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Retzius-Sparing and Ultra-Sparing Robot-Assisted Radical Prostatectomy: A Systematic Review and Network Meta-Analysis

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Abstract

BACKGROUND: Retzius-sparing and ultra-sparing robot-assisted radical prostatectomy (RARP) aim to accelerate functional recovery while maintaining oncologic safety. Their relative effects across functional, oncologic, and perioperative outcomes remain uncertain.

METHODS: We performed a frequentist random-effects network meta-analysis of conventional, Retzius-sparing and ultra-sparing/preservation RARP. We removed overlapping publications, retaining one report per cohort. Binary and continuous outcomes were summarized as odds ratios (ORs) and mean differences (MDs) with 95% confidence intervals (CIs). We assessed heterogeneity, agreement between direct and indirect evidence, small-study effects and randomized-trial sensitivity analyses where feasible. CINeMA assessed confidence in the primary-outcome network estimates across within-study bias, reporting bias, indirectness, imprecision, heterogeneity, and incoherence.

RESULTS: Thirty-five studies comprising 71 treatment arms and 5 395 participants were retained. Compared with conventional RARP, Retzius-sparing improved continence at 1 month (OR 4.29, 95% CI 3.16–5.82), 3 months (OR 4.57, 3.10–6.72), and 12 months (OR 2.95, 1.56–5.59). Ultra-sparing improved continence at 1 month (OR 2.08, 1.20–3.60), 3 months (OR 2.23, 1.21–4.10), and 6 months (OR 2.52, 1.14–5.58); its 12-month estimate was imprecise. Retzius-sparing was associated with higher overall positive surgical-margin odds (OR 1.26, 1.04–1.53), whereas overall complications did not differ clearly among approaches. CINeMA confidence was very low for all 12 primary comparisons.

CONCLUSIONS: Retzius-sparing RARP showed the most consistent continence advantage, while ultra-sparing approaches showed potential early functional benefit. Interpretation of all comparative effects requires caution because CINeMA confidence was very low, most evidence was nonrandomized, several networks were heterogeneous, and global inconsistency was present for selected perioperative outcomes.

Introduction

Robot-assisted radical prostatectomy has become the standard surgical approach for localized prostate cancer because of its minimally invasive nature and favourable oncologic outcomes. (ref. 1) Conventional robot-assisted radical prostatectomy (C-RARP) is performed through the anterior Retzius space; however, disruption of the puboprostatic ligaments, dorsal venous complex, and anterior bladder support structures may contribute to delayed urinary continence recovery. (ref. 2)

The Retzius-sparing robot-assisted radical prostatectomy (RS-RARP) technique, also known as the Bocciardi approach, uses a posterior dissection while preserving the Retzius space and its anatomical support structures. (ref. 3) This approach has been associated with improved early urinary continence and functional recovery compared with conventional techniques. (ref. 4)

More recently, ultra-sparing robot-assisted radical prostatectomy (US-RARP) has emerged as a further refinement focused on maximal preservation of periprostatic tissues, fascial planes, and neurovascular structures in an effort to optimize postoperative continence and erectile function outcomes. (ref. 5) Despite increasing adoption of these techniques, comparative evidence evaluating perioperative, functional, and oncologic outcomes among conventional, Retzius-sparing, and ultra-sparing approaches remains limited. Therefore, this network meta-analysis aimed to compare C-RARP, RS-RARP, and US-RARP in patients undergoing surgical treatment for localized prostate cancer.

Methods

Protocol and registration

The review was prospectively registered in PROSPERO (CRD420251241363). (ref. 6) The registered protocol specified a network meta-analysis comparing Retzius-sparing, ultra-sparing, and conventional RARP for oncologic, functional, and perioperative outcomes.

Eligibility criteria

Eligible studies included adults with histologically confirmed localized prostate cancer (clinical stage cT1, cT2, or selected cT3a) undergoing RARP with curative intent. Randomized and nonrandomized comparative studies were eligible. Studies of open or nonrobotic laparoscopic prostatectomy, salvage prostatectomy after prior radiotherapy or focal treatment, metastatic disease, or clinically node-positive disease before surgery were excluded.

Treatment nodes

The Retzius-sparing node comprised posterior/Bocciardi approaches that avoided the anterior Retzius space. The ultra-sparing node comprised techniques explicitly described as ultra-sparing or as extending tissue preservation beyond standard nerve-sparing, including extensive urethral, bladder-neck, puboprostatic, arcus tendineus, or seminal-vesicle preservation. The reference node was conventional anterior RARP.

Data collection

A comprehensive systematic literature search was conducted across MEDLINE/PubMed, Scopus, and Web of Science from inception through 31 March 2026, without language restrictions. Controlled vocabulary (MeSH terms) and free-text terms covered surgical technique, robotic radical prostatectomy, prostate cancer, and comparative study designs. Full reproducible search strategies are provided in Supplementary File 1. Screening and data extraction were undertaken independently by two reviewers,

with disagreements resolved by consensus. The study-level evidence inventory contained 35 eligible studies after eligibility exclusions and removal of overlapping publications, including Zeng et al. (ref. 27).

Outcomes

Primary outcomes were urinary continence at 1, 3, and 12 months and overall positive surgical margins. Additional outcomes were immediate, 2-week, and 6-month continence; overall and Clavien–Dindo complications; blood transfusion; operative time; console time; estimated blood loss; and length of stay. Potency, biochemical recurrence, stage-specific positive margins, and time to continence were not meta-analysed because definitions, denominators, time horizons, or units were insufficiently harmonized.

Risk of bias

Risk of bias was assessed independently by two reviewers using the Cochrane RoB 2 framework for randomized controlled trials and the ROBINS-I instrument for nonrandomized comparative studies. Assessment was performed at study-cluster and outcome-specific levels; disagreements were resolved by consensus (refs. 7, 8).

Data preparation

Arm-level values were normalized to the three treatment nodes. Binary data were represented as events and total participants; when a count and percentage were reported without a denominator, the arm population was used and flagged for verification. Continuous values explicitly reported as a median with first and third quartiles were converted to mean and standard deviation using the Luo S2 estimator for the mean and the Wan finite-sample estimator for the standard deviation. When only the interquartile-range width was reported, the median was used as the mean and the Wan estimator was used for the standard deviation. Median–minimum–maximum values and ambiguous parenthetical values were not converted and were excluded from continuous-outcome models (refs. 9, 10).

Statistical analysis

Frequentist network meta-analysis was performed in R using random-effects models and restricted maximum likelihood estimation of between-study variance. Binary outcomes were summarized as ORs and continuous outcomes as MDs, each with 95% CIs. Conventional RARP was the reference. A continuity correction of 0.5 was applied only to comparisons containing a zero cell. Heterogeneity was quantified using tau-squared and I2. Agreement between direct and indirect evidence was assessed using the design-by-treatment interaction and node-splitting analyses. Comparison-adjusted funnel plots and Egger regression were generated for outcomes with at least 10 studies. Randomized-trial-only sensitivity analyses were conducted when the restricted network remained connected (ref. 11). Confidence in the four primary outcome networks was reassessed using CINeMA across within-study

bias, reporting bias, indirectness, imprecision, heterogeneity, and incoherence. The prespecified clinical equivalence range was OR 0.80–1.25; prediction intervals informed heterogeneity judgements (ref. 12). Generative artificial intelligence (OpenAI GPT-5) was used solely for language and manuscript-formatting support; the authors reviewed and verified all content and remain responsible for the manuscript.

Results

Study selection

After eligibility exclusions and removal of overlapping publications, 35 studies were retained. The quantitative dataset comprised 71 treatment arms and 5 395 participants: 34 conventional arms with 2 741 participants, 28 Retzius-sparing arms with 1 967 participants, and 9 ultra-sparing/preservation arms with 687 participants. Each of the 15 analysed outcomes formed a connected three-node network.

Study characteristics

Following eligibility refinement and removal of duplicate publications, 35 distinct studies were included. This quantitative synthesis incorporated 5 395 participants across 71 treatment arms. Detailed study-level characteristics are reported in Table 1, and the final PRISMA flow diagram is provided as Fig. 1 (refs. 13–47).

Risk of bias

Among four randomized studies, one was judged at low risk of bias and three had some concerns. Among 31 nonrandomized studies, 27 were judged at serious risk and four at critical risk. The principal concerns were confounding, participant selection, missing data, and outcome measurement. All judgements were completed by two reviewers and are provided in Figs. 2 and 3. The updated CINeMA assessment rated all 12 comparisons across continence at 1, 3, and 12 months and overall positive surgical margins as very-low-confidence evidence. Major concerns for within-study bias were present in every comparison; reporting bias, indirectness, imprecision, or heterogeneity contributed additional downgrades depending on the outcome. The complete reassessment is reported in Supplementary File 3 and Supplementary Data 4.

Functional outcomes

Compared with conventional RARP, Retzius-sparing was associated with higher continence at 1 month (17 studies; OR 4.29, 95% CI 3.16–5.82; I2 = 31.2%), 3 months (22 studies; OR 4.57, 3.10–6.72; I2 = 64.6%), and 12 months (14 studies; OR 2.95, 1.56–5.59; I2 = 56.8%). Ultra-sparing was also associated with higher continence at 1 month (OR 2.08, 1.20–3.60), 3 months (OR 2.23, 1.21–4.10), and 6 months (OR 2.52, 1.14–5.58), whereas its 12-month estimate was imprecise (OR 2.24, 0.79–6.36). Immediate continence favoured Retzius-sparing (OR 6.47, 4.63–9.05) and ultra-sparing (OR 2.42, 1.12–5.25). Estimates at 2 weeks were highly imprecise.

Oncologic and safety outcomes

For overall positive surgical margins, Retzius-sparing was associated with higher odds than conventional RARP (29 studies; OR 1.26, 95% CI 1.04–1.53; I2 = 17.9%), whereas ultra-sparing was not (OR 1.00, 0.74–1.36). Overall complications were not clearly different for Retzius-sparing (21 studies; OR 1.09, 0.85–1.39) or ultra-sparing (OR 0.70, 0.45–1.07). Retzius-sparing was associated with fewer grade I–II complications (OR 0.51, 0.29–0.88), but neither approach clearly changed grade III-or-higher complications or transfusion.

Perioperative outcomes

Neither approach clearly changed operative time, estimated blood loss, or length of stay. Ultra-sparing was associated with shorter console time (10 studies; MD − 24.79 minutes, 95% CI − 45.92 to − 3.66), while the corresponding Retzius-sparing estimate crossed the null (MD − 9.32 minutes, 95% CI − 25.16 to 6.53). These continuous-outcome networks showed substantial-to-very-high heterogeneity; global inconsistency was also detected for console time and length of stay, so these estimates should be interpreted cautiously.

Heterogeneity, inconsistency, and small-study effects

Heterogeneity was low for positive surgical margins (I2 = 17.9%), overall complications (I2 = 1.7%), transfusion (I2 = 0%), grade I–II complications (I2 = 0%), and severe complications (I2 = 11.9%). It was moderate or substantial for several continence outcomes and substantial to very high for operative time (I2 = 90.8%), console time (I2 = 97.1%), blood loss (I2 = 80.5%), and length of stay (I2 = 61.7%). Ten outcomes met the threshold for Egger testing. Funnel asymmetry was detected for continence at 3 months (P = 0.008) and 12 months (P = 0.017), but not for immediate, 1-month, or 6-month continence, positive surgical margins, overall complications, operative time, console time, or blood loss. Global design-by-treatment tests were estimable for 12 of 15 outcomes and detected inconsistency for console time (P < 0.001) and length of stay (P = 0.024); all other estimable networks had P > 0.05. Node splitting was estimable for 36 comparisons across 12 outcomes and found no statistically detectable local inconsistency (minimum P = 0.159). Full diagnostics are in Supplementary File 2 and Supplementary Data 1.

Randomized-trial sensitivity analyses

Connected randomized-trial networks were available for three outcomes. No estimate was statistically significant after restriction to randomized trials. At 3 months, the ORs for continence were 2.92 (95% CI 0.53–16.08) for Retzius-sparing and 1.83 (0.76–4.41) for ultra-sparing. For positive surgical margins, the ORs were 2.17 (0.84–5.58) and 1.18 (0.70–2.01), respectively. For overall complications, the ORs were 1.70 (0.61–4.73) and 1.09 (0.48–2.49), respectively.

Discussion

Principal findings

In this three-node network meta-analysis, tissue-preserving RARP was generally associated with faster urinary continence recovery than conventional RARP. Retzius-sparing produced the most consistent benefit across early, intermediate, and 12-month time points. Ultra-sparing approaches also favoured several early outcomes, but their evidence base was smaller and long-term estimates were less precise. Retzius-sparing was associated with higher positive surgical-margin odds in the full network; however, this association was not statistically significant when the analysis was restricted to randomized trials. The updated CINeMA assessment rated every primary comparison as very-low-confidence evidence, so these results should be considered hypothesis-generating.

Functional recovery

The timing of the continence advantage is biologically plausible. Posterior Retzius-sparing dissection preserves anterior supporting structures and may reduce disruption of the bladder-urethral support complex. (refs. 3,4) The largest effects were observed immediately and at 1 month, suggesting that the principal benefit may be acceleration of recovery. Attenuation and imprecision in randomized trials indicate that case selection, surgeon experience, study design, and heterogeneous continence definitions may contribute to the larger estimates in the full network.

The favourable ultra-sparing estimates are hypothesis-generating. This node combined several preservation strategies that may not be technically equivalent and represented only 687 participants. Apparent rankings should therefore not be generalized to every ultra-sparing variant.

Oncologic safety

The higher positive surgical-margin odds with Retzius-sparing represent the most clinically important counterweight to the continence findings. This association was precise in the full network but was not statistically significant when the analysis was restricted to randomized trials. Stage-specific margin data were not synthesized because they were inconsistently reported. Without stratification by pathological stage, tumour location, surgeon learning curve, and margin definition, the mechanism cannot be resolved. The results support individualized technique selection and careful oncologic case selection rather than a universal preference based solely on continence ranking.

Perioperative outcomes and safety

The absence of clear differences in overall complications, severe complications, transfusion, operative time, blood loss, and length of stay is reassuring but not definitive. Continuous outcomes were characterized by substantial-to-very-high heterogeneity, and global inconsistency was present for console time and length of stay. The shorter console-time estimate for ultra-sparing should therefore be interpreted as exploratory until units, definitions, and technical variants are harmonized.

Strengths and limitations

Strengths include a registered protocol, simultaneous comparison of three clinically relevant strategies, formal removal of overlapping publications, random-effects modelling, formal assessment of global and local inconsistency, randomized-trial sensitivity analyses, and small-study-effect analyses. The deduplicated dataset included 35 studies, 71 arms, and 5 395 participants across 15 analysable outcomes.

The findings nevertheless remain limited by the predominance of nonrandomized evidence and serious or critical risk of bias in most nonrandomized studies. The ultra-sparing node was small and combined heterogeneous techniques. Continence and complication definitions varied. Potency, biochemical recurrence, time to continence, and stage-specific margins were not meta-analysed because of insufficiently harmonized reporting. Continuous outcomes showed substantial-to-very-high heterogeneity. Explicit median–interquartile-range data were converted using prespecified Luo and Wan estimators, whereas median–minimum–maximum and ambiguous values were excluded; one arm with a reported interquartile range of zero remained ineligible for inverse-variance analysis because its estimated standard deviation was zero. Egger tests suggested small-study effects for 3- and 12-month continence.

Conclusion

Retzius-sparing RARP was associated with the most consistent improvement in urinary continence recovery relative to conventional RARP. Ultra-sparing approaches also showed potential early functional benefits, although evidence was less abundant and several estimates were imprecise or highly heterogeneous. The higher positive surgical-margin odds observed with Retzius-sparing in the full network were not confirmed in randomized-trial sensitivity analysis. CINeMA rated all primary comparisons as very-low-confidence evidence. Technique selection should balance functional goals, tumour characteristics, oncologic safety, and surgeon expertise. Further well-powered randomized trials with standardized outcome definitions and longer oncologic follow-up are required.

Declarations

Ethics approval

Ethics approval was not required because the study synthesized aggregate data from published reports.

Conflicts of interest

The authors declared no conflicts of interest in the PROSPERO registration.

Consent for Publication

Not applicable.

Competing Interests

The authors declare no competing interests, consistent with the disclosures made in the PROSPERO registration (CRD420251241363).

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Author contributions

Carlos Esteban Vidal Valderrama: Conceptualization, statistical analysis, manuscript preparation, and study supervision. **Raul Antunez Perez**: Conceptualization, literature screening, and data acquisition. **Ramon Adrian Magaña Davalos**: Literature screening and data acquisition. **Fernando Chavez Morales**: Literature screening and data acquisition. **Jessica Edith Acevedo Rodriguez**: Data curation and drafting of the introduction. **Jorge David Magaña Rodriguez**: Project supervision and administrative support. **Salvador Alejandro Aguilar Campos**: Project supervision and administrative support. **Hassan Emanuel Govea Reyes**: Data curation, systematic extraction, and literature screening.

Data Availability

All data reported in this study were extracted from published reports. Full search strategies, study characteristics, risk-of-bias assessments, supplementary forest plots, arm-level data, individual-study effect estimates, and NMA diagnostics are available in the accompanying Supplementary Information. The validated analysis input, correction log, CINeMA decision table, and reproducibility code are supplied as Supplementary Data 2–4 and Supplementary Codes 1–2.

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Tables

Table 1 to 3 are available in the Supplementary Files section.

Figures

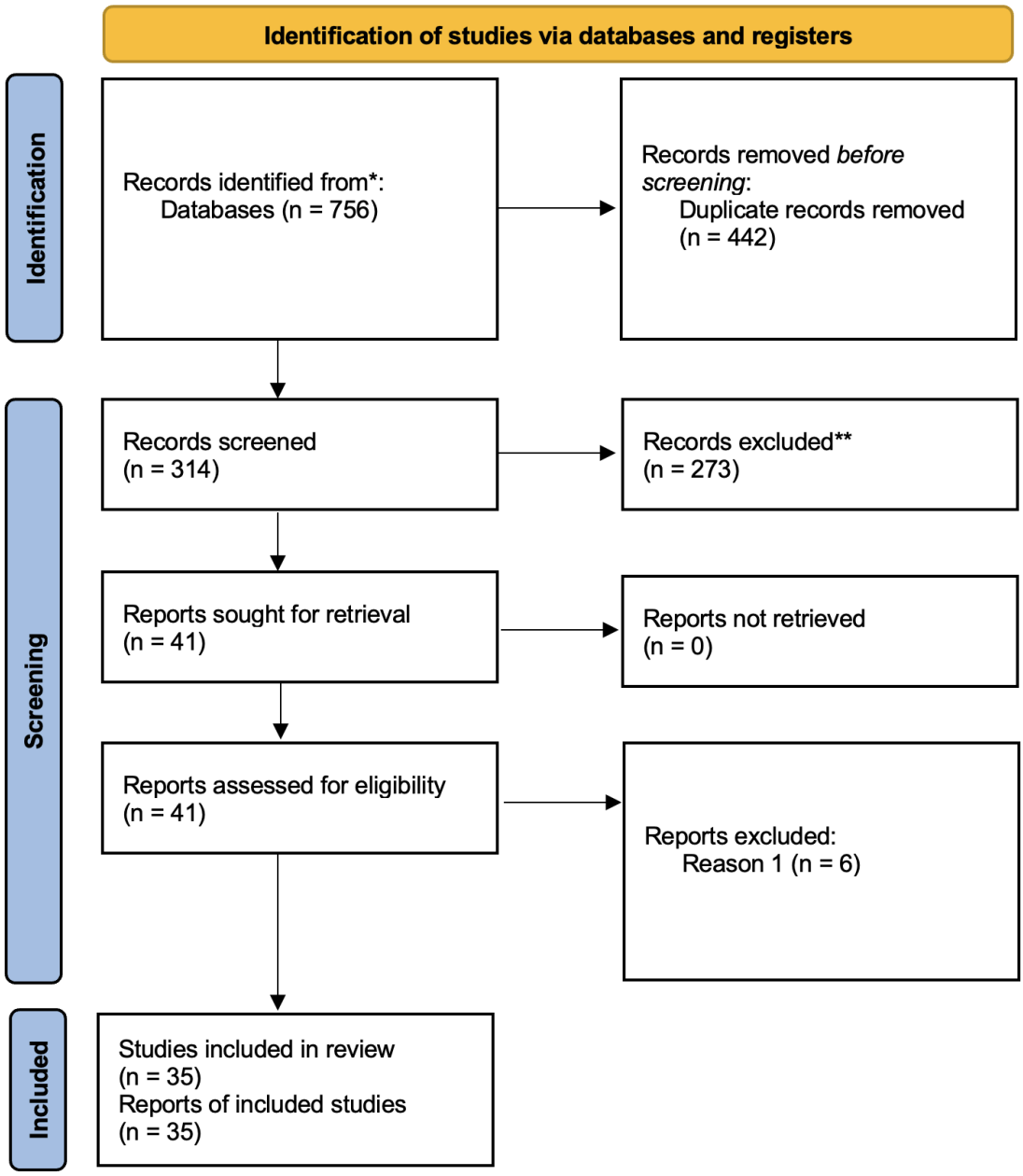


Figure 1

PRISMA 2020 flow diagram.

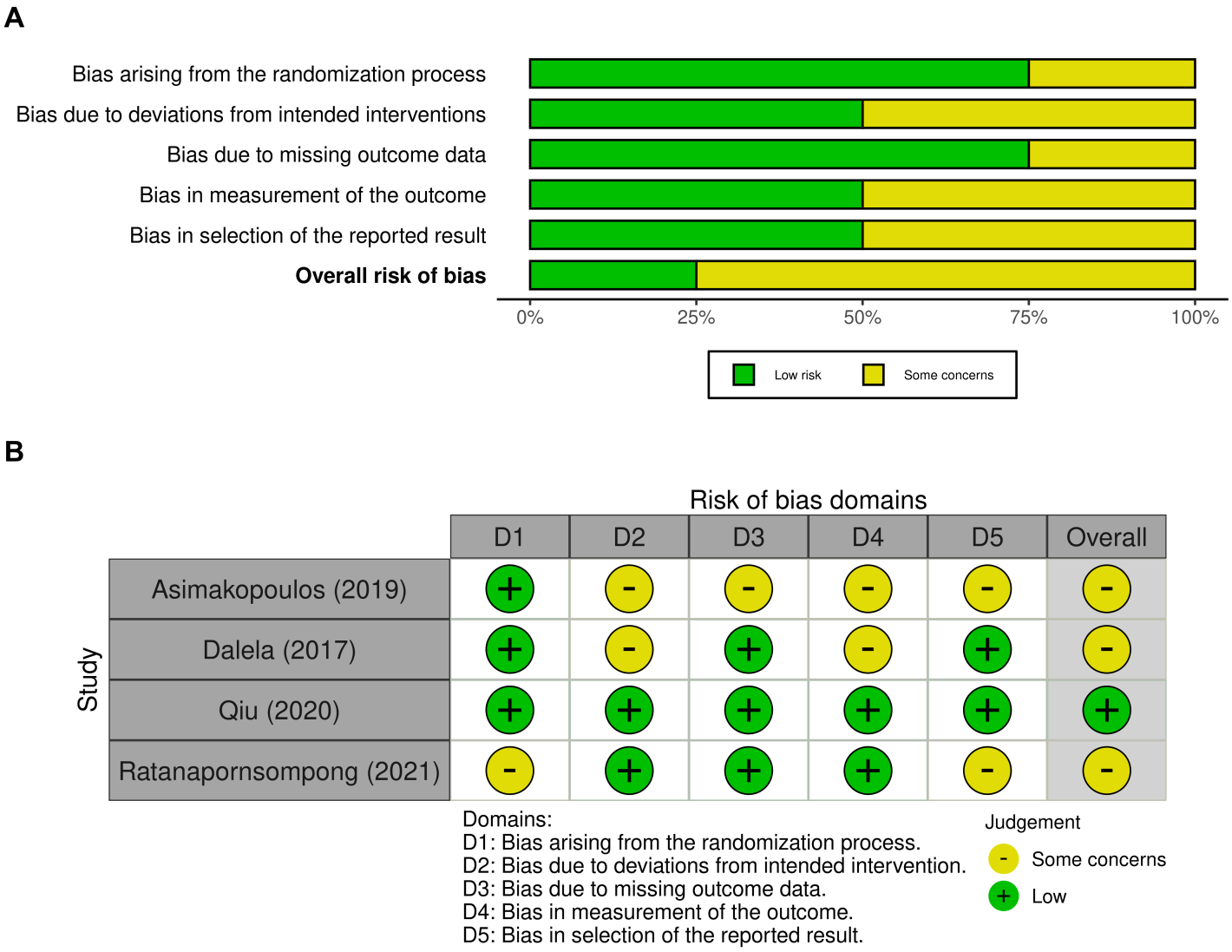


Figure 2

Risk of bias in randomized studies assessed with RoB 2. Panel A shows domain-level judgments; panel B shows the distribution of overall judgments.

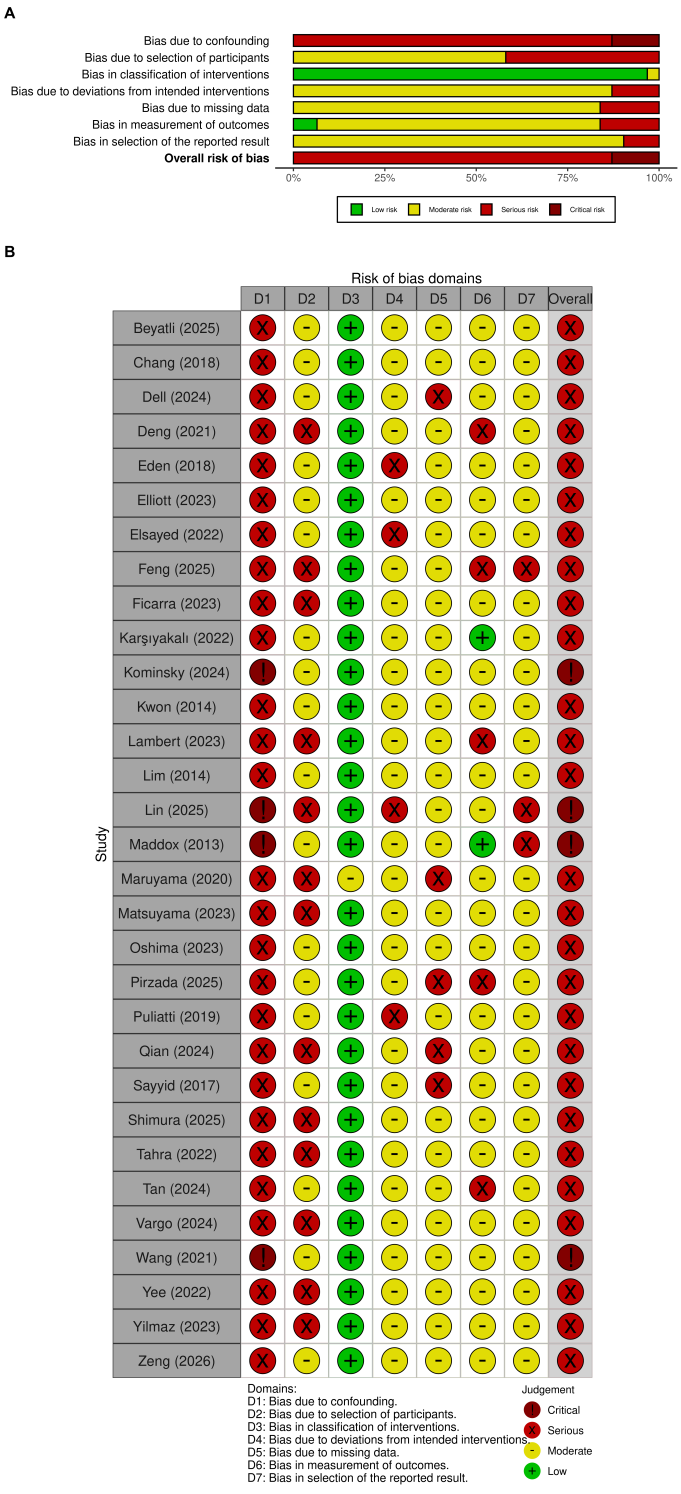


Figure 3

Risk of bias in nonrandomized studies assessed with ROBINS-I. Panel A shows domain-level judgments; panel B shows the distribution of overall judgments.

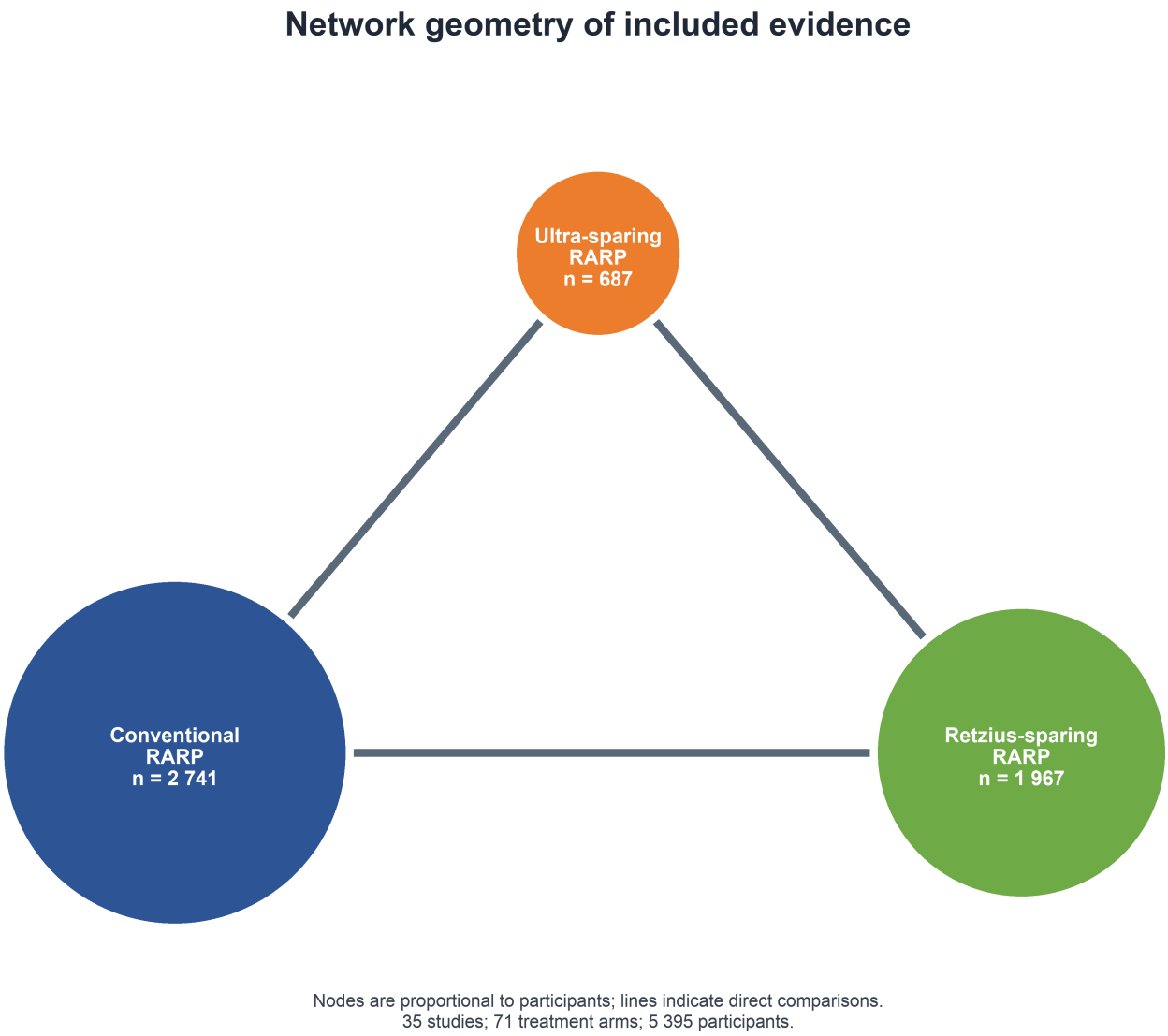


Figure 4

Network geometry of the included evidence. Node sizes are proportional to the number of participants assigned to each treatment; connecting lines indicate direct comparisons contributing to the network.

Supplementary Files

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