REVIEW

# The Efficacy and Safety of Single-Incision Mini-Slings for Stress Urinary Incontinence: A Network Meta-Analysis

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**Purpose:** To evaluate the efficacy and safety of single-incision mini-sling for stress urinary incontinence based on network Meta-analysis.

**Materials and Methods:** We searched PubMed, Embase, and Cochrane libraries from August 2008 to August 2019. Randomized controlled trials comparing two or more indicators of Miniarc (Single Incision Mini-slings), Ajust (Adjustable Single-Incision Sling), C-NDL (Contasure-Needleless), TFS (Tissue Fixation System), Ophria (Transobturator Vaginal Tap), TVT-O (Transobturator Vaginal Tape), and TOT (Trans-obturatortape) in treating female stress urinary incontinence were collected.

**Results:** Totally, 3,428 patients from 21 studies were included. Ajust had the highest subjective cure rate (Rank = 0.52), while Ophira had the worst (Rank = 0.67). TFS had the highest objective cure rate, and the worst was found in Ophira. TFS required the shortest operating time (Rank = 0.40), while TVT-O required the longest operating time (Rank = 0.47). Miniarc had the least bleeding (Rank = 0.47), while TVT-O had the most bleeding (Rank = 0.37). C-NDL had the shortest postoperative hospital stay (Rank=0.77), while Ajust had the longest postoperative hospital stay (Rank = 0.36). For postoperative complications, TFS performed best in groin pain (Rank = 0.84), urinary retention (Rank = 0.78), and repeat surgery (Rank=0.45). TVT-O performed worst in groin pain (Rank = 0.36), and urinary retention (Rank = 0.58). Miniarc had the highest repeat surgery rate (Rank = 0.35). Ajust had the lowest probability of tap erosion (Rank=0.30), while Ophira had the highest tap erosion level (Rank = 0.45). Miniarc showed the greatest advantage in urinary tract infections (Rank = 0.84) and de novo urgency (Rank = 0.60), while C-NDL had the highest incidence of urethral infections (Rank = 0.51). Ophira performed worst in de novo urgency (Rank = 0.60). C-NDL performed the best in sexual intercourse pain (Rank = 0.79) while Ajust was the worst (Rank = 0.49).

**Conclusion:** In view of comprehensive efficacy and safety, we recommend that TFS or Ajust should be selected first for single-incision sling and the application of Ophria should be minimized.

**Keywords:** single incision mini-slings; transobturator tension-free vaginal tapes; network meta-analysis; stress urinary incontinence

## INTRODUCTION

International Continence Society defines stress urinary incontinence (SUI) as involuntary leakage of urine from the external urethral orifice when abdominal pressure increases, such as laughter, cough and sneezing.(1) The incidence of SUI is 15~20% in women.(2) Although it is a non-fatal disease, the long course of the disease can cause psychological disorders, sexual dysfunction, social anxiety disorder and urinary dermatitis, which can seriously affect the patients' quality of life. Therefore, the treatment of SUI has been an important ongoing concern for decades, and new or improved therapies have emerged to treat the disease more thoroughly. Most female patients are treated conservatively, including lifestyle intervention, exercise of pelvic floor muscles, biofeedback therapy, electrical stimulation and etc.(3) However, surgical intervention is necessary in patients whose conservative therapy fails or with intrinsic sphincter deficiency.

Surgical procedures of SUI are developing in the preceding decades. Burch's Procedure was considered

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**Table 1.** The definition of "subjective" and "objective" cure rate of the included studies

| Study | Intervention T1/Size | T2/Size | Follow-up (months) | Definition of subjective cure | Definition of objective cure |
|---|---|---|---|---|---|
| Melendez-Munoz et al. (9) | Miniarc /121 | TVT-O/ 125 | 12 | No reported leakage with physical exertion by ICIQ-UI SF | Negative CST with full bladder |
| Pascom et al. (10) | Ophira/69 | TOT/61 | 36 | Patient reported satisfaction rate | Negative CST and pad test |
| Schellart P et al. (11) | Miniarc/97 | TOT/96 | 36 | Very much improved/ much improved in PGI-I | Negative CST with bladder volume >250 mL |
| Fernandez-Gonzalez et al. (12) | C-NDL/89 | TOT/98 | Average of 29 | Very satisfied/satisfied in questionnaire | Negative CST with full bladder |
| Gaber et al. (13) | C-NDL/70 | TVT-O/70 | 12 | Very much improved/ much improved in PGI-I | Negative CST with full bladder |
| Masata et al. (14) | Ajust/50 | TVT-O/50 | 12 | If the response to ICIQ-UI SF question 6 "When does urine leak? "was "Never/Urine does not leak" | Negative CST with bladder volume >300 mL |
| Dogan et al. (15) | C-NDL/90 | TOT/89 | 24 | If the response to ICIQ-UI SF question 6 "When does urine leak? "was "Never/Urine does not leak" | Negative CST with with a 300-ml saline-filled bladder |
| Xin et al. (16) | Ajust/184 | TVT-O/184 | 12 | Very much improved/much improved in PGI-I | Negative CST |
| Liapis et al. (17) | TOT/55 | TVT-O/65 | 12 | Response to Appendix | Negative CST and pad test |
| Sivaslioglu et al. (18) | TFS/40 | TOT/40 | Average of 64(We only use the data for the previous 36months) | If the patient reported restoration of urinary continence but the supine CSPT was positive, then treatment was regarded as a subjective cure | Negative CST |
| Tieu et al. (19) | Miniarc/49 | TOT/49 | 12 | Not mentioned | Negative CST with bladder volume >250 mL |
| Mostafa et al. (20) | Ajust/69 | TVT-O/68 | 12 | Very much improved/much improved in PGI-I | Negative CST |
| Grigoriadis et al. (21) | Ajust/85 | TVT-O/86 | Average of 22.3 | No loss of urine with exercise, coughing or weightlifting | Negative CST with with the bladder filled with 400 ml |
| Scheiner et al. (22) | TVT-O/40 | TOT/40 | 12 | Not mentioned | Negative CST and pad test |
| Boyers et al. (23) | Ajust/69 | TVT-O/68 | 12 | Very much improved/much improved in PGI-I | Negative CST with full bladder |
| Martinez et al. (24) | C-NDL/70 | TVT-O/68 | 36 | Very satisfied/satisfied in questionnaire | Negative CST with full bladder |
| Sabadell et al. (25) | Ajust/30 | TOT/28 | 12 | Completely satisfied/ moderately satisfied in questionnaire | Negative CST |
| Jurakova et al. (26) | Ophira/45 | TOT/48 | 12 | Very better/much better/a little better in PGI-I | Negative CST |
| Abdel-Fattah et al. (27) | TVT-O/170 | TOT/171 | 36 | Very much improved/much improved in PGI-I | Not mentioned |
| Fu et al. (28) | C-NDL/78 | TOT/86 | 12 | Very much improved/much improved in PGI-I | Not mentioned |
| Schweitzer J et al. (29) | Ajust/100 | TVT-O/56 | 12 | Very better/much better in PGI-I | Negative CST with bladder volume >300 mL |

ICIQ-UI SF: International Consultation on Incontinence Questionnaire Short Form; PGI-I: Patient Global Impression of Improvement; CST: cough stress test.

to be the gold standard surgical procedure for SUI.[4] But its application is limited by its long post-operative hospital stay and high incidence of pelvic organ prolapse caused by transabdominal operation.[5] McGuire et al.[6] improved the previous method of abdominal surgery and used the autopubic fascia sling for the first time. However, the most important milestone is the report of Ulmsten et al..[7] In 1996, according to the "Hammock Hypothesis" proposed by Delancey, the post-pubic polypropylene mesh was used to support the urethra through a tension-free vaginal tape (TVT). Thereafter, in order to decrease the incidence of serious complications such as bladder perforation after TVT, De L et al. improved the previous TVT procedure by Transobturator Vaginal Tape (TVT-O) in 2003. Transobturator Tension-free Vaginal Tape (TO-TVT) is known as the second generation of tension-free sling. The first generation of sling through retropubic approach has developed into a bottom-up (TVT) and top-down (SPARC) procedures. The succeeding generation of sling via obturator also derives from two procedures: outward-inward and inward-outward (TVT-O). The third generation of the sling is Single Incision Mini-sling (SIMS). The SIMS has high cure rates as those of RP-TVT and TO-TVT, and further reduces postoperative complications, thereby achieving minimal invasiveness and high safety. SIMS has a variety of methods and characteristics, which can be roughly divided into the following 10 types: TVT-Scure, Miniarc (Single Incision Mini-slings), Ajust (Adjustable Single-Incision Sling), Cure mesh, C-NDL (Contasure Needleless), TFS (Tissue Fixation System), Ophria (Transobturator Vaginal Tap), MiniTap, Alits, and, Solyx.[8] Among them, TVT-Secur has been withdrawn from clinical practice due to unsatisfactory efficacy, while Cure mesh, Mini-Tap, Alits, and Solyxy still have no prospects.
Therefore, in this study, we collected the latest information of comparative studies of Miniarc, Ajust, C-NDL, TFS, Ophria, TVT-O, and TOT through the network meta-analysis (NMA). We graded the mid-term efficacy and safety of SIMS to provide a reference for clinical applications. To the best of our knowledge, our study is the most comprehensive NMA on this topic.

## MATERIALS AND METHODS

### *Search strategy*

We conducted a computer-based search of PubMed, Embase, and Cochrane library databases from August 2008 to August 2019. MeSH terms and related synonyms including "stress urinary incontinence, urine pres-

**Table 2.** Characteristics of the included studies in the meta-analysis

| Authors | Years | Region | Study design | Experimental group(sample sizes) | Control group(sample sizes) | Follow-up (months) |
|---|---|---|---|---|---|---|
| Melendez-Munoz et al. (9) | 2018 | Australia | RCT | Miniarc /121 | TVT-O/ 125 | 12 |
| Pascom et al. (10) | 2018 | Brazil | RCT | Ophira/69 | TOT/61 | 36 |
| Schellart P et al. (11) | 2017 | Belgium | RCT | Miniarc/97 | TOT/96 | 36 |
| Fernandez-Gonzalez et al. (12) | 2016 | Spain | RCT | C-NDL/89 | TOT/98 | 29 |
| Gaber et al. (13) | 2016 | Egypt | RCT | C-NDL/70 | TVT-O/70 | 12 |
| Masata et al. (14) | 2016 | Czech Republic | RCT | Ajust/50 | TVT-O/50 | 12 |
| Dogan et al. (15) | 2018 | Turkey | RCT | C-NDL/90 | TOT/89 | 24 |
| Xin et al. (16) | 2016 | China | RCT | Ajust/184 | TVT-O/184 | 12 |
| Liapis et al. (17) | 2008 | Greece | RCT | TOT/55 | TVT-O/65 | 12 |
| Sivaslioglu et al. (18) | 2012 | Turkey | RCT | TFS/40 | TOT/40 | 36 |
| Tieu et al. (19) | 2017 | America | RCT | Miniarc/49 | TOT/49 | 12 |
| Mostafa et al. (20) | 2013 | Britain | RCT | Ajust/69 | TVT-O/68 | 12 |
| Grigoriadis et al. (21) | 2013 | Greece | RCT | Ajust/85 | TVT-O/86 | 22.3 |
| Scheiner et al. (22) | 2012 | Switzerland | RCT | TVT-O/40 | TOT/40 | 12 |
| Boyers et al. (23) | 2013 | Britain | RCT | Ajust/69 | TVT-O/68 | 12 |
| Martinez et al. (24) | 2014 | Spain | RCT | C-NDL/70 | TVT-O/68 | 36 |
| Sabadell et al. (25) | 2016 | Spain | RCT | Ajust/30 | TOT/28 | 12 |
| Jurakova et al. (26) | 2015 | Czech Republic | RCT | Ophira/45 | TOT/48 | 12 |
| Abdel-Fattah et al. (27) | 2012 | Britain | RCT | TVT-O/170 | TOT/171 | 36 |
| Fu et al. (28) | 2017 | China | RCT | C-NDL/78 | TOT/86 | 12 |
| Schweitzer J et al. (29) | 2015 | Netherlands | RCT | Ajust/100 | TVT-O/56 | 12 |

sure urinary incontinence, transobturator band, transobturator band, middle urethral sling, single incision sling, single incision mini sling, randomized controlled trial, Miniarc, Ajust, C-NDL, No Needle and No Needle, TFS, Tissue Fixation System, Ophria" and various keyword combinations were used in the search strategy. The search language was limited to English. We also manually searched a reference list of related publications from Wiley, Springlink, Science Direct databases, including reviews, meta-analyses, and other articles.

### *Inclusion and exclusion criteria*

The study inclusion criteria were: (1) Randomized controlled trial (RCT) focusing on females with SUI. (2) The interventions included at least two surgical treatments (Miniarc, Ajust, C-NDL, TFS, Ophria, TVT-O or TOT). (3) The results observed in the study included at least one of the following effects: treatment outcome

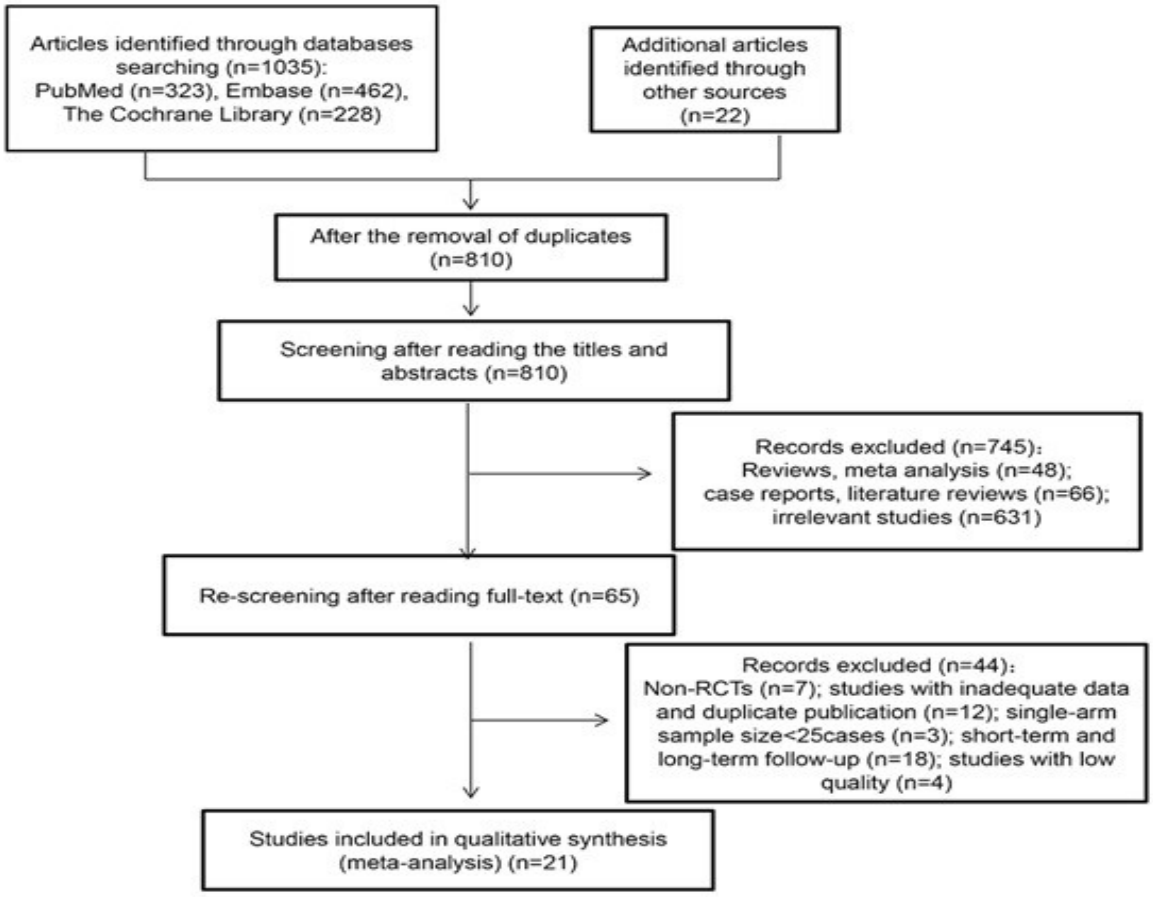


**Figure 1.** Flowchart for identification and selection of research publications

**Table 3.** Comparison of meta-analysis results of different surgical networks.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | **subjective cure rate (OR(95%Crl))** | | | |
| **Ajust** | | | | | | |
| 1.55 (0.74, 3.11) | **C-NDL** | | | | | |
| 1.51 (0.74, 3.29) | 0.96 (0.47, 2.15) | **MiniArc** | | | | |
| 2.19 (0.71, 6.50) | 1.43 (0.49, 4.12) | 1.45 (0.48, 4.17) | **OPhira** | | | |
| 1.19 (0.66, 2.24) | 0.77 (0.46, 1.33) | 0.79 (0.42, 1.43) | 0.55 (0.22, 1.38) | TOT | | |
| 1.09 (0.70, 1.68) | 0.70 (0.41, 1.26) | 0.73 (0.38, 1.31) | 0.50 (0.19, 1.41) | 0.91 (0.59, 1.43) | TVT-O | |
| | | | Objective cure rate (OR(95%Crl)) | | | |
| **Ajust** | | | | | | |
| 1.42 (0.65, 3.20) | **C-NDL** | | | | | |
| 1.63 (0.63, 4.45) | 1.12 (0.47, 2.80) | **Miniarc** | | | | |
| 2.32 (0.64, 8.78) | 1.59 (0.50, 4.95) | 1.38 (0.41, 5.23) | **Ophira** | | | |
| 0.74 (0.12, 4.10) | 0.51 (0.09, 2.53) | 0.45 (0.08, 2.33) | 0.32 (0.05, 1.85) | **TFS** | | |
| 1.16 (0.51, 2.69) | 0.80 (0.43, 1.54) | 0.71 (0.35, 1.46) | 0.51 (0.18, 1.35) | 1.58 (0.36, 7.82) | **TOT** | |
| 1.07 (0.67, 1.71) | 0.74 (0.38, 1.44) | 0.66 (0.28, 1.52) | 0.46 (0.13, 1.53) | 1.46 (0.29, 8.71) | 0.93 (0.45, 1.85) | **TVT-O** |
| | | | **operation time (OR(95%Crl))** | | | |
| **Ajust** | | | | | | |
| 4.59 (-5.43, 14.60) | **C-NDL** | | | | | |
| 2.28 (-13.48, 16.82) | -2.33 (-15.66, 10.60) | **Miniarc** | | | | |
| 0.40 (-15.00, 15.90) | -4.12 (-17.81, 9.30) | -1.70 (-17.49, 14.88) | **Ophira** | | | |
| 5.28 (-9.44, 20.14) | 0.63 (-12.27, 13.95) | 3.01 (-12.85, 18.98) | 4.74 (-11.23, 20.66) | **TFS** | | |
| -0.78 (-11.23, 9.25) | -5.36 (-12.61, 1.65) | -2.97 (-13.92, 8.29) | -1.21 (-12.71, 10.08) | -6.03 (-17.05, 4.93) | **TOT** | |
| -3.02 (-8.17, 2.04) | -7.65 (-16.49, 1.02) | -5.31 (-19.12, 9.47) | -3.50 (-17.87, 11.06) | -8.24 (-22.49, 5.56) | -2.32 (-11.04, 6.66) | **TVT-O** |
| | | | **amount of bleeding (OR(95%Crl))** | | | |
| **Ajust** | | | | | | |
| -0.70 (-17.37, 21.70) | **C-NDL** | | | | | |
| 5.20 (-21.33, 40.92) | 5.77 (-18.36, 33.88) | **Miniarc** | | | | |
| 0.42 (-26.60, 36.51) | 0.86 (-24.11, 30.20) | -4.95 (-34.18, 24.18) | **Ophira** | | | |
| -3.85 (-22.36, 24.49) | -3.33 (-16.99, 15.96) | -8.87 (-28.32, 11.48) | -3.76 (-24.95, 17.51) | **TOT** | | |
| -5.35 (-15.66, 6.56) | -4.64 (-23.60, 10.07) | -10.53 (-43.05, 15.08) | -5.67 (-39.11, 20.15) | -1.46 (-26.53, 14.95) | **TVT-O** | |
| | | | **hospital stay after surgery (OR(95%Crl))** | | | |
| **consistency model** | | | | | | |
| **Ajust** | | | | | | |
| 1.15 (-1.97, 4.27) | **C-NDL** | | | | | |
| 0.04 (-2.78, 2.83) | -1.13 (-2.49, 0.27) | **TOT** | | | | |
| -0.08 (-2.06, 1.92) | -1.23 (-3.63, 1.17) | -0.11 (-2.09, 1.86) | **TVT-O** | | | |
| | | | **inconsistency model** | | | |
| **Ajust** | | | | | | |
| 1.12 (-1.99, 4.29) | **C-NDL** | | | | | |
| -0.01 (-2.76, 2.80) | -1.12 (-2.53, 0.29) | **TOT** | | | | |
| -0.10 (-2.07, 1.90) | -1.22 (-3.65, 1.26) | -0.10 (-2.10, 1.90) | **TVT-O** | | | |
| | | | groin pain (OR(95%Crl)) | | | |
| **Ajust** | | | | | | |
| 0.70 (0.01, 61.74) | **Miniarc** | | | | | |
| 20.98 (0.15, 4245.33) | 30.37(0.09, 13027.02) | **TFS** | | | | |
| 0.71(0.03, 13.26) | 1.04(0.01, 78.32) | 0.04 (0.00, 1.49) | **TOT** | | | |
| 0.43(0.02, 8.02) | 0.61(0.02, 20.94) | 0.02 (0.00, 2.12) | 0.59 (0.05, 7.58) | **TVT-O** | | |
| | | | **urinary retention (OR(95%Crl))** | | | |
| **Ajust** | | | | | | |
| 0.92 (0.28, 3.64) | **C-NDL** | | | | | |
| 4.11 (0.24, 176.44) | 4.30 (0.22, 208.26) | **TFS** | | | | |
| 0.82 (0.28, 3.00) | 0.89(0.29, 2.65) | 0.22(0.01, | | | | |
| 2.69) TOT | | | | | | |
| 0.55(0.26, 1.26) | 0.57 (0.20, 1.61) | 0.14 (0.00, 2.32) | 0.65 (0.24, 1.70) | TVT-O | | |
| | | | **urinary tract infection (OR(95%Crl))** | | | |
| **Ajust** | | | | | | |
| 0.90 (0.09, 7.07) | **C-NDL** | | | | | |
| 14.77(0.54, 737.78) | 17.42 (0.69, 903.91) | **Miniarc** | | | | |
| 3.09 (0.46, 24.37) | 3.49 (0.60, 25.55) | 0.22 (0.01, 2.81) | **TOT** | | | |
| 1.87 (0.52, 6.76) | 2.11 (0.40, 11.83) | 0.13 (0.00, 2.68) | 0.59 (0.12, 2.62) | **TVT-O** | | |
| | | | **tape erosion (OR(95%Crl))** | | | |
| **Ajust** | | | | | | |
| 0.35 (0.04, 2.41) | **C-NDL** | | | | | |
| 0.95 (0.12, 7.10) | 2.66 (0.45, 18.45) | **Miniarc** | | | | |
| 0.20 (0.01, 5.95) | 0.58 (0.03, 11.68) | 0.21 (0.01, 5.12) | **Ophira** | | | |
| 0.63 (0.02, 22.41) | 1.83 (0.08, 57.38) | 0.62 (0.02, 24.06) | 2.99 (0.04, 185.22) | **TFS** | | |
| 0.23 (0.03, 1.32) | 0.66 (0.20, 1.98) | 0.24 (0.04, 1.04) | 1.07 (0.08, 36.10) | 0.37 (0.01, 7.02) | **TOT** | |
| 0.77 (0.18, 2.56) | 2.16 (0.48, 9.81) | 0.81 (0.15, 4.08) | 3.58 (0.19, 137.98) | 1.22 (0.03, 33.28) | 3.39 (0.95, 13.40) | **TVT-O** |

(objective and subjective cure rate) (**Table 1**), perioperative outcome (operation time, bleeding volume, postoperative hospital stays), postoperative complications (postoperative groin pain, urinary tract infection, injury of bladder, tape erosion, urinary retention, repeat surgery rate, dyspareunia, and postoperative pain). (4) The follow-up period of the study was mid-term (12-36 months was defined as mid-term follow-up, less than 12 months as short-term follow-up, and more than 36 months as long-term follow-up). (5) One-arm sample size was> 25 cases.

The exclusion criteria were: (1) Studies involving patients underwent multiple operations for SUI or with other diseases that may affect the outcome of the op-

**Table 4.** Rankings based on simulations.

| | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Rank 6 | Rank 7 |
|---|---|---|---|---|---|---|---|
| subjective cure rate (Rank 1 is best, rank 6 is worst) | | | | | | | |
| Ajust | 0.52 | 0.2 | 0.15 | 0.08 | 0.04 | 0.01 | |
| C-NDL | 0.04 | 0.05 | 0.1 | 0.25 | 0.4 | 0.17 | |
| MiniArc | 0.06 | 0.06 | 0.12 | 0.27 | 0.35 | 0.15 | |
| OPhira | 0.04 | 0.04 | 0.04 | 0.07 | 0.14 | 0.67 | |
| TOT | 0.14 | 0.21 | 0.36 | 0.23 | 0.05 | 0 | |
| TVT-O | 0.20 | 0.44 | 0.24 | 0.1 | 0.02 | 0 | |
| objective cure rate (Rank 1 is best, rank 7 is worst) | | | | | | | |
| Ajust | 0.23 | 0.28 | 0.18 | 0.15 | 0.09 | 0.05 | 0.02 |
| C-NDL | 0.02 | 0.05 | 0.09 | 0.19 | 0.3 | 0.25 | 0.1 |
| Miniarc | 0.03 | 0.05 | 0.07 | 0.12 | 0.18 | 0.33 | 0.23 |
| Ophira | 0.01 | 0.03 | 0.04 | 0.04 | 0.08 | 0.2 | 0.59 |
| TFS | 0.57 | 0.09 | 0.09 | 0.06 | 0.06 | 0.08 | 0.05 |
| TOT | 0.06 | 0.2 | 0.23 | 0.27 | 0.19 | 0.04 | 0.01 |
| TVT-O | 0.08 | 0.29 | 0.29 | 0.17 | 0.1 | 0.05 | 0.01 |
| | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Rank 6 | Rank 7 |
| operation time (Rank 1 is worst, rank 5 is best) | | | | | | | |
| Ajust | 0.06 | 0.25 | 0.18 | 0.19 | 0.17 | 0.1 | 0.05 |
| C-NDL | 0.01 | 0.01 | 0.04 | 0.1 | 0.24 | 0.33 | 0.27 |
| Miniarc | 0.12 | 0.1 | 0.1 | 0.15 | 0.18 | 0.18 | 0.17 |
| Ophira | 0.20 | 0.12 | 0.15 | 0.15 | 0.14 | 0.13 | 0.11 |
| TFS | 0.04 | 0.04 | 0.06 | 0.09 | 0.15 | 0.22 | 0.40 |
| TOT | 0.10 | 0.23 | 0.34 | 0.23 | 0.08 | 0.01 | 0 |
| TVT-O | 0.47 | 0.24 | 0.14 | 0.09 | 0.04 | 0.01 | 0 |
| | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Rank 6 | Rank 7 |
| amount of bleeding (Rank 1 is worst, rank 5 is best) | | | | | | | |
| Ajust | 0.08 | 0.19 | 0.14 | 0.17 | 0.23 | 0.19 | |
| C-NDL | 0.06 | 0.11 | 0.26 | 0.28 | 0.2 | 0.09 | |
| Miniarc | 0.07 | 0.07 | 0.09 | 0.11 | 0.2 | 0.47 | |
| Ophira | 0.22 | 0.1 | 0.11 | 0.12 | 0.22 | 0.23 | |
| TOT | 0.21 | 0.28 | 0.21 | 0.2 | 0.09 | 0.01 | |
| TVT-O | 0.37 | 0.25 | 0.19 | 0.12 | 0.06 | 0.01 | |
| hospital stay after surgery (Rank 1 is worst, rank 4 is best) | | | | | | | |
| Ajust | 0.36 | 0.24 | 0.25 | 0.16 | | | |
| C-NDL | 0.02 | 0.08 | 0.13 | 0.77 | | | |
| TOT | 0.32 | 0.25 | 0.41 | 0.02 | | | |
| TVT-O | 0.30 | 0.44 | 0.21 | 0.05 | | | |
| | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Rank 6 | Rank 7 |
| groin pain (Rank 1 is worst, rank 5 is best) | | | | | | | |
| Ajust | 0.14 | 0.17 | 0.27 | 0.36 | 0.06 | | |
| Miniarc | 0.29 | 0.18 | 0.18 | 0.27 | 0.08 | | |
| TFS | 0.02 | 0.02 | 0.03 | 0.09 | 0.84 | | |
| TOT | 0.19 | 0.24 | 0.34 | 0.23 | 0.01 | | |
| TVT-O | 0.36 | 0.39 | 0.18 | 0.06 | 0.01 | | |
| urinary retention (Rank 1 is worst, rank 5 is best) | | | | | | | |
| Ajust | 0.06 | 0.22 | 0.23 | 0.39 | 0.1 | | |
| C-NDL | 0.13 | 0.2 | 0.28 | 0.29 | 0.1 | | |
| TFS | 0.07 | 0.04 | 0.05 | 0.06 | 0.78 | | |
| TOT | 0.16 | 0.24 | 0.35 | 0.23 | 0.02 | | |
| TVT-O | 0.58 | 0.31 | 0.09 | 0.02 | 0 | | |
| urinary tract infection (Rank 1 is worst, rank 5 is best) | | | | | | | |
| Ajust | 0.43 | 0.37 | 0.12 | 0.05 | 0.03 | | |
| C-NDL | 0.51 | 0.28 | 0.15 | 0.05 | 0.01 | | |
| Miniarc | 0.02 | 0.03 | 0.03 | 0.07 | 0.84 | | |
| | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Rank 6 | Rank 7 |
| TOT | 0.02 | 0.09 | 0.18 | 0.63 | 0.08 | | |
| TVT-O | 0.03 | 0.23 | 0.51 | 0.2 | 0.04 | | |
| tape erosion (Rank 1 is worst, rank 7 is best) | | | | | | | |
| Ajust | 0.02 | 0.03 | 0.06 | 0.13 | 0.19 | 0.27 | 0.3 |
| C-NDL | 0.08 | 0.21 | 0.34 | 0.22 | 0.09 | 0.05 | 0.02 |
| Miniarc | 0.01 | 0.02 | 0.06 | 0.16 | 0.23 | 0.26 | 0.25 |
| Ophira | 0.45 | 0.15 | 0.13 | 0.09 | 0.06 | 0.05 | 0.07 |
| TFS | 0.19 | 0.1 | 0.11 | 0.12 | 0.09 | 0.11 | 0.29 |
| TOT | 0.25 | 0.46 | 0.23 | 0.04 | 0.01 | 0 | 0 |
| TVT-O | 0.01 | 0.02 | 0.07 | 0.24 | 0.34 | 0.26 | 0.07 |
| repetitive surgery (Rank 1 is worst, rank 7 is best) | | | | | | | |
| Ajust | 0.13 | 0.13 | 0.14 | 0.15 | 0.16 | 0.17 | 0.12 |
| C-NDL | 0.08 | 0.07 | 0.08 | 0.09 | 0.1 | 0.26 | 0.33 |
| Miniarc | 0.35 | 0.31 | 0.18 | 0.1 | 0.05 | 0.02 | 0 |
| Ophira | 0.31 | 0.25 | 0.15 | 0.12 | 0.09 | 0.05 | 0.02 |
| TFS | 0.1 | 0.07 | 0.06 | 0.06 | 0.07 | 0.19 | 0.45 |
| TOT | 0 | 0.06 | 0.19 | 0.26 | 0.3 | 0.15 | 0.03 |
| TVT-O | 0.03 | 0.11 | 0.19 | 0.23 | 0.23 | 0.16 | 0.05 |
| de novo urgency (Rank 1 is worst, rank 6 is best) | | | | | | | |
| Ajust | 0.27 | 0.38 | 0.18 | 0.09 | 0.05 | 0.02 | |
| C-NDL | 0.01 | 0.05 | 0.13 | 0.23 | 0.34 | 0.23 | |
| Miniarc | 0.07 | 0.1 | 0.07 | 0.08 | 0.09 | 0.6 | |
| Ophira | 0.6 | 0.16 | 0.09 | 0.05 | 0.06 | 0.04 | |
| TOT | 0.01 | 0.08 | 0.18 | 0.34 | 0.33 | 0.07 | |
| TVT-O | 0.03 | 0.24 | 0.35 | 0.21 | 0.13 | 0.04 | |
| sexual intercourse pain (Rank 1 is worst, rank 5 is best) | | | | | | | |
| Ajust | 0.49 | 0.21 | 0.14 | 0.1 | 0.06 | | |
| C-NDL | 0.01 | 0.02 | 0.06 | 0.12 | 0.79 | | |
| Miniarc | 0.41 | 0.32 | 0.14 | 0.12 | 0.02 | | |
| TOT | 0.05 | 0.29 | 0.41 | 0.23 | 0.01 | | |
| TVT-O | 0.04 | 0.15 | 0.25 | 0.43 | 0.13 | | |

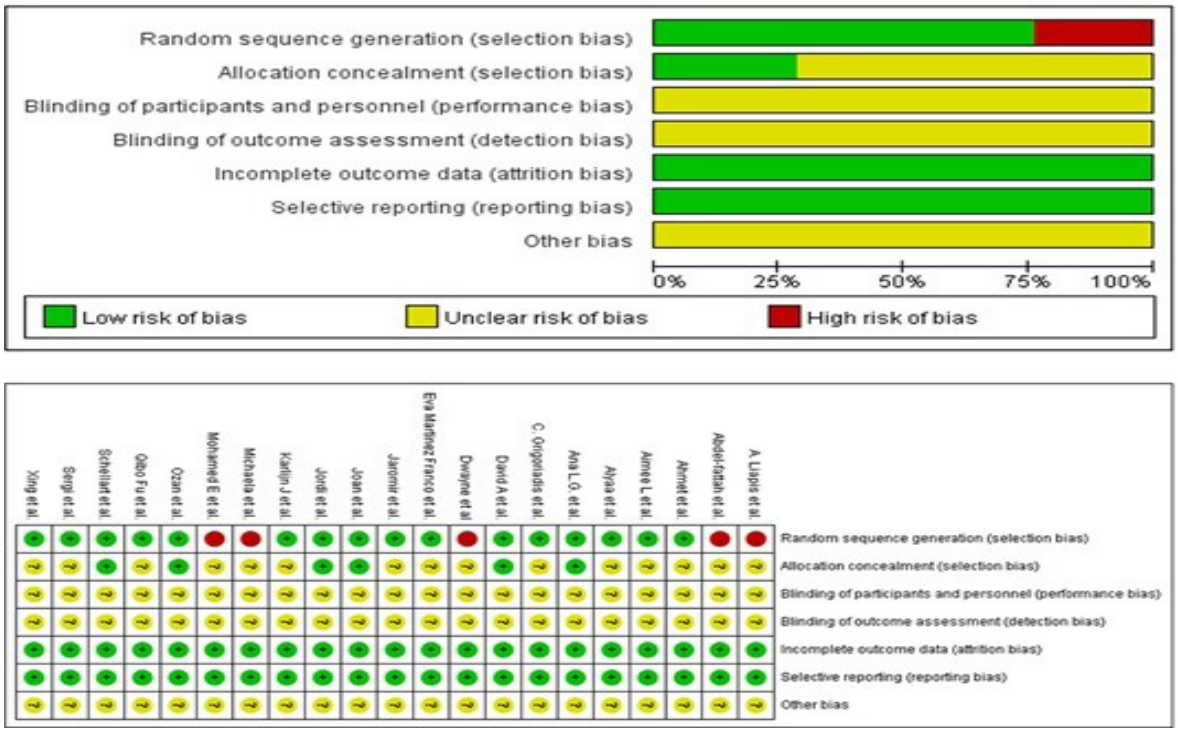


**Figure 2.** Graph of risk bias and summary of the included studies.

eration. (2) Retrospective studies, animal studies, correspondence, case reports, reviews, meta-analyses, reviews and conference abstracts. (3) Studies whose data on odds ratio (OR) or standardized mean difference (SMD) cannot be obtained.

### *Data extraction and quality assessment*

Data extractions were performed independently by two investigators. An agreement was reached through consulting a third researcher when disagreement occurred. The data extracted from the included studies were as follows: the first author's name, year of publication, study design, region, follow-up duration, and relevant clinical outcomes. Two independent reviewers assessed the methodological quality with the assessment tool presented by Cochrane Handbook for Systematic Reviews Interventions version 5.10. For included trials, the following criteria were evaluated and given a grade of low, medium, or high-risk bias: random sequence


**Figure 3.** Comparative network of treatments. The connection indicates that there is a direct comparative study between the two treatments, and the digit represents the number of direct comparative study.

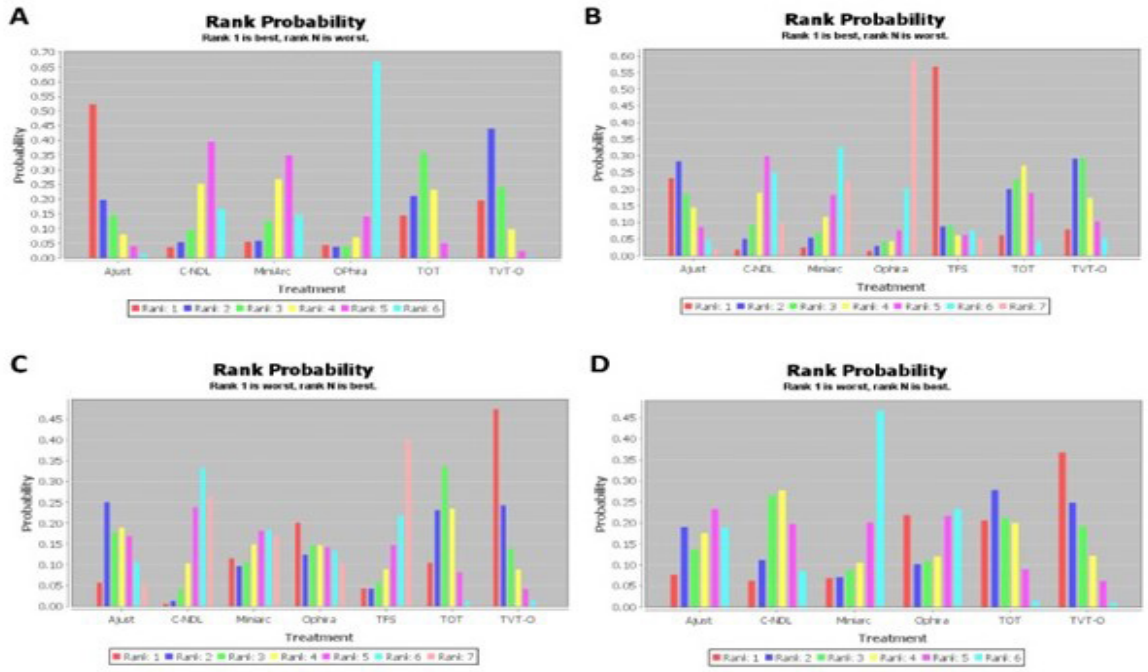


**Figure 4.** Correlation levels based on the probability of intervention at different endpoints. **(A)** subjective cure rate; **(B)** objective cure rate; **(C)** operation time; **(D)** amount of bleeding.

generation, allocation concealment, blinding of participants, and personnel blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Disagreements in risk of bias ratings were regularly resolved through discussion by the two reviewers or consultation with a third team member.

### *Statistical analysis*

Statistical analysis was performed using the ADDIS

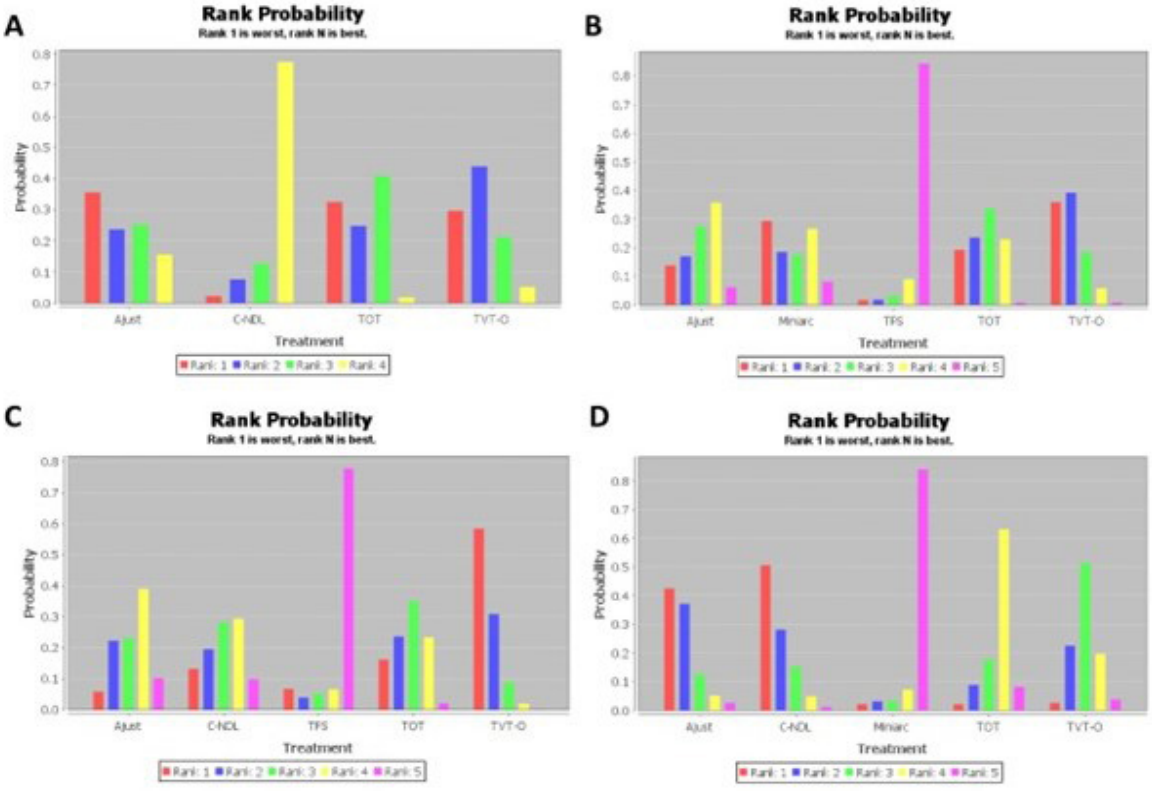


**Figure 5.** Correlation levels based on the probability of intervention at different endpoints. **(A)** hospital stay after surgery; **(B)** groin pain; **(C)** urinary retention; **(D)** urinary tract infection.

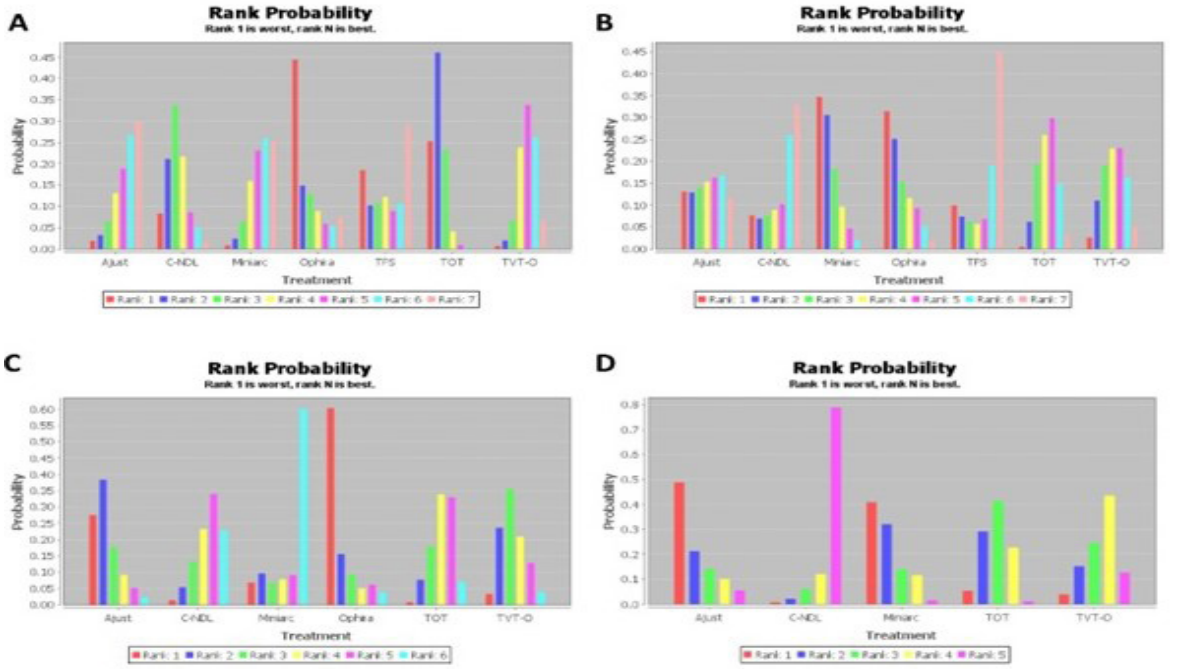


**Figure 6.** Correlation levels based on the probability of intervention at different endpoints.**(A)** tap erosion; **(B)** repetitive surgery; **(C)** de novo urgency; **(D)** sexual intercourse pain

software based on the Bayesian framework (version 1.16.8). Continuous variables were summarized using SMD and its 95% confidence interval (95% CI) for efficacy analysis. OR and its 95% CI were used as dichotomous variables for power analysis statistics. Consistency was evaluated through node segmentation models and inconsistent models. When $P > 0.05$, there is no inconsistency. NMA used a consistency model for analysis. If $P < 0.05$, an inconsistent model is used and the reasons for the inconsistency are analyzed. When node analysis was not possible, the results of the consistent model and the inconsistent model were compared. The potential scale reduction factor (PSRF) represented convergence. The closer the PSRF is to 1, the better the convergence and the more reliable the results obtained by the consensus model. PSRF < 1.20 is still acceptable. In addition to OR, the NMA also lists the SMD values and their 95% CI representative results and statistical significance, a grid relationship diagram for each indicator, a probability ranking table, and a probability ranking table. In the network diagram, links indicated a direct comparison between the two interventions, and numbers indicated the number of studies. In the probability ranking table and the ranking chart, if the result index is favorable, Rank1 is the best, and RankN is the worst. Conversely, if the result index is unfavorable, Rank1 is the worst and RankN is the worst.

## RESULTS

### *Characteristics of included studies*

A total of 1,035 publications were obtained, of which 1013 were from three major English databases, including 323 from Pubmed, 462 from EMbase, and 228 from Cochrane and 22 of other sources. We then removed 225 duplicates and excluded 745 by filtering titles and abstracts. Finally, through a full-text evaluation, we included 21 RCTs, which involved 3428 patients.[9-29] Among them, seven articles compared Ajust and TO-TVT, five articles compared Amini and TO-TVT, and five articles compared C-NDL and TO-TVT. One article compared TFS with TO-TVT. Three articles compared TVT-O with TOT. No article compared directly SIMS with other surgical methods. All of the trials were two-arm trials. The process of literature searching and screening for NMA was shown in **Figure 1**. Characteristics of the included studies in meta-analysis were illustrated in **Table 2**.

Quality assessment of methodology of included studies

The methodological quality of the study was assessed according to the Cochrane collaborative tool. All 21 studies mentioned randomness, of which 9 were computer-generated random sequences, 7 were random sequences generated by digital tables, and the remaining 5 did not specifically describe the sequence generation method. Eight studies showed the allocation concealment method and others did not describe their procedures. Data from all studies were incomplete, there were no selective reports, and it was unclear whether there are other biases. The risk profile for bias and a summary of the included studies is shown in **Figure 2**.

Network meta-analysis of the treatment efficacy

Eighteen of all 21 studies reported subjective cure rates from a comparison of Miniarc, Ajust, C-NDL, Ophria, TVT-O, and TOT (**Figure 3A**). Eighteen studies also reported objective cure rates by comparing all seven procedures (**Figure 3B**). No significant inconsistency was found between the various treatments ($P$ >0.05). This means that the consistency model is reliable. In addition, the PSRF is limited to 1, and this study can achieve satisfactory convergence efficiency. NMA results showed no significant difference in subjective and objective cure rates between any two surgical procedures. The 95% interval of OR value was over 1 (**Table 3**). The probability ranking results showed that Ajust's subjective cure rate was higher than the other 5 surgi-

cal methods (rank = 0.52), followed by TVT-O (rank = 0.20), and the worst was Ophira (rank = 0.67) (**Table 4 and Figure 4A**). The objective cure rate of TFS was higher than the other 6 surgical methods (rank = 0.57), followed by Ajust (rank = 0.23), and the worst was OPhira (rank = 0.59) (**Table 4 and Figure 4B**).

Network meta-analysis of the perioperative outcomes

Twelve studies described surgical time by comparing all seven surgical procedures (**Figure 3C**). A total of 8 studies reported bleeding volume (**Figure 3D**), which included comparisons of Miniarc, Ajust, C-NDL, Ophria, TVT-O and TOT. Four studies described length of hospital stay, including comparisons of TVT-O, TOT, Ajust, and C-NDL (**Figure 3E**). No obvious inconsistency was found in various surgical time treatments, and the bleeding volume ($P > 0.05$). This means that the consistency model is reliable. In addition, the PSRF is limited to 1, and the study can achieve satisfactory convergence efficiency. NMA results showed no statistical difference between any two surgical methods and the 95% interval of SMD value was over 0 (**Table 2**). According to the probability of the grade chart, the operation time required by TFS was shorter than the other 6 surgical procedures (rank = 0.40), while TVT-O had the longest operation time (rank = 0.47) (**Table 4 and Figure 4C**). The bleeding amount of Miniarc was less than the other 5 surgical methods (rank = 0.47), and that of TVT-O was the largest (rank = 0.37) (Table 4 and Figure 4D). The length of hospital stay after surgery was an indicator that could not be tested by node analysis because it did not form a network relationship between the included studies. Therefore, we listed the results of the consistency model and the inconsistent model separately, and found that the results of the two models were consistent. There was no statistical difference between the two models. According to the possibility of the grade chart, the postoperative hospital stay of C-NDL was shorter than the other three types of surgery (Rank = 0.77), while that of Ajust was the longest (Rank = 0.36) (**Table 4 and Figure 5A**).

### *Network meta-analysis of the postoperative complications*

There were 6 studies that described postoperative groin pain by comparison of Miniarc, Ajust, TFS, TVT-O and TOT (**Figure 3F**). A total of 13 studies reported postoperative urinary retention after comparing Ajust, C-NDL, TFS Comparison, TVT-O, and TOT (**Figure 3G**). Eight studies described postoperative urinary tract infections and compared Miniarc, Ajust, C-NDL, TVT-O, and TOT (**Figure 3H**). A total of 12 studies reported the incidence of repeat surgery after comparison of all 7 surgical procedures (**Figure 3I**). Ten studies reported de novo urgency and compared six surgical procedures except TFS (**Figure 3J**). Five studies reported postoperative sexual intercourse pain by comparing Miniarc, Ajust, C-NDL, TVT-O, and TOT (**Figure 3K**). The adverse events of tape erosion were reported in 11 studies, including a comparison of all 7 surgical methods (**Figure 3L**). Except for postoperative sexual intercourse pain, node-slitting analysis, including consistency model and inconsistent model, was performed for statistical analysis. There was no significant inconsistency among the postoperative complications except postoperative sexual intercourse pain ($P > 0.05$), indicating that the consistency model is reliable. The PSRF was limited to 1, suggesting the satisfactory convergence efficiency of this study. NMA results showed that there was no statistical difference between any two surgical methods, and the 95% interval of OR value was over 1 (**Table 3**). According to Probabilities of rank plot, TFS had the lowest incidence of groin pain (rank = 0.84) and TVT-O had the highest incidence (**Table 4 and Figure 5B**). TFS had the lowest incidence of urine retention (rank = 0.78) and TVT-O had the highest incidence (Rank = 0.58) (**Table 4 and Figure 4G**). Miniarc had the lowest incidence of urinary tract infections (rank = 0.84) and C-NDL had the highest (rank = 0.51) (**Table 4 and Figures 5C and 5D**). Ajust had the lowest probability of occurrence of the tape erosion (rank = 0.30), and Ophira had the highest probability (rank = 0.45) (Table 4 and Figure 6A). TFS had the lowest recurrence rate (rank = 0.45), while Miniarc had the highest rate (rank = 0.35) (**Table 4 and Figure 6B**). Miniarc had the lowest incidence of de novo urgency and Ophira had the highest incidence (rank = 0.60) (**Table 4 and Figure 6C**). For the incidence of pain during intercourse, there was no significant difference between any two surgical methods (95% interval of OR values were over 1). The probability ranking results showed that C-NDL had the lowest incidence of intercourse pain (rank = 0.79), and Ajust had the highest incidence of intercourse pain (rank = 0.49) (**Table 4 and Figure 6D**).

## DISCUSSION

Standard tension-free midurethral sling is considered to be the gold standard surgical procedure for curing SUI at present. TVT, as the first generation of tension-free sling, provided evident effect for the treatment of SUI, however, it could cause several serious complications, such as pelvic organs injury, iliac vessels trauma and nerve injury. The modified surgical procedure TOT and TVT-O could decrease the incidence of postoperative hematoma, bladder injury or perforation after TVT.[30] There seems to be no anatomical difference between TOT and TVT-O. Most scholars draw similar conclusions based on the autopsy results. They suggest that compared with TVT-O, the sling of TOT is farther away from obturator vessel, posterior branch of obturator nerve and obturator canal,[30,31] and the difference of material and product design between TOT and TVT-O also makes the evaluation of efficacy and safety different. Although the second generation of sling TO-TVT has been significantly improved compared with the previous generation TVT, the groin pain caused by obturator nerve injury while traversing obturator muscle group is still the most significant complication. The third generation of the sling is SIMS. In addition to following the basic operation principle of TO-TVT, SIMS uses the method of single incision, and the length of the sling is shorter, usually only 6.5-12cm,[32] thus achieving minimal invasiveness and fewer complications. SIMS has a variety of surgical procedures, including TVT-Scure, Miniarc, Ajust, Cure mesh, C-NDL, TFS, Ophria, MiniTap, Alits, Solyx, etc.

SIMS seems to have many potential advantages, such as achieving the same urethral support as traditional midurethral slings through a single incision, which is more minimally invasive; avoiding the occurrence of tissue injury and pain through the retropubic or inguinal region during the operation, which makes the operation to be completed without sedative local anesthesia.[33] In

addition, SIMS has lower complications than standard midurethral slings with comparable efficacy.[34] However, there is a lack of comparisons among different surgical procedures for SIMS. The purpose of this study is to rank the efficacy or complications of various SIMS procedures, and to give evidence for the selection of many SIMS procedures in clinical practice.

In our study, there was no significant difference among Miniarc, Ajust, C-NDL, TFS, Ophria, TVT-O and TOT in terms of subjective cure rate, objective cure rate, perioperative outcomes and postoperative complications. Thus, even if with only a slight difference, we could also sort these methods through the advantages and disadvantages of each indicator and procedure. This is also the advantage of NMA.

From the results of our NMA, we found that: (1) For the treatment efficacy, Ajust had the best subjective cure rate, while Ohira had the worst; TFS had the best objective cure rate, followed by Ajust; and Ophira had the worst; (2) For the perioperative outcomes, the operation time of TFS was the shortest and that of TVT-O was the longest; The bleeding amount of Miniarc was the least while that of TVT-O was the largest; C-NDL had the shortest hospitalization time; (3) For the postoperative complications, TFS had the greatest advantage in reducing the incidence of groin pain, urinary retention and repetitive surgery, while TVT-O had the highest incidence of groin pain and urinary retention. Miniarc had the highest rate of repetitive surgery. Ajust had the lowest incidence of tap erosion, while Ophira had the highest. Miniarc had the lowest rate of urinary tract infection and de novo urgency, while C-NDL had the highest rate of urinary tract infection and Ophira had the highest rate of de novo urgency. In terms of sexual intercourse pain, C-NDL performed the best and Ajust was the worst.

The methodological advantages of this study were as follows: 1) The outcome measurements analyzed in this study included 12 indicators of treatment efficacy, perioperative outcomes and postoperative complications, which could comprehensively evaluate the safety and effectiveness of each surgical procedure. The 21 articles included in this study were all of high quality and reliable RCTs. 2) By using ADDIS software and NMA, we could effectively compare two or more SUI surgical methods without direct comparison and rank them as good or bad. 3) We use a comprehensive search strategy to reduce the risk of publication bias.

However, our research still has certain limitations. First, the number of studies included in some surgical procedures was small, and the outcome indicators observed in the studies were not comprehensive. Second, due to limited literature reports, only the mid-term follow-up were analyzed, and the long-term efficacy was not systematically evaluated. Thus, the clinical reference value is limited. Third, only 7 SIMS procedures were compared.

## CONCLUSIONS

In summary, there is no statistical difference in treatment efficacy, perioperative outcome, and postoperative complications among the seven procedures. SIMS and TO-TVT are equally safe and effective. According to the probability ranking results, each procedure has its own advantages and disadvantages. The cure rates of TFS and Ajust are better than others. TFS not only requires the shortest operation time, but also has the greatest advantages in postoperative groin pain, urine retention, and repeat surgery. Meanwhile, Ajust performs well in tap erosion. In contrast, Ophria performed poorly in terms of cure rates and complications. Therefore, in view of comprehensive efficacy and safety, we recommend that TFS or Ajust should be selected first for SIMS surgery and the use of Ophria should be minimized.

## ACKNOWLEDGEMENTS

Not applicable.

## CONFLICT ON INTEREST

The authors declare that they have no competing interests.

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