Biomolecules and Biomedicine
ISSN: 2831-0896 (Print) | ISSN: 2831-090X (Online)
Journal Impact Factor® (2023): 3.1
CiteScore® (2023): 7.4
www.biomolbiomed.com | www.blog.bjbms.org

META-ANALYSIS ARTICLE

An et al: Robotic, traditional, and endoscopic NSM

Comparison of robotic, conventional, and endoscopic nipple-sparing mastectomy with immediate prosthetic breast reconstruction for breast cancer: A systematic review and meta-analysis

Na An, Wenjuan Wang, Dandan Dai, Fei Yuan and Yufeng Zhang*

Department of Breast Diseases, Weifang People's Hospital, Weifang City, Shandong Province, China.

***Correspondence to** Yufeng Zhang: NurseZhang2266@yeah.net.

DOI: https://doi.org/10.17305/bb.2025.11687

ABSTRACT

In this network meta-analysis, we aimed to evaluate the relative efficacy of robotic nipple-sparing mastectomy (RNSM), conventional nipple-sparing mastectomy (CNSM), and endoscope-assisted nipple-sparing mastectomy (ENSM), each combined with immediate prosthetic breast reconstruction (IPBR), for the treatment of breast cancer. Relevant studies published up to June 15, 2024, were identified through searches of PubMed, Embase, the Cochrane Library, and Web of Science. Data extracted from these studies were analyzed using Stata 15.1 and the Gemtc 1.0.1 package in R 4.2.3. A Bayesian framework and a Markov Chain Monte Carlo model were employed to conduct the network meta-analysis. Additionally, a ranking chart was generated to compare the advantages and disadvantages of the surgical methods. Ten studies met the inclusion criteria and were included in the network meta-analysis. The results indicated that ENSM with immediate implant-based reconstruction was associated with a smaller incision compared to CNSM. RNSM combined with IPBR was linked to a lower incidence of total complications, Grade 3 complications, and nipple-areola complex necrosis than CNSM. Furthermore, RNSM with IPBR demonstrated a lower recurrence rate than CNSM. However, CNSM with IPBR showed better outcomes in terms of surgical time, hospital stay, and positive margin infiltration. In contrast, RNSM and ENSM, both combined with IPBR, outperformed CNSM in terms of incision length, complication rates, and recurrence outcomes.

Keywords: Breast cancer; robotic nipple-sparing mastectomy; RNSM; conventional / nipple-sparing mastectomy; CNSM; endoscope-assisted nipple-sparing mastectomy; ENSM; network meta-analysis

INTRODUCTION

Breast cancer is a common malignant cancer with a high incidence rate[1]. Previous studies reported approximately 2.3 million new cases and 685,000 related deaths in 2020 [2]. The risk factors for breast cancer are multifaceted and include age, obesity, alcohol consumption, hormone/reproductive factors, and genetic factors [3-5]. Even with other treatments, the 5-year survival rate for metastatic cases remains below 30% [6]. Breast cancer is highly heterogeneous and requires different treatment approaches based on molecular subtypes [7]. Molecular technology has categorized breast cancer into four distinct subtypes, aiding in timely diagnosis and improving prognosis [8].

The treatment options for breast cancer vary depending on the stage, with the ultimate goal of prolonging life [9]. In 1894, radical mastectomy was first proposed to ensure complete excision of pathological tissue while minimizing the risk of recurrence or metastasis [10]. Mastectomy techniques have since evolved to better preserve the natural appearance of the breast while ensuring complete cancer removal [11]. This trend led to the development of new approaches, including the introduction of nipple-sparing mastectomy (NSM) in the 1980s as a surgical option to improve patient satisfaction with esthetic outcomes. NSM allows for oncologically safe cancer removal while preserving the skin and areola complex, and local recurrence rates are reportedly comparable to those of traditional mastectomies, with higher patient satisfaction [12]. When combined with immediate breast reconstruction, NSM can reduce recurrence and mortality rates, minimize scarring, and improve patient satisfaction [13]. However, conventional NSM (CNSM) leaves a large and visible scar on the breast, and the risk of nipple-areola complex necrosis is high [14].

Currently, endoscopic-assisted NSM (ENSM) and robotic-assisted NSM (RNSM) are emerging as new treatment trends, providing better cosmetic results and high patient acceptance [15]. A previous study suggested that RNSM results in higher patient satisfaction, less blood loss, longer surgical times, and higher medical costs than ENSM [16]. Another study showed that, compared to CNSM, RNSM had longer surgical times and higher costs but a lower incidence of grade 2–3 breast complications [17]. In recent years, the number of patients undergoing minimal access breast surgery (MABS) has increased. Compared to conventional breast surgery, MABS effectively reduces scar length and shortens operation time, and is widely accepted by patients [18]. However, not all CNSM procedures require long or visible incisions. In recent years, the inframammary approach has emerged as a promising technique in NSM surgery, particularly for its potential to optimize both esthetic and functional outcomes [19].

Network meta-analysis (NMA) is a statistical method that summarizes and compares the efficacy of different treatments without direct evidence [20, 21]. The basic principle of meta-analysis is to use statistical methods to combine the results of multiple independent studies on the same issue to reach a conclusion. ENSM or RNSM offers esthetic advantages, such as scar-free mastectomy and improved patient satisfaction; however, they are associated with longer surgery times and higher costs [15, 22]. Currently, few studies have compared the effectiveness of different NSM approaches combined with immediate breast reconstruction. Therefore, in this NMA, we aimed to evaluate the relative efficacy of RNSM, CNSM, and ENSM combined with immediate prosthetic breast reconstruction (IPBR) for breast cancer.

MATERIALS AND METHODS

Search strategy

Our systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [21, 23]. The protocol has been registered in the Open Science Framework (OSF) registry with the registration code osf.io/5j3dk. We searched for relevant articles up to June 15, 2024, in the Embase, PubMed, Web of Science, and Cochrane Library databases. All searches used medical subject headings and common keywords, including "Endoscopy," "Endoscopic," "Robotic," "Robotics," "Robot," "Robots," "Robotically," "Breast," "Mammary," "Neoplasm," "Neoplasms," "Tumor," "Tumors," "Cancer," "Cancers," "Carcinoma," "Carcinomas," "Implantation," "Implantations," "Reconstruction," "Reconstructions," "Flap," "Flaps," "Reconstructive," "Mammaplasty," "Mammaplasties," "Mammoplasty," "Mammoplasties," "Mastectomy," “Mastectomies,” “Mammectomy,” “Mammectomies.” The key terms based on the PICOS search method are presented in Table 1 [24]. We did not limit the outcomes or study design in the search terms to avoid missing potentially relevant studies from our review. The detailed searchsyntax and records retrieved from each database are shown in Table S1. The literature was imported into EndNote X20 and screened by reading the titles and abstracts. Subsequently, the full texts were read to exclude studies that did not meet the inclusion criteria, and the remaining studies were included in this analysis.

Inclusion and exclusion criteria

The inclusion criteria for this study were as follows:

1. **Participants**: Patients with breast cancer undergoing RNSM, CNSM, ENSM, and IPBR.
2. **Intervention**: Studies on RNSM combined with immediate breast reconstruction, ENSM combined with immediate breast reconstruction, and traditional surgery combined with immediate breast reconstruction.
3. **Outcomes**: a) Incision length (cm); b) Total operation time (min); c) Blood loss (mL); d) Hospital stay (days); e) Overall complication rate and incidence of grade 3 complications (Clavien–Dindo classification), as well as specific complication rates; f) Positive margin involvement, where cancer cells are found at the edge of the removed tumor tissue, indicating incomplete tumor removal and possible remaining cancer cells in the patient's body; g) Recurrence. type is clinical trial or observational study.
4. **Study type**: Clinical trials or observational studies.

The exclusion criteria for this analysis were as follows: animal experimental research; reviews, meta-analyses, case reports, conference abstracts, editorial materials, trial registration records, guidelines, books, and notes; studies with inconsistent themes; non-English literature; and retracted studies.

Data extraction

Initially, studies were screened based on the inclusion and exclusion criteria. Data, such as the first author, publication year, study design, study duration, and sample size, were extracted from the publications. We also collected patient characteristics, including sample size, age, body mass index (BMI), lymph node surgery, tumor size, tumor stage, and histopathological grade. Two researchers independently reviewed and agreed on the data extraction; if no consensus was reached, a third researcher was consulted to resolve the disagreement.

Literature quality assessment

Randomized controlled trials were evaluated using an improved Jadad scale [25], which assesses random sequence generation, randomization concealment, blinding, dropout, and loss to follow-up. Studies with scores of 1–3 points were classified as having low quality, and those with scores of 4–7 points were classified as having high quality. Cohort and case-control studies were evaluated using the Newcastle–Ottawa Scale (NOS) [26], which scores studies on a 0–9-point scale, with 0–3 points indicating low quality, 4–6 points indicating medium quality, and 7–9 points indicating high quality. Non-randomized controlled intervention studies were assessed using the MINORS scale [27], which includes 12 items and a total score of 24 points.

Meta-analysis

This study conducted an NMA using a Bayesian framework and Monte Carlo Markov chain model. The model was run with four chains, 20,000 initial iterations, 50,000 continuous updates, and a step size of 1.

Statistical analysis

Data were analyzed using the Gemtc 1.0.1 package in R software (version 4.2.3, R Software for Statistical Computing, Vienna, Austria) and Stata software (version 15.1, StataCorp, College Station, TX, USA). Heterogeneity was measured using the I^2 statistic [28]. The consistency of the model was evaluated by comparing the Deviance Information Criterion (DIC) of the consistency and inconsistency models, with a smaller value indicating a better fit. If the difference in DIC was <5, the data were considered to meet the consistency assumption[29]. For outcomes such as incision length, total operation time, blood loss, and hospital stay, weighted mean differences (WMDs) and 95% confidence intervals (95% CIs) were reported[30]. For complication rate, positive margin involvement, and recurrence, relative risk (RR) values and 95% CI were reported [24]. Forest plots were used to present directly and indirectly compared RR values or WMDs and 95% CIs. A ranking chart was drawn to predict the advantages and disadvantages of each surgical approach.

RESULTS

Inclusion of literature

According to the search strategy, 8,142 articles were retrieved. The documents were imported into EndNote X20 and screened by reading their titles and abstracts. After removing duplicate and non-compliant titles and abstracts, 45 articles remained. Subsequently, 35 articles that did not meet the inclusion criteria were excluded, and the remaining 10 articles were included in the meta-analysis [16, 17] [31-38]. The flowchart of the literature retrieval process is presented in Figure 1.

Quality evaluation

The total study population included 1,525 patients: 504 in the RNSM group, 771 in the CNSM group, and 250 in the ENSM group. Detailed information on the basic characteristics, such as age, BMI, tumor size (cm), lymph node surgery, TNM stage, histopathological grade, and follow-up duration (months), are presented in Table 2. The literature quality evaluation is presented in Supplementary Table S2–5. The NOS scores of the included studies ranged from 6 to 8 points, indicating that the overall quality of the studies was medium to good.

Results of meta-analysis

Incision length (cm)

The connections between RNSM and CNSM, as well as ENSM and CNSM, indicate a larger number of direct comparison studies for CNSM, suggesting a larger sample size (Figure 2A). The incision length was shorter in the ENSM group than in the CNSM group, with a WMD of -5.57 (95% CI, -10.74–-0.69). However, the incision length was not significantly different between the other groups (Figure 2B). In addition, regarding incision length, ENSM appears to be the best surgical option, followed by RNSM, and lastly CNSM (Figure 2C).

Total operation time (min)

There are more studies comparing RNSM and CNSM with large sample sizes (Figure 3A). The total operation time was longer in both the ENSM (WMD: 63.4; 95% CI: 21.18–105.59) and RNSM groups (WMD: 61.22; 95% CI: 24.26–98.24) than in the CNSM group (Figure 3B). Regarding the total operation time, CNSM appeared to be the best surgical option, followed by RNSM (Figure 3C).

Blood loss (mL)

More studies and a larger sample size were used for the direct comparison between RNSM and CNSM (Figure 4A). The forest plot showed no significant differences in blood loss among the groups (Figure 4B). As shown in Figure 4C, RNSM may be the best surgical option for minimizing blood loss, followed by CNSM.

Hospital stay (days)

As shown in Figure 5A, the sample size was larger for the comparison between RNSM and CNSM and between ENSM and CNSM. However, the forest plot showed no statistically significant differences in the length of hospital stay among the groups (Figure 5B). According to Figure 5C, CNSM may be the best surgical approach for shortening hospital stays, followed by ENSM.

Complications

Overall, there are more studies and a larger sample size for direct comparisons between RNSM and CNSM (Figure 6A, D, G). Compared to CNSM, RNSM had a lower incidence of overall complication rate (WMD: 0.73; 95% CI: 0.61–0.88), grade 3 complications (WMD: 0.37; 95% CI: 0.20–0.62), and total nipple-areola complex (NAC) necrosis (WMD: 5.5e-09; 95% CI: 9.5e-21–0.058) (Figure 6B, E, H). For these complications, RNSM had the lowest incidence, followed by ENSM, whereas CNSM had the highest incidence (Figure 6C, G, I). However, there were no significant differences in other complications, including hematoma, infection, and implant loss (Supplementary Figure 1).

Positive margin involvement

There are many studies and a large sample size for the direct comparison between RNSM and CNSM (Figure 7A). However, no statistical difference was observed between the groups (Figure 7B). For positive margin involvement, CNSM may be the best surgical option (Figure 7C).

Recurrence

There are many studies and a large sample size for the direct comparison between RNSM and CNSM (Figure 8A). As shown in Figure 8B, the recurrence rate in the RNSM group was significantly lower than that in the CNSM group (WMD: 0.060; 95% CI: 0.0018–0.47).

According to the ranking probability graph, RNSM had the lowest recurrence rate, followed by ENSM, while CNSM had the highest recurrence rate (Figure 8C).

DISCUSSION

Despite the increasing survival rate of patients with breast cancer following surgical treatment, some patients still experience relapse or metastasis [39-41]. In recent years, the effects of RNSM and ENSM in patients with breast cancer have been extensively studied. It has been found that both RNSM and ENSM offer esthetic advantages, such as scarless mastectomy and high patient satisfaction [42, 43]. However, the efficacy of RNSM, CNSM, or ENSM combined with IPBR in breast cancer treatment remains unclear. In this NMA, 10 studies were included to compare the efficacy of RNSM, CNSM, and ENSM combined with IPBR in breast cancer treatment. The risk of postoperative complications stems from a combination of patient-related and surgery-related factors. While the mastectomy technique plays an important role in defining patient outcomes, the IPBR technique must also be considered. Different IPBR techniques are associated with varying risks of specific complications. For instance, submuscular IPBR is more likely to cause postoperative pain, shoulder movement impairment, and animation deformity, whereas prepectoral IPBR carries an increased risk of rippling. Among the 10 studies included in this meta-analysis, Lai et al. [32] used submuscular IPBR, Qiu et al. [36] generally used submuscular IPBR but applied prepectoral IPBR in special cases, and Moon et al. [34] used prepectoral IPBR. Other studies did not specify the type of IPBR used [16, 17, 31, 33, 35, 37, 38]. The risk of complications associated with IPBR was not analyzed because of the paucity of literature specifying the type of IPBR used. Among these ten studies, one originated from France[17], three from Korea [33-35], one from Italy [37], and five from China [16, 31, 32, 36, 38]. Notably, European studies were predominantly multicenter prospective cohorts, whereas studies in China and South Korea mainly relied on single-center retrospective designs, which may have overestimated the short-term benefits of RNSM (such as reduced hospital stay). Furthermore, Europe emphasized long-term survival rates, whereas Asia focused more on short-term efficacy, with a lack of data on long-term complications. Additionally, geographical heterogeneity and cultural characteristics may amplify technical disparities. In the future, cross-national collaboration will be essential to balance the quality of evidence with regional specificity, thereby promoting the globalization of individualized treatment strategies.

Our meta-analysis revealed no statistically significant differences in clinical outcomes between RNSM and ENSM with immediate implant breast reconstruction. The robotic surgical system reduces the surgeon's workload and promotes precision [35]. Currently, RNSM is gaining increasing support because of its greater precision and accuracy, enabling more efficient removal of breast tissue. RNSM offers advantages such as smaller scars, minimal bleeding, and a low incidence of surgical complications, leading to a better quality of life for patients who undergo the procedure [42]. Lee et al. reported that the incidence of postoperative papillary necrosis and complications was significantly lower in the RNSM group than in the CNSM group [44]. Additionally, RNSM combined with IPBR can reduce the incidence of major necrosis [45]. This NMA found that, compared to CNSM combined with immediate breast reconstruction, RNSM combined with immediate breast reconstruction was associated with lower total complication rates, fewer grade 3 complications, and a reduced incidence of total NAC necrosis. Moreover, the recurrence rate in the RNSM combined with IPBR group was lower than that in the CNSM combined with IPBR group.

RNSM is a new treatment strategy for patients with breast cancer, and has been associated with low perioperative morbidity, improved cosmetic outcomes, and better nipple preservation sensitivity [46]. RNSM has been reported as an effective and safe treatment and preventive approach [47-49]. Furthermore, ENSM is a minimally invasive method with good cosmetic results, inconspicuous scars, and high patient satisfaction [50]. A previous study found that, compared to CNSM, RNSM or ENSM offered better wound healing but at higher costs [32]. Our findings revealed that the combination of ENSM and IPBR resulted in smaller incisions compared to CNSM. Additionally, the combination of RNSM and ENSM for immediate breast reconstruction was superior to CNSM in terms of surgical incision length, complication incidence, and recurrence outcomes. Among these, RNSM combined with IPBR yielded the best results. However, CNSM combined with IPBR was superior to both RNSM and ENSM combined with IPBR in terms of total operation time, hospital stay, and positive margin involvement.

Many previous meta-analyses have analyzed the efficacy of RNSM and CNSM, or RNSM and ENSM in the treatment of breast cancer. For example, one meta-analysis compared the efficacy of RNSM and CNSM in breast cancer cases and found that the RNSM group had significantly longer surgery times, a lower necrosis rate, and fewer overall complications than the CNSM group [51]. Additionally, another meta-analysis found no significant difference in complication rates between NSM and RNSM, suggesting that RNSM can be safely used for patients requiring mastectomy [52]. Other reports have indicated that RNSM is feasible and has an acceptable short-term efficacy [53]. Compared to CNSM, minimally invasive NSM has longer surgical and hospitalization times but significantly reduces patient bleeding, lowers the incidence of complications and nipple necrosis events, and notably increases patient satisfaction [54]. These findings are consistent with those of the present study. However, given the higher costs and increased operative time associated with RNSM, this approach is most appropriate for specific cases in which the benefits are most pronounced.

The meta-analysis in this study offers several advantages. First, a systematic literature search strategy was employed to minimize the risk of publication bias. Second, Bayesian methods were used to rank all the analyzed interventions, providing more accurate estimates. Finally, to the best of our knowledge, this is the first study to systematically compare the effects of different NSM (CNSM, RNSM, ENSM) combined with IPBR.

However, this study has some limitations. First, some studies had small sample sizes, which may have influenced the stability of the results. Second, because of the limited number of included studies, subgroup analyses investigating the impact of different treatment strategies on outcomes were not performed. Lastly, as some studies did not report the timing of outcomes, we were unable to break down the results by specific time points. Therefore, despite the significant advantages of RNSM and ENSM, further extensive independent and replicated association analyses are required to validate the findings of this meta-analysis.

CONCLUSION

In summary, this NMA suggests that RNSM or ENSM combined with IPBR is superior to CNSM combined with IPBR in terms of surgical incision length, complication occurrence, and recurrence outcomes. RNSM or ENSM combined with IPBR shows better efficacy and safety than other available treatment options. However, high quality randomized clinical trials are required to validate these conclusions.

Conflicts of interest: Authors declare no conflicts of interest.

Funding: Authors received no specific funding for this work.

Data availability: Data can be obtained from corresponding authors.

Submitted: 15 November 2024

Accepted: 29 March 2025

Published online: April 2025

REFERENCES

[1]Farkas AH, Nattinger AB. Breast Cancer Screening and Prevention. Ann Intern Med. 2023;176(11):Itc161-itc76.https://doi.org/10.7326/aitc202311210

[2]Arnold M, Morgan E, Rumgay H, Mafra A, Singh D, Laversanne M, et al. Current and future burden of breast cancer: Global statistics for 2020 and 2040. Breast. 2022;66:15-23.https://doi.org/10.1016/j.breast.2022.08.010

[3]Wilkinson L, Gathani T. Understanding breast cancer as a global health concern. Br J Radiol. 2022;95(1130):20211033.https://doi.org/10.1259/bjr.20211033

[4]Hoxha I, Sadiku F, Hoxha L, Nasim M, Christine Buteau MA, Grezda K, et al. Breast Cancer and Lifestyle Factors: Umbrella Review. Hematol Oncol Clin North Am. 2024;38(1):137-70.https://doi.org/10.1016/j.hoc.2023.07.005

[5]Hanusek K, Karczmarski J, Litwiniuk A, Urbańska K, Ambrozkiewicz F, Kwiatkowski A, et al. Obesity as a Risk Factor for Breast Cancer-The Role of miRNA. Int J Mol Sci. 2022;23(24).https://doi.org/10.3390/ijms232415683

[6]Riggio AI, Varley KE, Welm AL. The lingering mysteries of metastatic recurrence in breast cancer. Br J Cancer. 2021;124(1):13-26.https://doi.org/10.1038/s41416-020-01161-4

[7]Kashyap D, Pal D, Sharma R, Garg VK, Goel N, Koundal D, et al. Global Increase in Breast Cancer Incidence: Risk Factors and Preventive Measures. Biomed Res Int. 2022;2022:9605439.https://doi.org/10.1155/2022/9605439

[8]Roy M, Fowler AM, Ulaner GA, Mahajan A. Molecular Classification of Breast Cancer. PET Clin. 2023;18(4):441-58.https://doi.org/10.1016/j.cpet.2023.04.002

[9]Trayes KP, Cokenakes SEH. Breast Cancer Treatment. Am Fam Physician. 2021;104(2):171-8

[10]Freeman MD, Gopman JM, Salzberg CA. The evolution of mastectomy surgical technique: from mutilation to medicine. Gland Surg. 2018;7(3):308-15.https://doi.org/10.21037/gs.2017.09.07

[11]Goethals A, Menon G, Rose J. Mastectomy. StatPearls. Treasure Island (FL): StatPearls Publishing

Copyright © 2025, StatPearls Publishing LLC.; 2025.

[12]Parks L. Nipple-Sparing Mastectomy in Breast Cancer: Impact on Surgical Resection, Oncologic Safety, and Psychological Well-Being. J Adv Pract Oncol. 2021;12(5):499-506.https://doi.org/10.6004/jadpro.2021.12.5.5

[13]Kerr AJ, Dodwell D, McGale P, Holt F, Duane F, Mannu G, et al. Adjuvant and neoadjuvant breast cancer treatments: A systematic review of their effects on mortality. Cancer Treat Rev. 2022;105:102375.https://doi.org/10.1016/j.ctrv.2022.102375

[14]Kim JH, Ryu JM, Bae SJ, Ko BS, Choi JE, Kim KS, et al. Minimal Access vs Conventional Nipple-Sparing Mastectomy. JAMA Surg. 2024;159(10):1177-86.https://doi.org/10.1001/jamasurg.2024.2977

[15]Zhang S, Xie Y, Liang F, Wang Y, Lv Q, Du Z. Endoscopic-assisted Nipple-sparing Mastectomy with Direct-to-Implant Subpectoral Breast Reconstruction in the Management of Breast Cancer. Plast Reconstr Surg Glob Open. 2021;9(12):e3978.https://doi.org/10.1097/gox.0000000000003978

[16]Lai HW, Chen ST, Tai CM, Lin SL, Lin YJ, Huang RH, et al. Robotic- Versus Endoscopic-Assisted Nipple-Sparing Mastectomy with Immediate Prosthesis Breast

Reconstruction in the Management of Breast Cancer: A Case-Control Comparison Study with Analysis of Clinical Outcomes, Learning Curve, Patient-Reported Aesthetic Results, and Medical Cost. Ann Surg Oncol. 2020;27(7):2255-68.https://doi.org/10.1245/s10434-020-08223-0
[17]Houvenaeghel G, Barrou J, Jauffret C, Rua S, Sabiani L, Van Troy A, et al. Robotic Versus Conventional Nipple-Sparing Mastectomy With Immediate Breast Reconstruction. Front Oncol. 2021;11:637049.https://doi.org/10.3389/fonc.2021.637049
[18]Lai HW, Chen ST, Lin YJ, Lin SL, Lin CM, Chen DR, et al. Minimal Access (Endoscopic and Robotic) Breast Surgery in the Surgical Treatment of Early Breast Cancer-Trend and Clinical Outcome From a Single-Surgeon Experience Over 10 Years. Front Oncol. 2021;11:739144.https://doi.org/10.3389/fonc.2021.739144
[19]Kaciulyte J, Sordi S, Luridiana G, Marcasciano M, Torto FL, Cavalieri E, et al. The harmony of proportions: Exploring the golden ratio concept in nipple-sparing mastectomy through inframammary fold incision. Il Giornale di Chirurgia-Journal of the Italian Surgical Association. 2024;44(6):e61
[20]Mbuagbaw L, Rochwerg B, Jaeschke R, Heels-Andsell D, Alhazzani W, Thabane L, et al. Approaches to interpreting and choosing the best treatments in network meta-analyses. Syst Rev. 2017;6(1):79.https://doi.org/10.1186/s13643-017-0473-z
[21]Mills EJ, Thorlund K, Ioannidis JP. Demystifying trial networks and network meta-analysis. Bmj. 2013;346:f2914.https://doi.org/10.1136/bmj.f2914
[22]Burns HR, McCarter JH, King BW, Yu JZ, Hwang RF. Robotic-Assisted Nipple Sparing Mastectomy. Semin Plast Surg. 2023;37(3):176-83.https://doi.org/10.1055/s-0043-1771047
[23]Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Bmj. 2021;372:n71.https://doi.org/10.1136/bmj.n71
[24]Cui S, Xu D, Xiong H, Zhuang Y, He Z. Stress-induced hyperglycemia and mortality in patients with traumatic brain injury without preexisting diabetes: A meta-analysis. Biomol Biomed. 2025;25(2):291-303.https://doi.org/10.17305/bb.2024.10865
[25]Wang W, Long F, Wu X, Li S, Lin J. Clinical Efficacy of Mechanical Traction as Physical Therapy for Lumbar Disc Herniation: A Meta-Analysis. Comput Math Methods Med. 2022;2022:5670303.https://doi.org/10.1155/2022/5670303
[26]Zhu Y, Wang C. Serum pentraxin-3 in patients with chronic obstructive pulmonary disease: A meta-analysis. Biomol Biomed. 2024;24(6):1535-45.https://doi.org/10.17305/bb.2024.10875
[27]Lederhuber H, Massey LH, Kantola VE, Siddiqui MRS, Sayers AE, McDermott FD, et al. Clinical management of high-output stoma: a systematic literature review and meta-analysis. Tech Coloproctol. 2023;27(12):1139-54.https://doi.org/10.1007/s10151-023-02830-1
[28]Xie Y, Quan X, Yang X. Raised levels of chemerin in women with preeclampsia: A meta-analysis. Biomol Biomed. 2024;24(3):454-64.https://doi.org/10.17305/bb.2023.9671
[29]Ye N, Wei C, Deng J, Wang Y, Xie H. Preoxygenation strategies before intubation in patients with acute hypoxic respiratory failure: a network meta-analysis. Front Med (Lausanne). 2025;12:1532911.https://doi.org/10.3389/fmed.2025.1532911
[30]Ashtary-Larky D, Bagheri R, Tinsley GM, Asbaghi O, Paoli A, Moro T. Effects of intermittent fasting combined with resistance training on body composition: a systematic review and meta-analysis. Physiol Behav. 2021;237:113453.https://doi.org/10.1016/j.physbeh.2021.113453

[31]Lai HW, Chen ST, Mok CW, Lin YJ, Wu HK, Lin SL, et al. Robotic versus conventional nipple sparing mastectomy and immediate gel implant breast reconstruction in the management of breast cancer- A case control comparison study with analysis of clinical outcome, medical cost, and patient-reported cosmetic results. J Plast Reconstr Aesthet Surg. 2020;73(8):1514-25.https://doi.org/10.1016/j.bjps.2020.02.021
[32]Lai HW, Chen DR, Liu LC, Chen ST, Kuo YL, Lin SL, et al. Robotic Versus Conventional or Endoscopic-assisted Nipple-sparing Mastectomy and Immediate Prosthesis Breast Reconstruction in the Management of Breast Cancer: A Prospectively Designed Multicenter Trial Comparing Clinical Outcomes, Medical Cost, and Patient-reported Outcomes (RCENSM-P). Ann Surg. 2024;279(1):138-46.https://doi.org/10.1097/sla.0000000000005924
[33]Lee HY, Chang YW, Yu DY, Lee TY, Kim DW, Kim WY, et al. Comparison of Single Incision Endoscopic Nipple-Sparing Mastectomy and Conventional Nipple-Sparing Mastectomy for Breast Cancer Based on Initial Experience. J Breast Cancer. 2021;24(2):196-205.https://doi.org/10.4048/jbc.2021.24.e18
[34]Moon J, Lee J, Lee DW, Lee HS, Nam DJ, Kim MJ, et al. Postoperative pain assessment of robotic nipple-sparing mastectomy with immediate prepectoral prosthesis breast reconstruction: a comparison with conventional nipple-sparing mastectomy. Int J Med Sci. 2021;18(11):2409-16.https://doi.org/10.7150/ijms.56997
[35]Park HS, Lee J, Lai HW, Park JM, Ryu JM, Lee JE, et al. Surgical and Oncologic Outcomes of Robotic and Conventional Nipple-Sparing Mastectomy with Immediate Reconstruction: International Multicenter Pooled Data Analysis. Ann Surg Oncol. 2022;29(11):6646-57.https://doi.org/10.1245/s10434-022-11865-x
[36]Qiu J, Wen N, Xie Y, Feng Y, Liang F, Lv Q, et al. Novel technique for endoscopic-assisted nipple-sparing mastectomy and immediate breast reconstruction with endoscopic-assisted latissimus dorsi muscle flap harvest through a single axillary incision: a retrospective cohort study of comparing endoscopic and open surgery. Gland Surg. 2022;11(8):1383-94.https://doi.org/10.21037/gs-22-398
[37]Toesca A, Sangalli C, Maisonneuve P, Massari G, Girardi A, Baker JL, et al. A Randomized Trial of Robotic Mastectomy Versus Open Surgery in Women With Breast Cancer or BrCA Mutation. Ann Surg. 2022;276(1):11-9.https://doi.org/10.1097/sla.0000000000004969
[38]Wang ZH, Gao GX, Liu WH, Wu SS, Xie F, Xu W, et al. Single-port nipple-sparing subcutaneous mastectomy with immediate prosthetic breast reconstruction for breast cancer. Surg Endosc. 2023;37(5):3842-51.https://doi.org/10.1007/s00464-023-09862-6
[39]Grasset EM, Dunworth M, Sharma G, Loth M, Tandurella J, Cimino-Mathews A, et al. Triple-negative breast cancer metastasis involves complex epithelial-mesenchymal transition dynamics and requires vimentin. Sci Transl Med. 2022;14(656):eabn7571.https://doi.org/10.1126/scitranslmed.abn7571
[40]Herzog SK, Fuqua SAW. ESR1 mutations and therapeutic resistance in metastatic breast cancer: progress and remaining challenges. Br J Cancer. 2022;126(2):174-86.https://doi.org/10.1038/s41416-021-01564-x
[41]Song Y, Barry WT, Seah DS, Tung NM, Garber JE, Lin NU. Patterns of recurrence and metastasis in BRCA1/BRCA2-associated breast cancers. Cancer. 2020;126(2):271-80.https://doi.org/10.1002/cncr.32540
[42]Kim JH, Toesca A, Pozzi G, Gazzetta G, Marrazzo E, Park HS. Controversies and strengths of robot-assisted mastectomy. Eur J Cancer Prev. 2023;32(4):388-90.https://doi.org/10.1097/cej.0000000000000812

[43]Shin H. Current Trends in and Indications for Endoscopy-Assisted Breast Surgery for Breast Cancer. Adv Exp Med Biol. 2021;1187:567-90.https://doi.org/10.1007/978-981-32-9620-6_30
[44]Lee J, Park HS, Lee H, Lee DW, Song SY, Lew DH, et al. Post-Operative Complications and Nipple Necrosis Rates Between Conventional and Robotic Nipple-Sparing Mastectomy. Front Oncol. 2020;10:594388.https://doi.org/10.3389/fonc.2020.594388

[45]Sanson C, Roulot A, Honart JF, Rimareix F, Leymarie N, Sarfati B. Robotic Prophylactic Nipple-Sparing Mastectomy with Immediate Prosthetic Breast Reconstruction: A prospective Study of 138 Procedures. Chirurgia (Bucur). 2021;116(2):135-42.https://doi.org/10.21614/chirurgia.116.2.135
[46]Park KU, Cha C, Pozzi G, Kang YJ, Gregorc V, Sapino A, et al. Robot-assisted Nipple Sparing Mastectomy: Recent Advancements and Ongoing Controversies. Curr Breast Cancer Rep. 2023;15(2):127-34.https://doi.org/10.1007/s12609-023-00487-1
[47]Ryu JM, Lee J, Lee J, Ko B, Kim JH, Shin H, et al. Mastectomy with Reconstruction Including Robotic Endoscopic Surgery (MARRES): a prospective cohort study of the Korea Robot-Endoscopy Minimal Access Breast Surgery Study Group (KoREa-BSG) and Korean Breast Cancer Study Group (KBCSG). BMC Cancer. 2023;23(1):571.https://doi.org/10.1186/s12885-023-10978-0
[48]Park KU, Tozbikian GH, Ferry D, Tsung A, Chetta M, Schulz S, et al. Residual breast tissue after robot-assisted nipple sparing mastectomy. Breast. 2021;55:25-9.https://doi.org/10.1016/j.breast.2020.11.022
[49]Wu WP, Lai HW, Liao CY, Lin J, Huang HI, Chen ST, et al. Use of Magnetic Resonance Imaging for Evaluating Residual Breast Tissue After Robotic-Assisted Nipple-Sparing Mastectomy in Women With Early Breast Cancer. Korean J Radiol. 2023;24(7):640-6.https://doi.org/10.3348/kjr.2022.0708
[50]Takemoto N, Koyanagi A, Yamamoto H. Ten-year follow up of cosmetic outcome, overall survival, and disease-free survival in endoscope-assisted partial mastectomy with filling of dead space using absorbable mesh for stage ≤ IIA breast cancer: comparison with conventional conservative method. BMC Womens Health. 2021;21(1):253.https://doi.org/10.1186/s12905-021-01399-x
[51]De la Cruz-Ku G, Chambergo-Michilot D, Perez A, Valcarcel B, Pamen L, Linshaw D, et al. Outcomes of robotic nipple-sparing mastectomy versus conventional nipple-sparing mastectomy in women with breast cancer: a systematic review and meta-analysis. J Robot Surg. 2023;17(4):1493-509.https://doi.org/10.1007/s11701-023-01547-5
[52]Filipe MD, de Bock E, Postma EL, Bastian OW, Schellekens PPA, Vriens MR, et al. Robotic nipple-sparing mastectomy complication rate compared to traditional nipple-sparing mastectomy: a systematic review and meta-analysis. J Robot Surg. 2022;16(2):265-72.https://doi.org/10.1007/s11701-021-01265-w
[53]Angarita FA, Castelo M, Englesakis M, McCready DR, Cil TD. Robot-assisted nipple-sparing mastectomy: systematic review. Br J Surg. 2020;107(12):1580-94.https://doi.org/10.1002/bjs.11837
[54]Xu X, Gao X, Pan C, Hou J, Zhang L, Lin S. Postoperative outcomes of minimally invasive versus conventional nipple-sparing mastectomy with prosthesis breast reconstruction in breast cancer: a meta-analysis. J Robot Surg. 2024;18(1):274.https://doi.org/10.1007/s11701-024-02030-5

TABLES AND FIGURES WITH LEGENDS

Table 1. PICOS framework for key search terms.

Category	Search terms
Population	"Breast Neoplasm" OR "Breast Tumor" OR "Breast Cancer" OR "Breast Carcinoma"
Intervention	endoscopic-assisted nipple sparing mastectomy
Comparision	"robotic-assisted nipple sparing mastectomy"OR "conventional nipple sparing mastectomy"
Outcomes	Incision length (not limited in search terms)
Study design	Clinical trials and observational studies (not limited in search terms)

Table 2. Baseline information.

	Country	Group	N	Age,year	BMI,kg/m²	tumor size(cm)	Lymph node surgery	TNM stage	Histopathologic grade	follow-up,months
Houvenaeghel, 2021	France	RNSM	87	Mean,47.8	≤24.9,73;25-29.9,9;≥30,5	NR	NR	NR	NR	12
		CNSM	142	Mean,52.7	≤24.9,119;25-29.9,17;≥30,6	NR	NR	NR	NR	12
Lai[a], 2020	Taiwan, China	RNSM	40	49±10*	NR	2.5±2.5*	SLNB only,31;SLNB then ALND,7;ALND,1;Not down,1	0,9;I,11;IIa,11;IIb,6;IIIa,2;IIIc,1	I,8;II,17;III,6	13.5±6.8*
		ENSM	91	49±10*	NR	2.2±1.5*	SLNB only,75;SLNB then ALND,13;ALND,1;Not down,2	0,28;I,28;IIa,23;IIb,8;IIIa,4;IIIc,0	I,13;II,54;III,16	45.6±25.5*
Lai[b], 2020	Taiwan, China	RNSM	54	48±9.3*	NR	2.5±2.3*	SLNB only,40;SLNB then ALND,11;ALND,2;Not down,1	0,8;I,14;IIa,16;IIb,7;IIIa,6	I,13;II,25;III,9	14.6±8.8*
		CNSM	62	49±11*	NR	2.5±1.6*	SLNB only,37;SLNB then ALND,12;ALND,6;Not down,7	0,14;I,15;IIa,17;IIb,7;IIIa,2	I,8;II,34;III,11	47.3±19.6*

Lai, 2024	Taiwan, China	CNSM	73	46.1±8.0*	<18,4;18-24,45;≥24,24	NR	No,9;SLNB only,48;SLNB then ALND,9;ALND,7	NR	NA,16;I,14;II,34;III,9	25.5±8.5*
		ENSM	84	46.9±8.3*	<18,4;18-24,54;≥24,26	NR	No,5;SLNB only,62;SLNB then ALND,12;ALND,5	NR	NA,9;I,17;II,36;III,22	26.9±6.9*
		RNSM	76	48.2±9.5*	<18,3;18-24,59;≥24,14	NR	No,13;SLNB only,48;SLNB then ALND,6;ALND,9	NR	NA,16;I,10;II,33;III,17	28.4±8*
Lee, 2021	Korea	ENSM	20	47.2±9.5*	24.1±3.8*	NR	ALND,2	0,10;Ia,3;IIa,5;IIb,1;IIIa,1	NR	NR
		CNSM	25	44.6±9.6*	22.3±3.6*	NR	ALND,4	0,6;Ia,11;IIa,5;IIb,2;IIIa,1	NR	NR
Moon, 2021	Korea	RNSM	40	46±8*	22.2±3.5*	1.6±1.3	SLNB only,37;SLNB then ALND,3	NR	Grade I,13;Grade II,23;Grade III,4	NR
		CNSM	41	49±10*	23.9±3.6*	1.8±1.1	SLNB only,36;SLNB then ALND,5	NR	Grade I,10;Grade II,21;Grade III,9	NR
Park, 2022	Korea	RNSM	167	45(28-71)^	<25,152;≥25,15	NR	NR	≤Stage I,111;>Stage I,45;Benign，11	NR	18
		CNSM	334	44(23-71)^	<25,294;≥25,40	NR	NR	≤Stage I,227;>Stage I,85;Benign,22	NR	
Toesca, 2022	Italy	CNSM	40	45.5(29-62)^	Underweight,8;Normal weight(18.5-24.9kg/m2)^,32	NR	NR	0,5;Ia,15;IIa,9;IIb,6;IIIa,0;IV,0	NR	28.6(range 3.7–43.3)
		RNSM	40	44.5(30-60)^	Underweight,4;Normal weight(18.5-24.9kg/m2)^,36	NR	NR	0,7;Ia,12;IIa,9;IIb,3;IIIa,2;IV,1	NR	
Wang, 2023	China	ENSM	38	42.00(36.75-51.75)^	21.91(19.98-24.10)^	NR	NR	NR	NR	51.5
		CNSM	26	45.50(39.00-59.00)^	25.57(21.11-28.10)^	NR	NR	NR	NR	
Qiu, 2022	China	ENSM	17	35.9±6.4*	21.3±1.3*	NR	SLNB,12;ALND,5	NR	NR	NR
		CNSM	28	39.1±7.7*	22.3±4.6*	NR	SLNB,13;ALND,15	NR	NR	NR

*Note: *,mean±SD;^,Median(Q1,Q3);NR,non-Reported;RNSM, robotic nipple sparing mastectomy; CNSM, conventional NSM;ENSM,endoscopic-assisted NSM;SLNB,sentinel lymph node biopsy;ALND,axillary lymph node dissection;* TNM,(Tumor,Node,Metastasis).

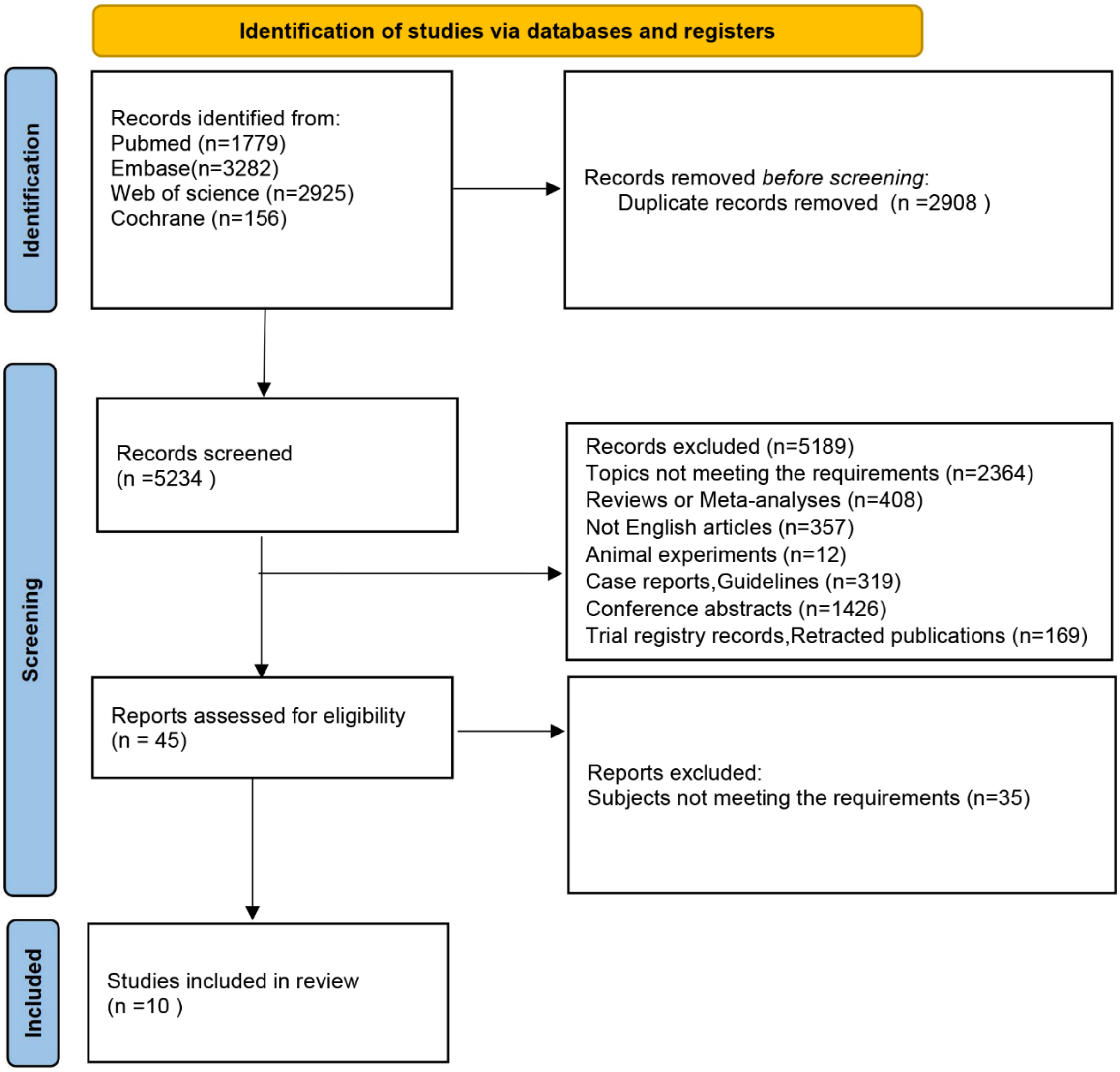


Figure 1. Flow chart of the search process for the Network meta-analysis.

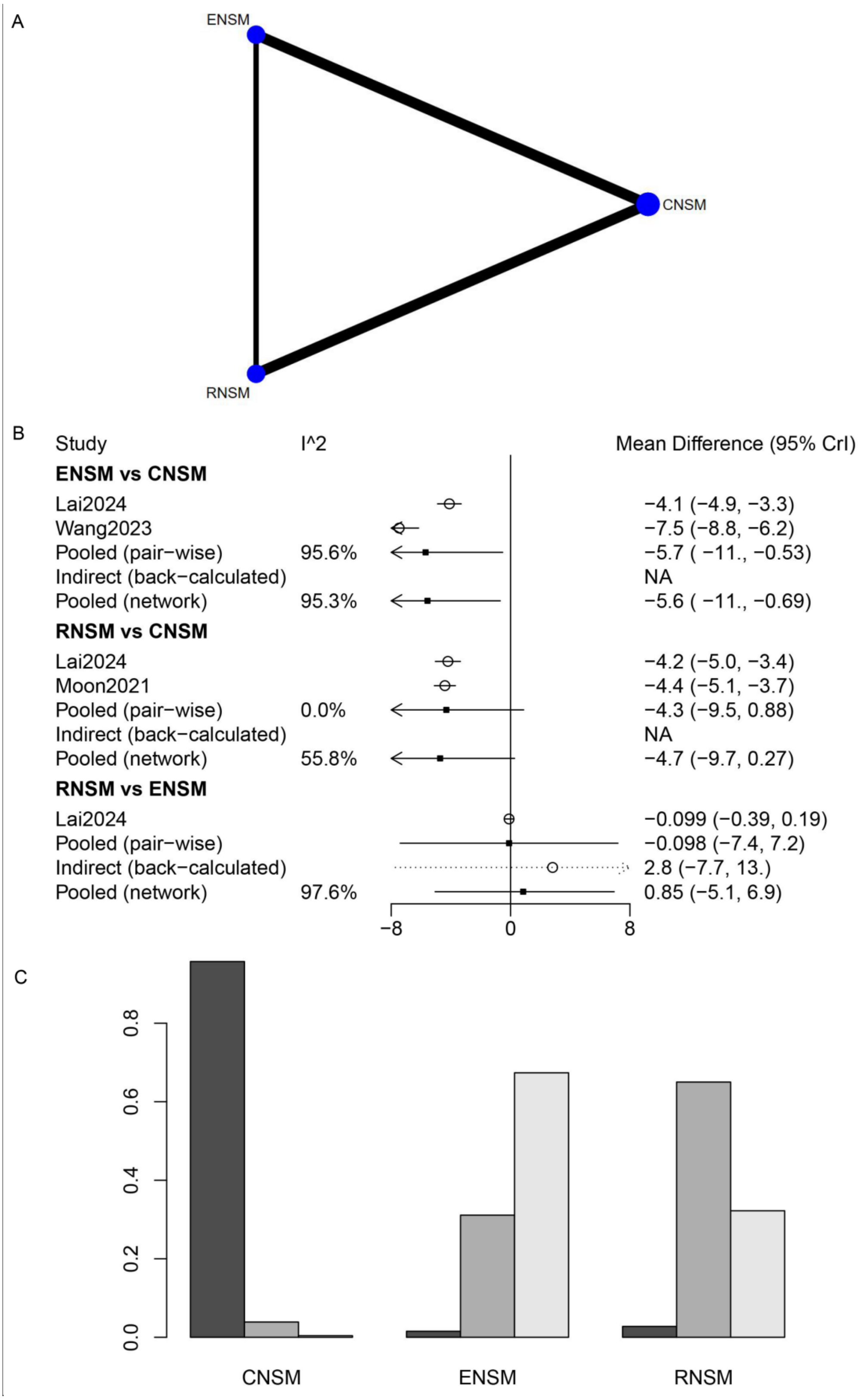


Figure 2. Meta-analysis results of incision length. **A**, Network diagram; **B**, Forest plot; **C**, Sorting probability graph.

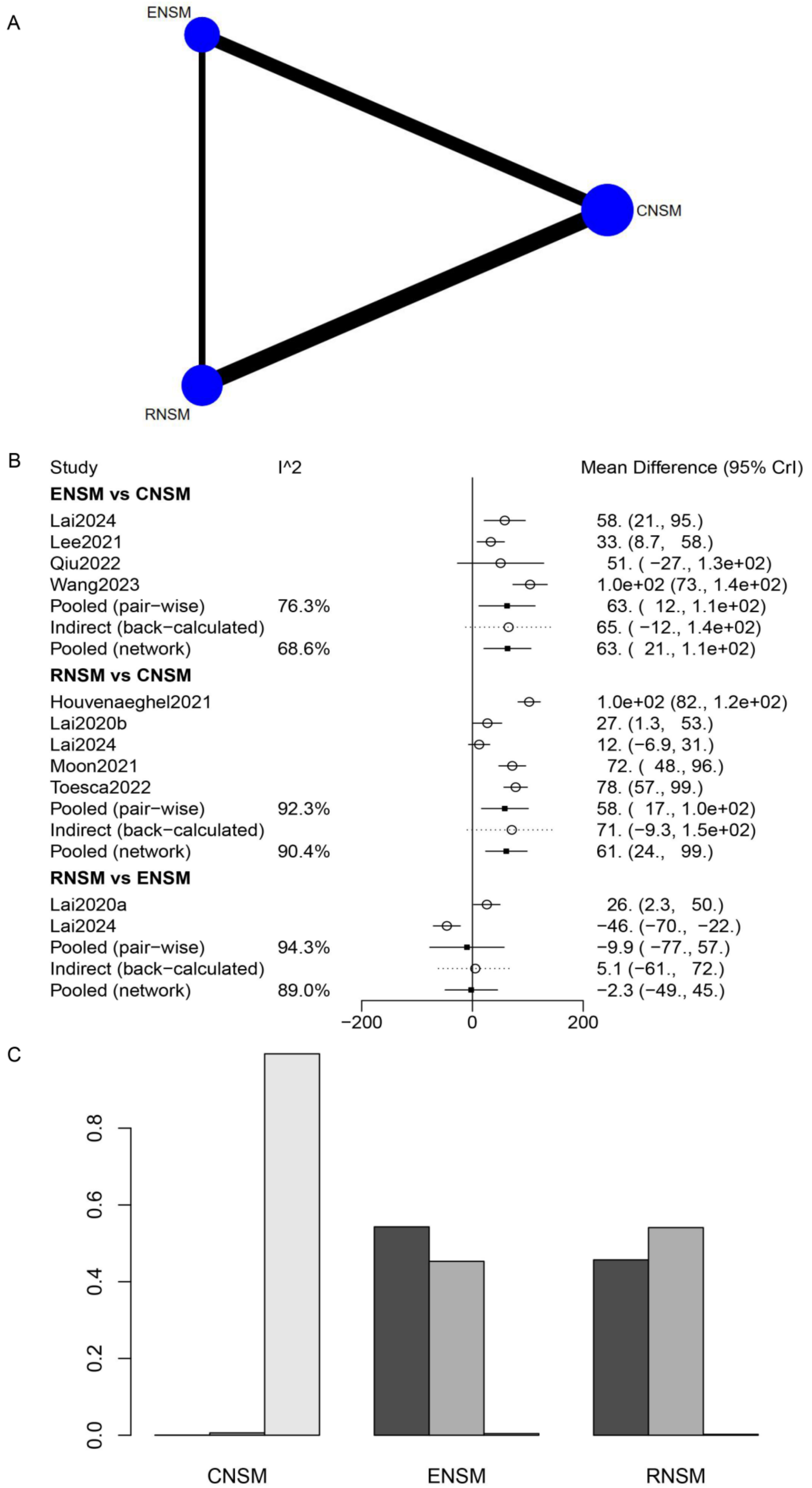

A
ENSM
CNSM
RNSM
B
Study
I^2
Mean Difference (95% CrI)
ENSM vs CNSM
Lai2024 58. (21., 95.)
Lee2021 33. (8.7, 58.)
Qiu2022 51. (−27., 1.3e+02)
Wang2023 1.0e+02 (73., 1.4e+02)
Pooled (pair−wise) 76.3% 63. (12., 1.1e+02)
Indirect (back−calculated) 65. (−12., 1.4e+02)
Pooled (network) 68.6% 63. (21., 1.1e+02)
RNSM vs CNSM
Houvenaeghel2021 1.0e+02 (82., 1.2e+02)
Lai2020b 27. (1.3, 53.)
Lai2024 12. (−6.9, 31.)
Moon2021 72. (48., 96.)
Toesca2022 78. (57., 99.)
Pooled (pair−wise) 92.3% 58. (17., 1.0e+02)
Indirect (back−calculated) 71. (−9.3, 1.5e+02)
Pooled (network) 90.4% 61. (24., 99.)
RNSM vs ENSM
Lai2020a 26. (2.3, 50.)
Lai2024 −46. (−70., −22.)
Pooled (pair−wise) 94.3% −9.9 (−77., 57.)
Indirect (back−calculated) 5.1 (−61., 72.)
Pooled (network) 89.0% −2.3 (−49., 45.)
−200
0
200
C
0.0
0.2
0.4
0.6
0.8
CNSM
ENSM
RNSM

Figure 3. Meta-analysis results of all operation time. **A,** Network diagram; **B,** Forest plot; **C,** Sorting probability graph.

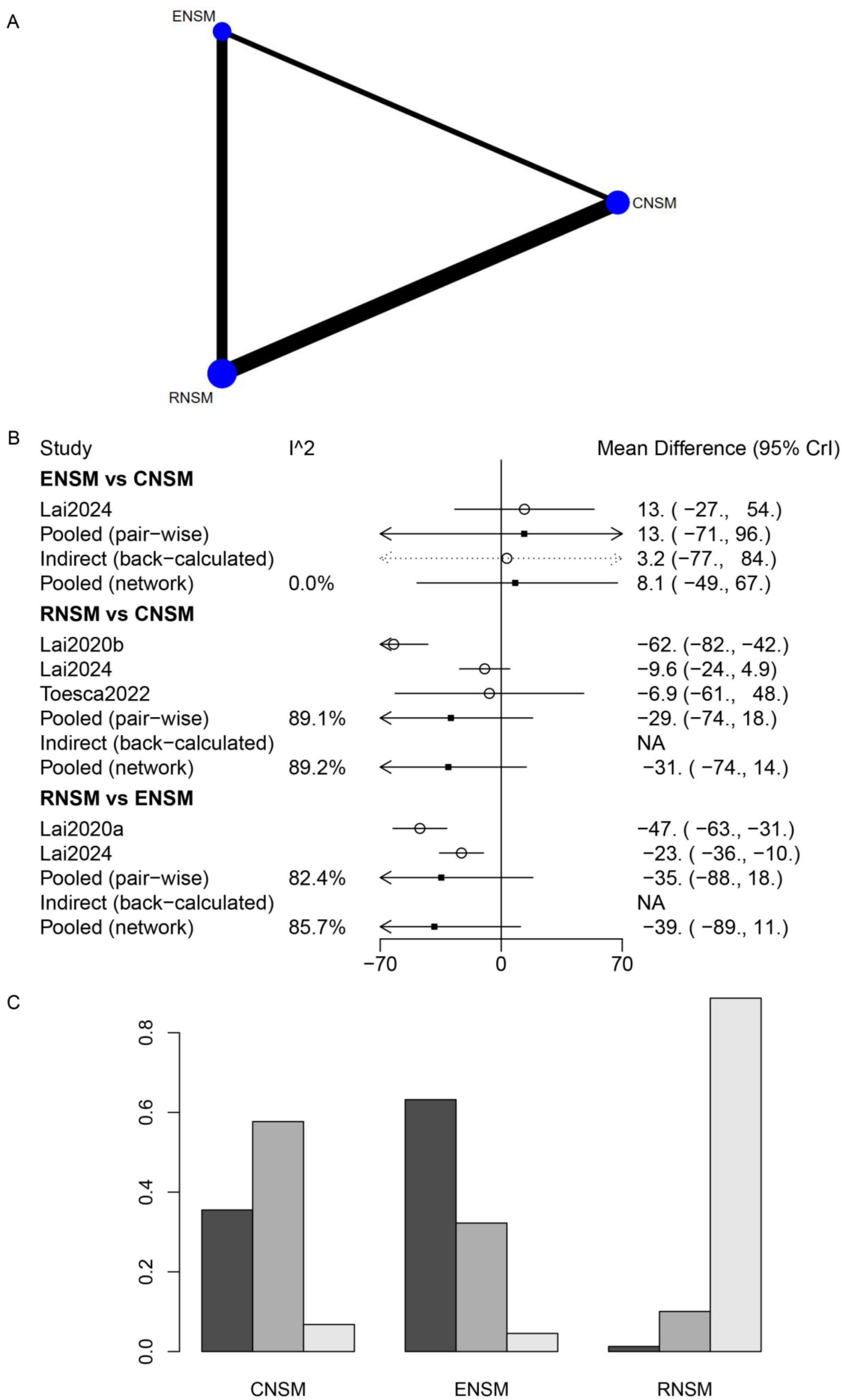

A
ENSM
CNSM
RNSM
B
Study
I^2
Mean Difference (95% CrI)
ENSM vs CNSM
Lai2024
13. (−27., 54.)
Pooled (pair−wise)
13. (−71., 96.)
Indirect (back−calculated)
3.2 (−77., 84.)
Pooled (network)
0.0%
8.1 (−49., 67.)
RNSM vs CNSM
Lai2020b
−62. (−82., −42.)
Lai2024
−9.6 (−24., 4.9)
Toesca2022
−6.9 (−61., 48.)
Pooled (pair−wise)
89.1%
−29. (−74., 18.)
Indirect (back−calculated)
NA
Pooled (network)
89.2%
−31. (−74., 14.)
RNSM vs ENSM
Lai2020a
−47. (−63., −31.)
Lai2024
−23. (−36., −10.)
Pooled (pair−wise)
82.4%
−35. (−88., 18.)
Indirect (back−calculated)
NA
Pooled (network)
85.7%
−39. (−89., 11.)
−70
0
70
C
0.0
0.2
0.4
0.6
0.8
CNSM
ENSM
RNSM

Figure 4. Meta-analysis results of blood loss. **A,** Network diagram; **B,** Forest plot; **C,** Sorting probability graph.

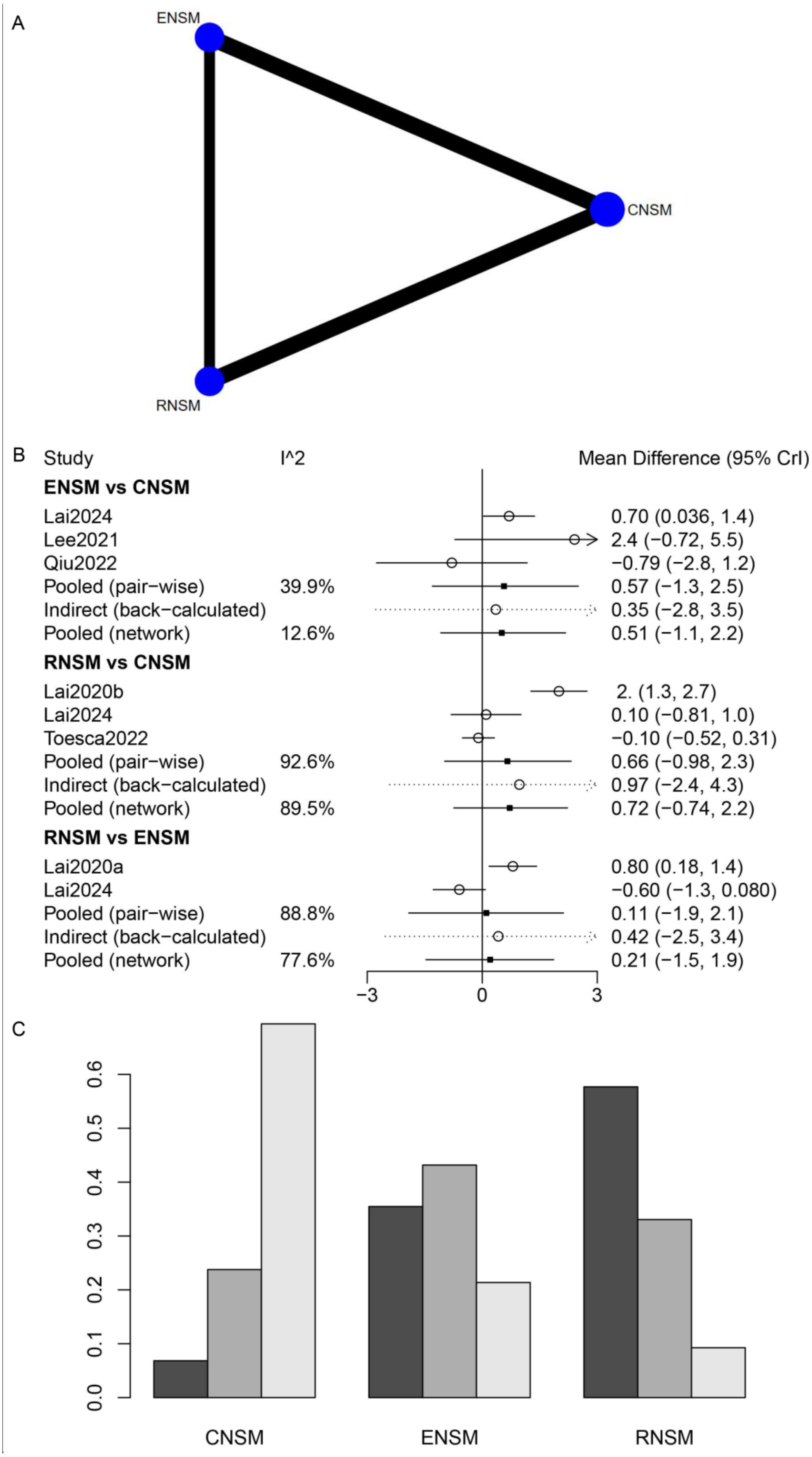
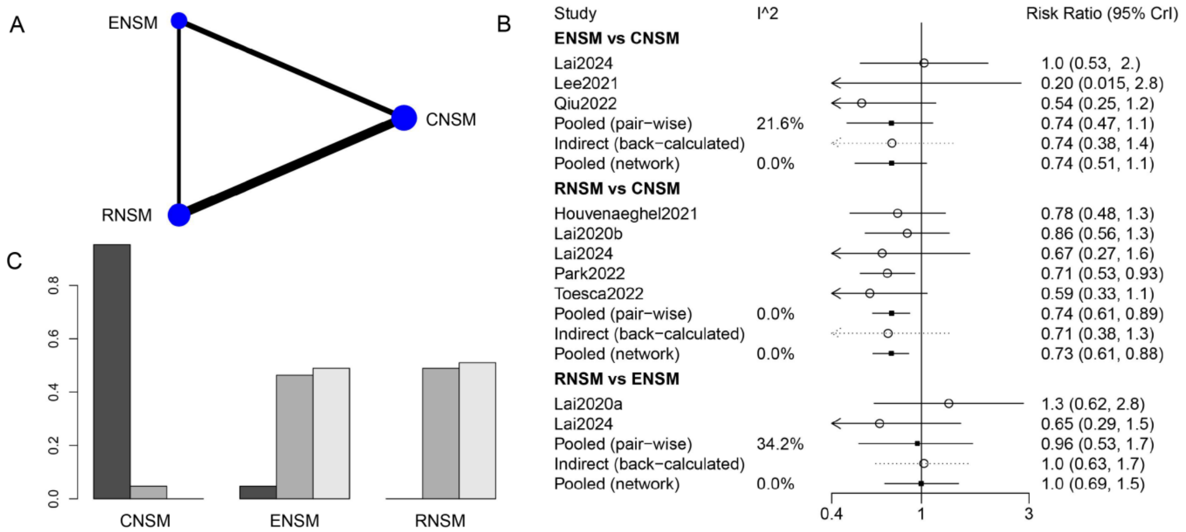
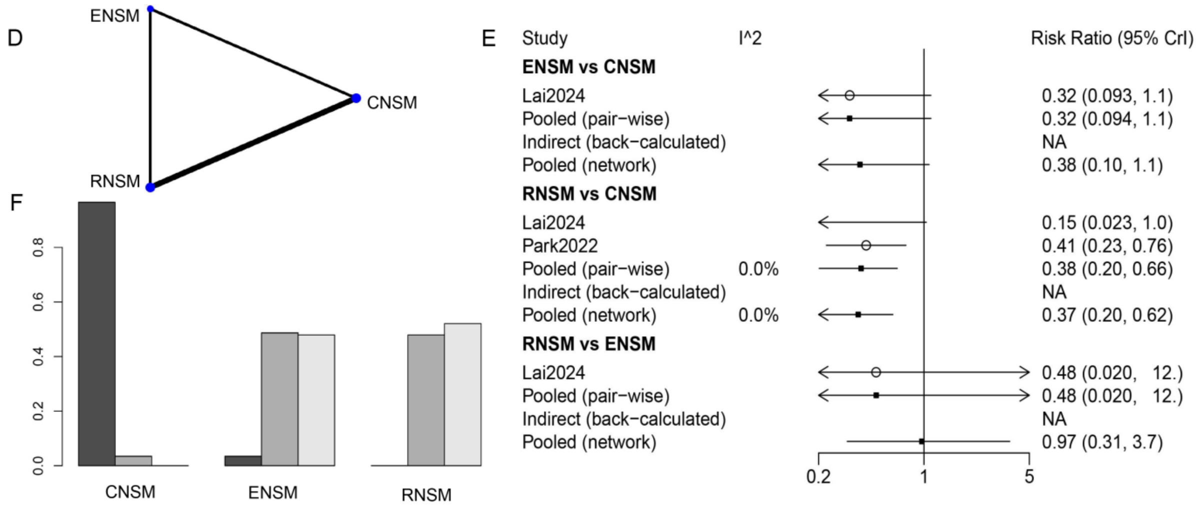

A
ENSM
CNSM
RNSM
B
Study
I^2
Mean Difference (95% CrI)
ENSM vs CNSM
Lai2024
0.70 (0.036, 1.4)
Lee2021
2.4 (−0.72, 5.5)
Qiu2022
−0.79 (−2.8, 1.2)
Pooled (pair−wise)
39.9%
0.57 (−1.3, 2.5)
Indirect (back−calculated)
0.35 (−2.8, 3.5)
Pooled (network)
12.6%
0.51 (−1.1, 2.2)
RNSM vs CNSM
Lai2020b
2. (1.3, 2.7)
Lai2024
0.10 (−0.81, 1.0)
Toesca2022
−0.10 (−0.52, 0.31)
Pooled (pair−wise)
92.6%
0.66 (−0.98, 2.3)
Indirect (back−calculated)
0.97 (−2.4, 4.3)
Pooled (network)
89.5%
0.72 (−0.74, 2.2)
RNSM vs ENSM
Lai2020a
0.80 (0.18, 1.4)
Lai2024
−0.60 (−1.3, 0.080)
Pooled (pair−wise)
88.8%
0.11 (−1.9, 2.1)
Indirect (back−calculated)
0.42 (−2.5, 3.4)
Pooled (network)
77.6%
0.21 (−1.5, 1.9)
−3
0
3
C
0.0
0.1
0.2
0.3
0.4
0.5
0.6
CNSM
ENSM
RNSM

Figure 5. Meta-analysis results of hospital stay meta. **A,** Network diagram; **B,** Forest plot; **C,** Sorting probability graph.

Total complication rate



Complication rate, Grade 3



Total NAC necrosis

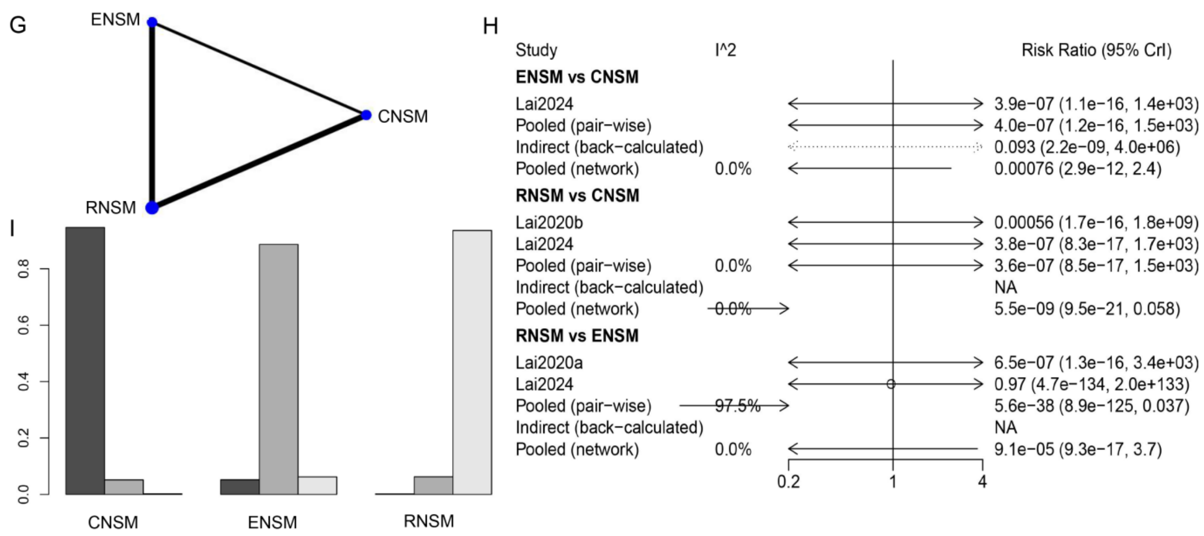


Figure 6. Meta-analysis results of complication (total complication rate; complication rate, Grade 3 and total Nipple-areola complex(NAC) necrosis). **A, D, G,** Network diagram; **B, E, H,** Forest plot; **C, F, I,** Sorting probability graph.

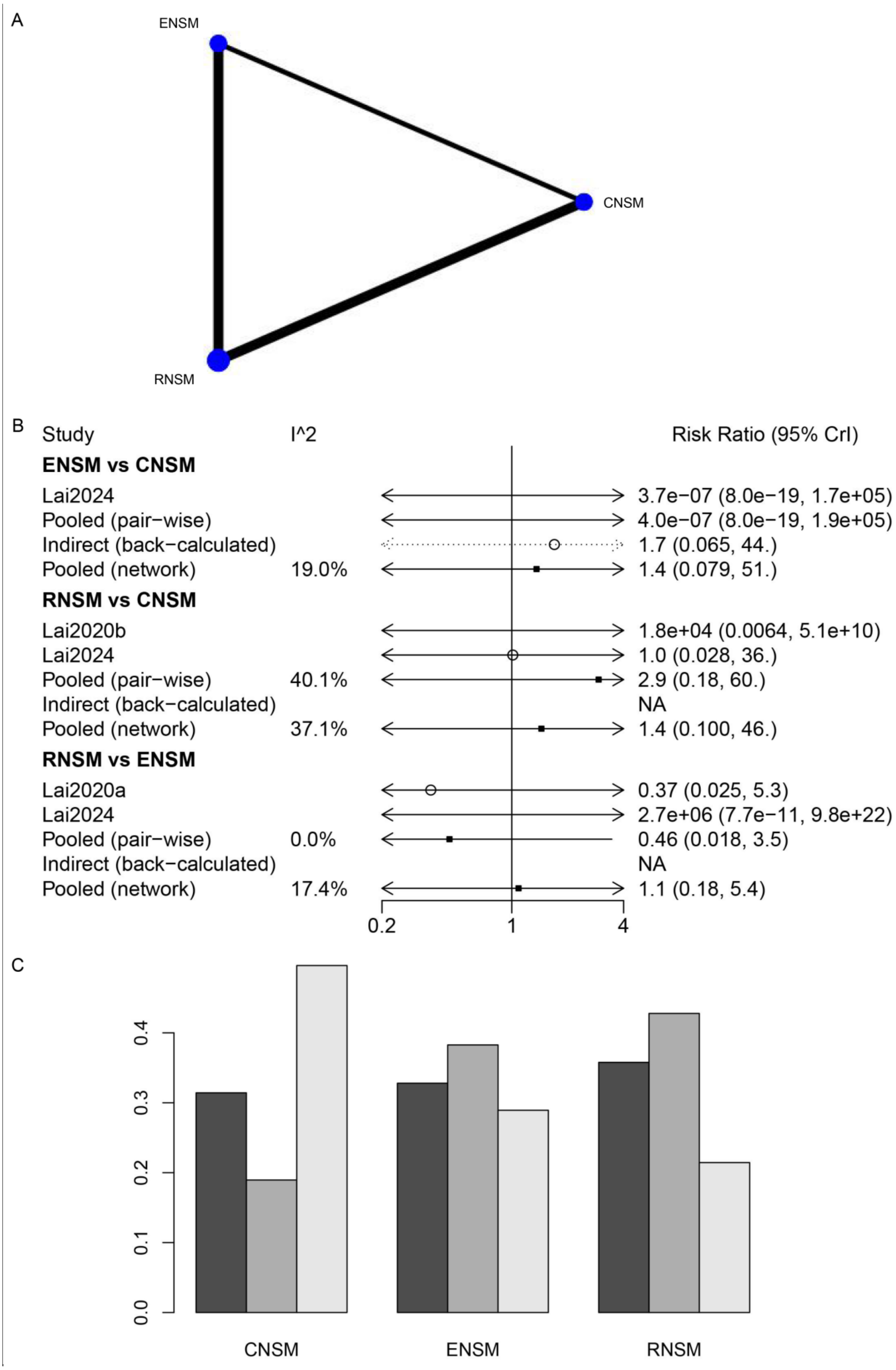
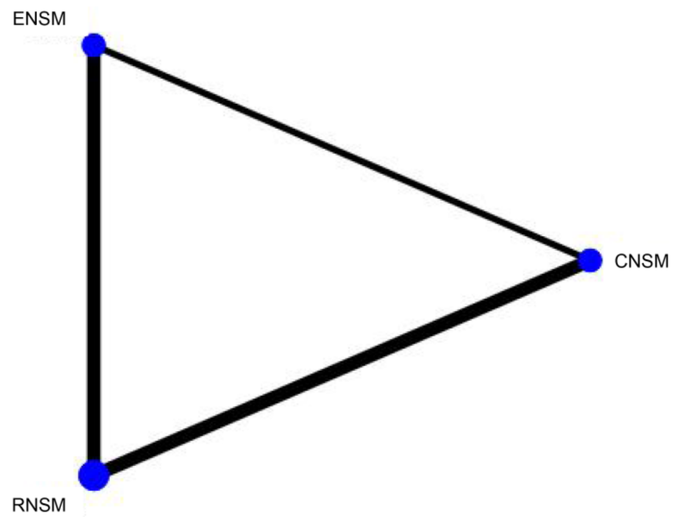


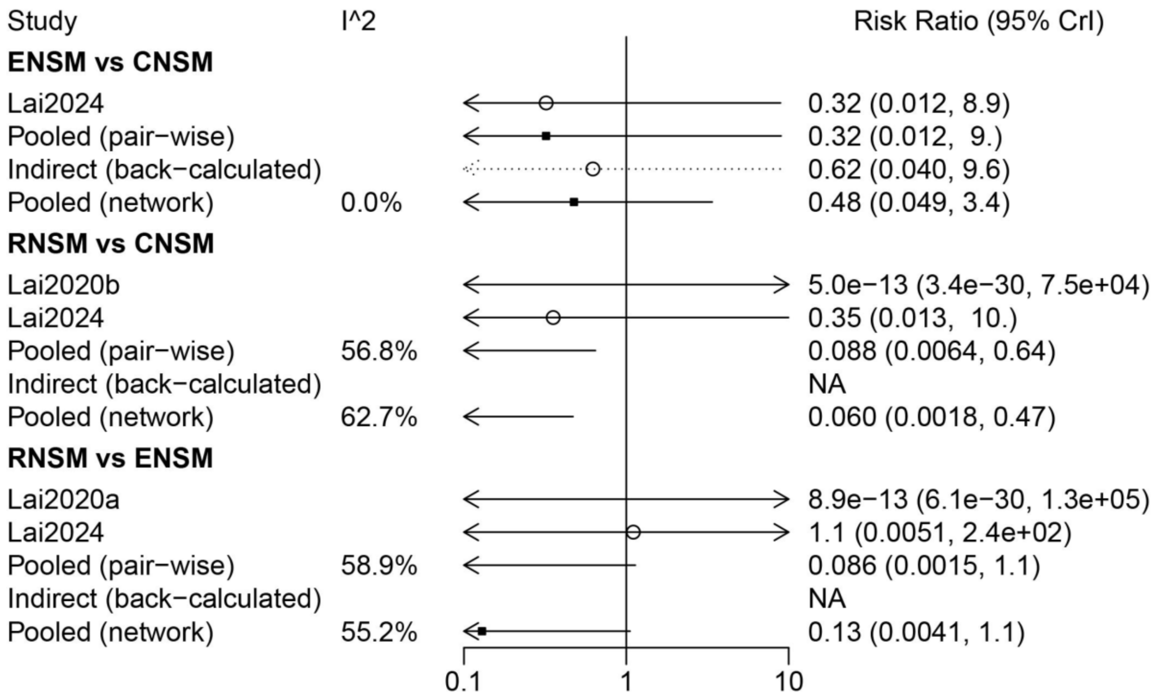
Figure 7. Meta-analysis results of positive margin involvement. **A**, Network diagram; **B**, Forest plot; **C**, Sorting probability graph.

A



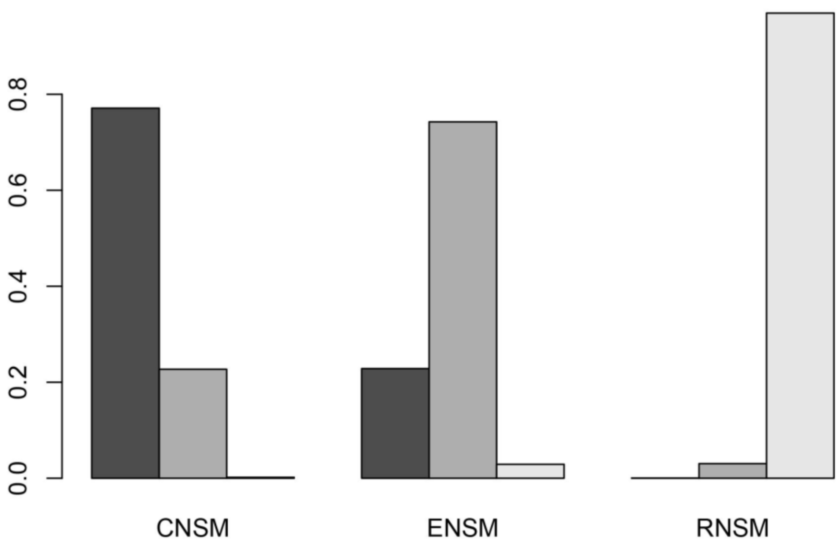
ENSM
CNSM
RNSM

B



Study
I^2
Risk Ratio (95% CrI)
ENSM vs CNSM
Lai2024
0.32 (0.012, 8.9)
Pooled (pair−wise)
0.32 (0.012, 9.)
Indirect (back−calculated)
0.62 (0.040, 9.6)
Pooled (network)
0.0%
0.48 (0.049, 3.4)
RNSM vs CNSM
Lai2020b
5.0e−13 (3.4e−30, 7.5e+04)
Lai2024
0.35 (0.013, 10.)
Pooled (pair−wise)
56.8%
0.088 (0.0064, 0.64)
Indirect (back−calculated)
NA
Pooled (network)
62.7%
0.060 (0.0018, 0.47)
RNSM vs ENSM
Lai2020a
8.9e−13 (6.1e−30, 1.3e+05)
Lai2024
1.1 (0.0051, 2.4e+02)
Pooled (pair−wise)
58.9%
0.086 (0.0015, 1.1)
Indirect (back−calculated)
NA
Pooled (network)
55.2%
0.13 (0.0041, 1.1)
0.1
1
10

C



0.0
0.2
0.4
0.6
0.8
CNSM
ENSM
RNSM

Figure 8. Meta-analysis results of recurrence. **A,** Network diagram; **B,** Forest plot; **C,** Sorting probability graph.

SUPPLEMENTAL DATA

Supplemental data are available at the following link:

https://www.bjbms.org/ojs/index.php/bjbms/article/view/11687/3840