Gissler M, Mikkola TS, Mentula MJ. Pregnancy and delivery after mid-urethral sling operation. *Int Urogynecol J*. 2021;32(1):179-186. doi:10.1007/s00192-020-04497-w
6. Arunkalaivanan AS, Barrington JW. Questionnaire-based survey on obstetricians and gynaecologists' attitudes towards the surgical management of urinary incontinence in women during their childbearing years. *European Journal of Obstetrics and Gynecology and Reproductive Biology*. 2003;108(1):85-93. doi:10.1016/S0301-2115(02)00431-1
7. Adams-Piper E, Buono K, Whitcomb E, Mallipeddi P, Castillo P, Guaderrama N. A Large Retrospective Series of Pregnancy and Delivery after Midurethral Sling for Stress Urinary Incontinence. *Female Pelvic Med Reconstr Surg*. 2016;22(5):307-310. doi:10.1097/SPV.0000000000000276
8. Cavkaytar S, Kokanali MK, Ozer I, Erkilinc S, Aksakal OS, Doganay M. Effect of pregnancy and delivery on urinary incontinence after the midurethral sling procedure. *Int Urogynecol J*. 2015;26(5):693-698. doi:10.1007/s00192-014-2568-6
9. Panel L, Triopon G, Courtieu C, Marès P, Tayrac R. How to advise a woman who wants to get pregnant after a sub-urethral tape placement? *Int Urogynecol J*. 2008;19(3):347-350. doi:10.1007/s00192-007-0444-3
10. Dyrkorn OA, Staff AC, Kulseng-Hanssen S, Schiøtz HA, Svenningsen R. Childbirth after mid-urethral sling surgery: effects on long-term success and complications. *Int Urogynecol J*. 2020;31(3):485-492. doi:10.1007/s00192-019-04067-9

11. Bergman I, Söderberg MW, Lundqvist A, Ek M. Associations between childbirth and urinary incontinence after midurethral sling surgery. *Obstetrics and Gynecology*. 2018;131(2):297-303. doi:10.1097/AOG.0000000000002445
12. Cumpston M, Chandler J. Chapter IV: Updating a review. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ WV (editors). *Cochrane Handbook for Systematic Reviews of Interventions Version 6.0 (Updated August 2019).*; 2019. doi:10.1002/9781119536604
13. Wells G, Shea B, O'Connell D, Peterson J. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Ottawa, ON: Ottawa Hospital Research Institute.
14. Balshem H, Helfand M, Schünemann HJ, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol*. 2011;64(4):401-406. doi:10.1016/J.JCLINEPI.2010.07.015
15. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *JAMA*. 2000;283(15):2008-2012. doi:10.1001/JAMA.283.15.2008
16. Adams-Piper E, Buono K, Whitcomb E, Mallipeddi P, Castillo P, Guaderrama N. A Large Retrospective Series of Pregnancy and Delivery after Midurethral Sling for Stress Urinary Incontinence. *Female Pelvic Med Reconstr Surg*. 2016;22(5):307-310. doi:10.1097/SPV.0000000000000276
17. Cavkaytar S, Kokanali MK, Ozer I, Erkilinc S, Aksakal OS, Doganay M. Effect of pregnancy and delivery on urinary incontinence after the midurethral sling procedure. *Int Urogynecol J*. 2015;26(5):693-698. doi:10.1007/s00192-014-2568-6
18. Dyrkorn OA, Staff AC, Kulseng-Hanssen S, Schiøtz HA, Svenningsen R. Childbirth after mid-urethral sling surgery: effects on long-term success and complications. *Int Urogynecol J*. 2020;31(3):485-492. doi:10.1007/s00192-019-04067-9
19. Panel L, Triopon G, Courtieu C, Marès P, Tayrac R. How to advise a woman who wants to get pregnant after a sub-urethral tape placement? *Int Urogynecol J*. 2008;19(3):347-350. doi:10.1007/s00192-007-0444-3
20. Tulokas SA, Rahkola-Soisalo P, Gissler M, Mikkola TS, Mentula MJ. Pregnancy and delivery after mid-urethral sling operation. *Int Urogynecol J*. 2021;32(1):179-186. doi:10.1007/s00192-020-04497-w
21. Bergman I, Söderberg MW, Lundqvist A, Ek M. Associations between childbirth and urinary incontinence after midurethral sling surgery. *Obstetrics and Gynecology*. 2018;131(2):297-303. doi:10.1097/AOG.0000000000002445

22. Barca JA, Bravo C, Pintado-Recarte MP, et al. Pelvic Floor Morbidity Following Vaginal Delivery versus Cesarean Delivery: Systematic Review and Meta-Analysis. *J Clin Med*. 2021;10(8). doi:10.3390/JCM10081652
23. Arunkalaivanan AS, Barrington JW. Questionnaire-based survey on obstetricians and gynaecologists' attitudes towards the surgical management of urinary incontinence in women during their childbearing years. *European Journal of Obstetrics and Gynecology and Reproductive Biology*. 2003;108(1):85-93. doi:10.1016/S0301-2115(02)00431-1
24. Kirby AC, Nager CW. Indications, contraindications, and complications of mesh in the surgical treatment of urinary incontinence. *Clin Obstet Gynecol*. 2013;56(2):257-275. doi:10.1097/GRF.0b013e31828563d2
25. Dainer M, Hall CD, Choe J, Bhatia N. Pregnancy following incontinence surgery. *Int Urogynecol J Pelvic Floor Dysfunct*. 1998;9(6):385-390. doi:10.1007/BF02199571
26. Wieslander CK, Weinstein MM, Handa VL, Collins SA. Pregnancy in Women With Prior Treatments for Pelvic Floor Disorders. *Female Pelvic Med Reconstr Surg*. 2020;26(5):299-305. doi:10.1097/SPV.0000000000000822
27. Jonsson Funk M, Siddiqui NY, Kawasaki A, Wu JM. Long-term outcomes after stress urinary incontinence surgery. *Obstetrics and gynecology*. 2012;120(1):83-90. doi:10.1097/AOG.0B013E318258FBDE
28. Karmakar D, Dwyer PL, Murray C, Schierlitz L, Dykes N, Zilberlicht A. Long-term effectiveness and safety of open Burch colposuspension vs retropubic midurethral sling for stress urinary incontinence-results from a large comparative study. *Am J Obstet Gynecol*. 2021;224(6):593.e1-593.e8. doi:10.1016/j.AJOG.2020.11.043
29. Pradhan A, Jain P, Latthe PM. Effectiveness of midurethral slings in recurrent stress urinary incontinence: a systematic review and meta-analysis. *Int Urogynecol J*. 2012;23(7):831-841. doi:10.1007/S00192-012-1803-2
30. Adams-Piper E, Darbinian J, Postlethwaite D, Castillo PA. Pregnancy after transvaginal sling for stress urinary incontinence: A case series. *Female Pelvic Med Reconstr Surg*. 2013;19:S73-S74. doi:10.1097/SPV.0b013e3182a5ddfd

426 **Legends:**

427 Figure 1: Flow chart of database searching and study selection.

428 Figure 2: Forest plots for risk following childbirth; A: Risk for SUI recurrence. B: Risk  
429 for MUS re-operation.

430 Figure 3: Forest plots for risk according to delivery method; A: Risk for SUI  
431 recurrence. B: Risk for MUS re-operation.

Table 1: Characteristics of population-based studies

Study	Country	Design	n	Type of MUS	Mean age at surgery for SUI		Time from MUS to delivery	Delivery by vaginal birth – n (%)	Delivery by cesarean section – n (%)	SUI following delivery – n (%)	SUI recurrence without delivery – n (%)	Repeat MUS- n (%)		Mean follow-up
					With delivery	Without delivery						with delivery	without delivery	
Bergman 2018	Sweden	population-based cohort study	163	374 retropubic/transobrotator	N/A	N/A	N/A	64 (39%)	95 (61%)	36 (22%)	63 (17%)	20 (12%)	28 (8%)	9 years (range 2-15)
Dyrkorn 2020	Norway	population-based cohort study	72	156 TVT/TOT/TVT-O/AJUST	34 years (range 24-44)	38 years (range 28-44)	27 months (range 10-116)	39 (54%)	33 (46%)	12 (17%)	37 (24%)	4 (6%)	5 (3%)	120 months (range 22-215)
Tolukas 2020	Finland	register-based case-control study	94	330 retropubic/transobrotator	36 years (range 32-38)	36 years (range 33-38)	2.6 years (range 1.6-4.6)	54 (57%)	40 (43%)	14 (61%)	57 (66%)	3 (3%)	17 (5%)	10.7 years (IQR 7.2-13.9)

- Additional 4 patients had both vaginal birth and cesarean section.

MUS- Midurethral sling; SUI- stress urinary incontinence; TVT- tension free vaginal tape; TOT- transobrotator tape, TVT-O- tension free vaginal tape obturator; AJUST – adjustable sling-incision sling.



Table 2: Characteristics of retrospective studies

Study	Country	Design	n	Type of MUS	Mean age at surgery for SUI (range)	Time from MUS to pregnancy (range)	Delivery by vaginal birth – n (%)	Delivery by cesarean section- n (%)	SUI following VD – n (%)	SUI following CS -n (%)	Repeat MUS- n (%)	Mean follow-up months (range)
Panel 2007	France	retrospective	19 *	TVT/TOT	33.9 years (range 20-42)	21.6 months (range 3-63)	10 (53%)	9 (47%)	2 (20%)	1 (12.5%)	1 (5%)	13.8 (1-52)
Cavkaytar 2014	Turkey	retrospective	12	TVT/TOT	33.1 years (range 27-40)	30.2 months (range 13-56)	5 (42%)	7 (58%)	2 (40%)	0	N/A	52 (30-68)
Adams-Piper 2016	California	retrospective	21 ***	retropubic/transobtorator	35.4 years (range 28-48)	28.3 months (range 10-70) **	10 (48%)	11 (52%)	0	1 (9%)	1 (5%)	19.8 (1-51)

\* Excluding one patient still pregnant during the study.

\*\* to delivery.

\*\*\* Five patients in original research excluded from analysis due to SUI prior to delivery.

MUS- Midurethral sling; SUI- stress urinary incontinence; TVT- tension free vaginal tape; TOT- transobtorator tape; N/A- not available.

Figure 1: Flow Chart of Database Searching and Study Selection

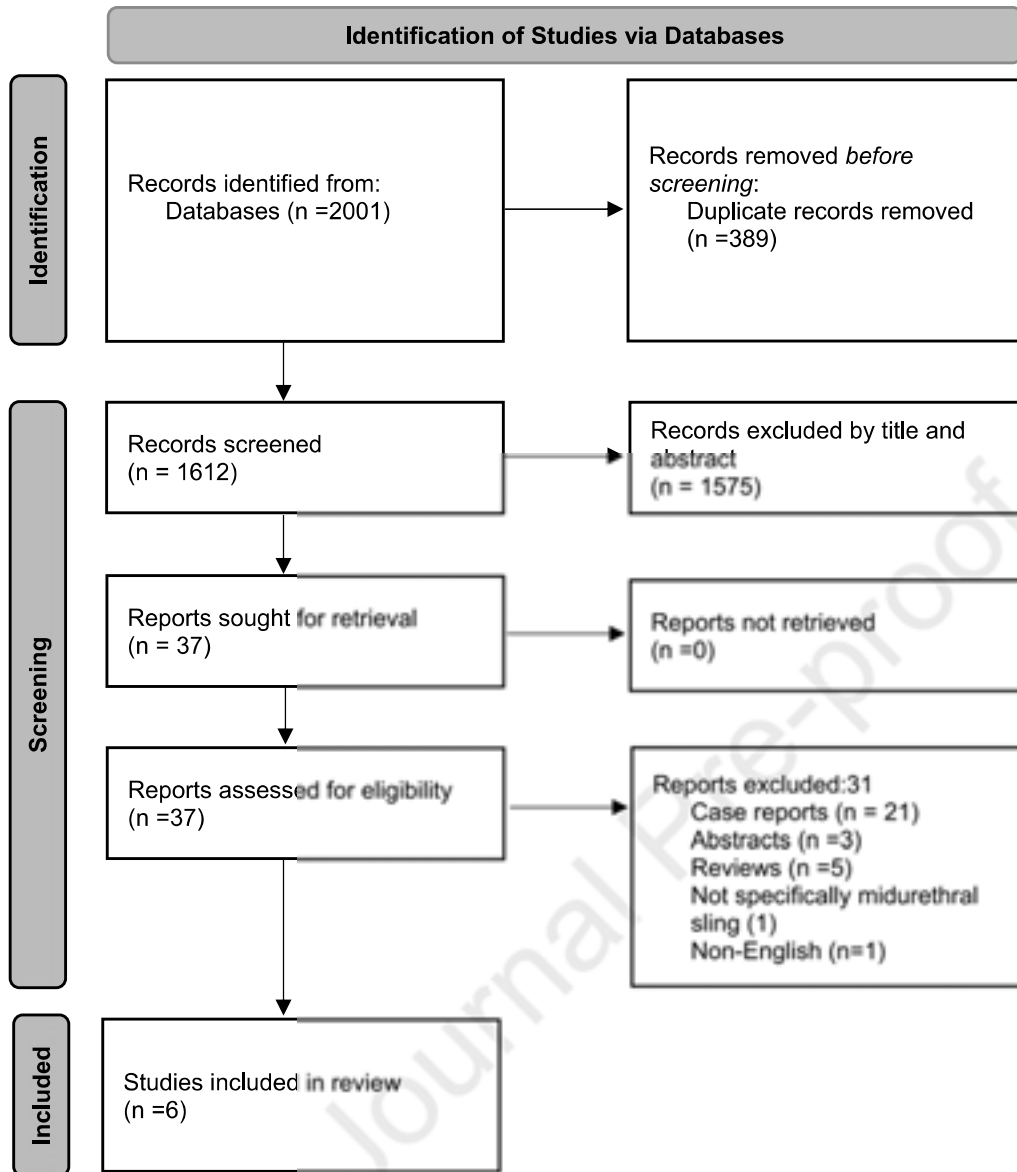
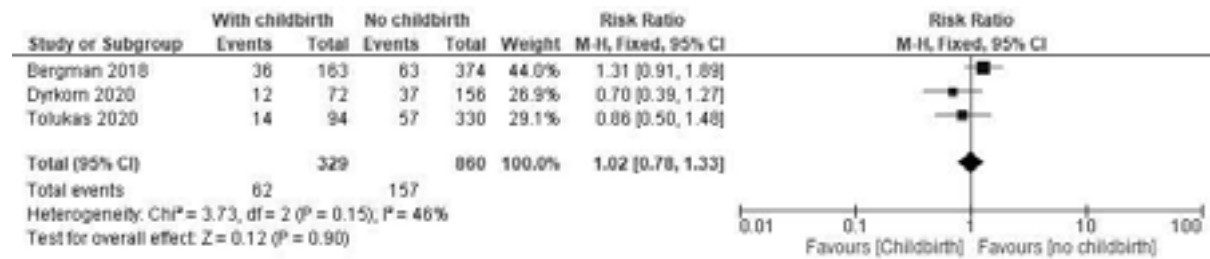


Figure 2: Forest Plots for Risk Following Childbirth

## A: Risk for Stress Urinary Incontinence Recurrence



## B: Risk for Midurethral Sling Re-operation

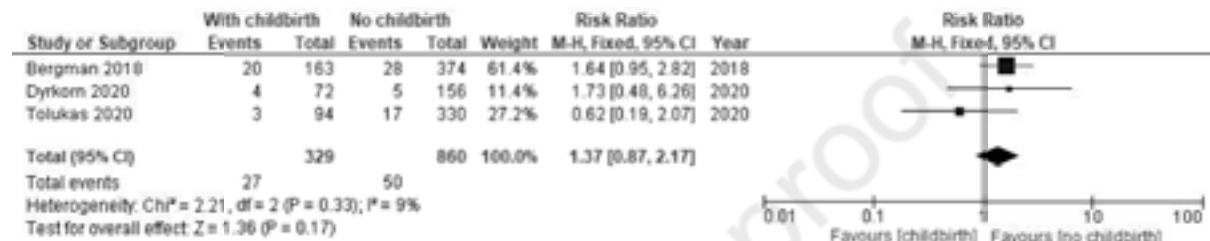
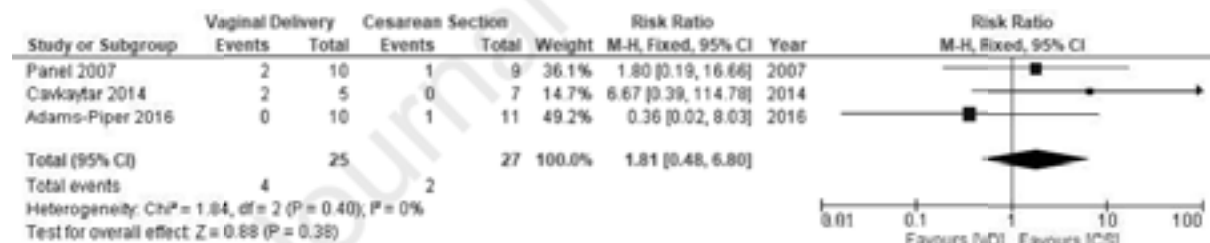
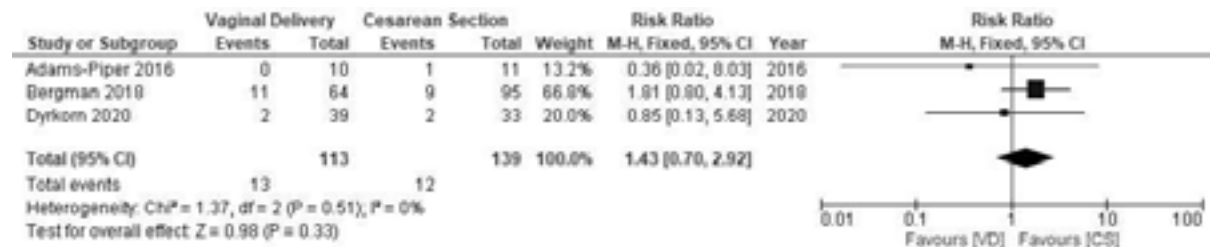


Figure 3: Forest Plots for Risk According to Delivery Mode

## A: Risk for Stress Urinary Incontinence Recurrence



## B: Risk for Midurethral Sling Re-operation



Supplementary Table S1: Reasons for study exclusion at full-text evaluation stage

Reason for non-inclusion	References
Abstracts, Comments, Surveys	(1-3)
Case reports	(4-24)
Reviews	(25-29)
Not specifically midurethral sling	(30)
Non-English papers	(31)

1. Alas, A., Chinthakanan, O., Espaillet, L., Plowright, L., & Davila, G. (2014). Long term outcomes of slings in various age groups. *International Urogynecology Journal and Pelvic Floor Dysfunction*, 25(1), S154–S155. <https://doi.org/10.1007/s00192-014-2429-3>
2. Dainer, M., Hall, C. D., Choe, J., & Bhatia, N. (1998). Pregnancy following incontinence surgery. *International Urogynecology Journal*, 9(6), 385–390. <https://doi.org/10.1007/BF02199571>
3. Patnam, R. (2020). Commentary on childbirth after mid-urethral sling surgery: effects on long term success and complications. *International Urogynecology Journal*, 31(3), 493. <https://doi.org/10.1007/s00192-019-04094-6>
4. Anglim, B., & McDermott, C. D. (2020). Aftermath of a midurethral sling placed in the first trimester: A case report. *Female Pelvic Medicine and Reconstructive Surgery*, 26(1), E4–E6. <https://doi.org/10.1097/SPV.0000000000000774>
5. Cutner, A., Cardozo, L. D., & Wise, B. G. (1991). The effects of pregnancy on previous incontinence surgery. Case report. *British Journal of Obstetrics and Gynaecology*, 98(11), 1181–1183. <https://doi.org/10.1111/j.1471-0528.1991.tb15377.x>
6. El-Ghobashy, A., Haw, W., Brook, G., & Calvert, S. (2007). Pregnancy after TVT-O: Case report and literature review. *International Urogynecology Journal*, 18(12), 1491–1493. <https://doi.org/10.1007/s00192-007-0377-x>
7. Fitzpatrick, C. C., III, S. J. S., Konnack, J. W., McGuire, E. J., & DeLancey, J. O. (1994). Vaginal delivery after pubovaginal sling surgery. *International Urogynecology Journal*, 5(4), 247–248. <https://www.embase.com/search/results?subaction=viewrecord&id=L24286922&from=export>
8. Gauruder-Burmester, A., & Tunn, R. (2001). Pregnancy and labor after TVT-plasty. *Acta Obstetrica et Gynecologica Scandinavica*, 80(3), 283–284. <https://doi.org/10.1034/j.1600-0412.2001.080003283.x>
9. Groenen, R., Vos, M. C., Willekes, C., & Vervest, H. A. M. (2008). Pregnancy and delivery after mid-urethral sling procedures for stress urinary incontinence: Case reports and a review of literature. *International Urogynecology Journal*, 19(3), 441–448. <https://doi.org/10.1007/s00192-007-0509-3>

10. Iskander, M. N., & Kapoor, D. (2000). Pregnancy following tension-free vaginal taping. *International Urogynecology Journal*, 11(3), 199–200. <https://doi.org/10.1007/s001920070049>
11. Kohorst, F., Flock, F., Kreienberg, R., & Reich, A. (2010). Pregnancy and delivery after tension-free vaginal tape (TVT) procedure: literature review and case report. *European Journal of Obstetrics and Gynecology and Reproductive Biology*, 151(1), 10–13. <https://doi.org/10.1016/j.ejogrb.2010.03.020>
12. Lewis, C. M., Salamon, C., & Culligan, P. (2011). Uncomplicated vaginal delivery following midurethral sling. *Female Pelvic Medicine & Reconstructive Surgery*, 17(3), 147–148. <https://doi.org/10.1097/SPV.0b013e3182175f54>
13. Lo, T.-S., Huang, H.-J., & Tseng, L.-H. (2001). Success of tension-free vaginal tape procedure after pregnancy and vaginal delivery. *Journal of Gynecologic Surgery*, 17(4), 129–131. <https://doi.org/10.1089/104240601317207110>
14. Lynch, C. M., Powers, A. K., & Keating, A. B. (2001). Pregnancy complicated by a suburethral sling: A case report. *International Urogynecology Journal*, 12(3), 218–219. <https://doi.org/10.1007/s001920170067>
15. Pacheco, G. B., Brito, C. R., Lorente, A. M. R., González, E. P., Adelantado, T. S., Pedreño, A. P., & Kaloup, M. C. I. (2010). Pregnancy after surgical treatment for stress incontinence using transobturator tape: A case report. *Journal of Maternal-Fetal and Neonatal Medicine*, 23, 470. <https://doi.org/10.3109/14767051003802503>
16. Roberts, L., Rantell, A., & Cardozo, L. (2016). Antepartum voiding symptoms following prior tension-free vaginal tape (TVT) operation: A case report. *Journal of Obstetrics and Gynaecology : The Journal of the Institute of Obstetrics and Gynaecology*, 36(8), 1002–1003. <https://doi.org/10.1080/01443615.2016.1217512>
17. Pregnancy after transobturator insertion of a suburethral sling: A case report and review of the literature
18. Schyrba, V., Bolla, D., Drack, G., Eisele, L., & Hornung, R. (2013). Normal vaginal delivery after a tension-free vaginal tape procedure: Case report and literature review. *Journal of Gynecologic Surgery*, 29(1), 27–30. <https://doi.org/10.1089/gyn.2012.0071>
19. Sergeant, F., & Marpeau, L. (2007). Recurrence of stress urinary incontinence after tension-free vaginal tape and childbirth. *Gynecologie Obstetrique et Fertilité*, 35(12), 1239–1241. <https://doi.org/10.1016/j.gyobfe.2007.10.010>
20. Shamsuddin, L., Malone, S., & Chamberlain, J. (2012). Three cases of pregnancy after tension-free vaginal tape and review of the literature. *BJOG: An International Journal of Obstetrics and Gynaecology*, 119, 216. <https://doi.org/10.1111/j.1471-0528.2012.03382.x>
21. Tommaselli, G. A., Carlo, C. di, D'Afiero, A., Formisano, C., Fabozzi, A., & Nappi, C. (2011). Two delivery methods following TVT-O and TVT-Secur. *International Urogynecology Journal and Pelvic Floor Dysfunction*, 22, S1937–S1938. <https://doi.org/10.1007/s00192-011-1521-1>
22. Tommaselli, G. A., Carlo, C. di, Formisano, C., Fabozzi, A., & Nappi, C. (2013). Vaginal delivery following single incision sling (TVT-Secur) for female stress urinary incontinence. *Journal of Obstetrics and Gynaecology Research*, 39(2), 608–610. <https://doi.org/10.1111/j.1447-0756.2012.01991.x>
23. Vella, M., Robinson, D., Brown, R., & Cardozo, L. (2007). Pregnancy and delivery following tension-free vaginal tape. *International Urogynecology Journal*, 18(3), 347–348. <https://doi.org/10.1007/s00192-006-0144-4>
24. Wein, A. J. (2010). Pregnancy and Delivery After Mid-Urethral Sling Procedures for Stress Urinary Incontinence: Case Reports and a Review of Literature Editorial Comment. *JOURNAL OF UROLOGY*, 184(3), 1047–1048.

25. Demaria, F., Bricou, A., Sakr, R., Boquet, B., & Benifla, J. L. (2007). Pregnancy and delivery after stress urinary incontinence surgery. *PELVI-PERINEOLOGIE*, 2(4), 336–341. <https://doi.org/10.1007/s11608-007-0159-4>
26. Huser, M., Belkov, I. A., Janku, P., & Sedlakova, K. (2012). Pregnancy and delivery following midurethral sling surgery for stress urinary incontinence. *International Journal of Gynecology and Obstetrics*, 119(2), 117–120. <https://doi.org/10.1016/j.ijgo.2012.05.038>
27. Panel, L., Mares, P., & de Tayrac, R. (2009). Urinary incontinence, should fertile women undergo surgical procedure? *Gynecologie Obstetrique et Fertilité*, 37(2), 167–171. <https://doi.org/10.1016/j.gyobfe.2008.09.018>
28. Pollard, M. E., Morrisroe, S., & Anger, J. T. (2012). Outcomes of pregnancy following surgery for stress urinary incontinence: A systematic review. *Journal of Urology*, 187(6), 1966–1970. <https://doi.org/10.1016/j.juro.2012.01.068>
29. Wieslander, C. K., Weinstein, M. M., Handa, V. L., & Collins, S. A. (2020). Pregnancy in Women With Prior Treatments for Pelvic Floor Disorders. *Female Pelvic Medicine & Reconstructive Surgery*, 26(5), 299–305. <https://doi.org/10.1097/SPV.0000000000000822>
30. Pradhan, A., Tincello, D. G., & Kearney, R. (2013). Childbirth after pelvic floor surgery: Analysis of Hospital Episode Statistics in England, 2002-2008. *BJOG: An International Journal of Obstetrics and Gynaecology*, 120(2), 200–204. <https://doi.org/10.1111/1471-0528.12076>
31. Lichert, F. (2018). Midurethral sling surgery: Effects of a subsequent childbirth investigated. *Geburtshilfe Und Frauenheilkunde*, 78(5), 442–444. <https://doi.org/10.1055/a-0576-4251>

Supplementary Table S2: Quality Assessment of the Included Studies According to Newcastle–Ottawa Scale.

First author (year)	Selection	Comparability	Outcome/exposure	Total	Quality*
Panel 2007 <sup>19</sup>	2	0	2	4	Low
Cavkaytar 2014 <sup>17</sup>	3	1	3	7	Medium
Adams-Piper 2016 <sup>16</sup>	2	0	2	4	Low
Bergman 2018 <sup>21</sup>	3	2	2	7	Medium
Dyrkorn 2020 <sup>18</sup>	3	2	2	7	Medium
Tolukas 2020 <sup>20</sup>	3	2	2	7	Medium

\* Low – up to 5 points, Medium – 6-7 points, High – 8-9 points.

Supplementary Table S3: Inclusion and Exclusion criteria for Included Studies

	<b>Inclusion criteria</b>	<b>Exclusion Criteria</b>
Bergman 2018	Women who had undergone a MUS procedure and afterwards a delivery.	N/A
Dyrkorn 2020	Case group- having undergone one or more childbirths after MUS surgery. Control – No subsequent birth following MUS	Inability to consent to follow-up
Tolukas 2020	Women who had had a pregnancy ending in delivery after MUS	Hypospadias as indication for procedure, Age under 18 at MUS, more than one MUS procedure before childbirth
Panel 2007	Pregnancies after treatment of SUI by TVT or TOT	N/A
Cavkaytar 2014	Women who has an infant after MUS placement to treat SUI	N/A
Adams-Piper 2016	Cases with the date of a live birth subsequent to the date of MUS	N/A