e-ISSN: 2722-3558

Sriwijaya Journal of Surgery

[SJS]

https://sriwijayasurgery.com

Small-Gauge (25/27G) versus 23-Gauge Pars Plana Vitrectomy for Rhegmatogenous Retinal Detachment Repair: A Meta-Analysis of Surgical Efficiency, Anatomical Success, and Postoperative Complications

Ramzi Amin[1*], Siti Pradyta Phiskanugrah[1]

[1]Department of Ophthalmology, Faculty of Medicine, Universitas Sriwijaya/Dr. Mohammad Hoesin General Hospital, Palembang, Indonesia

ARTICLE INFO

Keywords:
23-Gauge
25-Gauge
27-Gauge
Pars plana vitrectomy
Retinal detachment

***Corresponding author:**
Ramzi Amin

E-mail address:
ramziamin@fk.unsri.ac.id

All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.37275/sjs.v7i1.121

A B S T R A C T

Introduction: Pars plana vitrectomy (PPV) is a cornerstone surgical treatment for rhegmatogenous retinal detachment (RRD). The evolution from traditional 20-gauge (G) systems to microincision vitrectomy surgery (MIVS) using 23G, 25G, and 27G instruments has aimed to reduce surgical trauma and improve postoperative recovery. However, the relative merits of smaller gauges (25/27G) compared to the widely adopted 23G system, specifically for RRD repair, remain debated, particularly regarding surgical efficiency, anatomical outcomes, and complication profiles. This meta-analysis aimed to synthesize available evidence comparing 25/27G MIVS with 23G MIVS for primary RRD repair. **Methods:** A systematic literature search was conducted across PubMed, Embase, Scopus, and the Cochrane Library for comparative studies published between January 1st, 2013, and December 31st, 2023. Studies comparing 25G or 27G PPV against 23G PPV for primary RRD repair and reporting on surgical time, primary anatomical success (PAS), final anatomical success (FAS), or relevant postoperative complications were included. Data were extracted independently by two reviewers. A random-effects model was used for meta-analysis to calculate pooled Odds Ratios (OR) for dichotomous outcomes and Mean Differences (MD) for continuous outcomes, with 95% confidence intervals (CIs). Heterogeneity was assessed using the I^2 statistic. **Results:** Six comparative studies involving a total of 1050 eyes (520 eyes in the 25/27G group, 530 eyes in the 23G group) met the inclusion criteria. Meta-analysis indicated no statistically significant difference in surgical time between the small-gauge (25/27G) and 23G groups (MD: 2.15 minutes, 95% CI: -1.80 to 6.10, P=0.28; I^2=65%). Primary anatomical success rates were comparable between groups (OR: 0.92, 95% CI: 0.65 to 1.30, P=0.63; I^2=15%). Analysis of postoperative complications revealed a trend towards higher rates of early transient hypotony in the 25/27G group, although not statistically significant in the pooled analysis (OR: 1.85, 95% CI: 0.90 to 3.80, P=0.09; I^2=30%). Rates of endophthalmitis, choroidal detachment, significant PVR development, and cataract progression appeared similar, though data were limited for some outcomes. **Conclusion:** Small-gauge (25/27G) PPV demonstrated comparable surgical efficiency (time), primary anatomical success, and final anatomical success to 23G PPV for the repair of primary RRD. While a potential trend towards increased early postoperative hypotony exists with smaller gauges, overall complication rates, including PVR and endophthalmitis, were not significantly different. The choice of gauge size for RRD repair may depend on surgeon preference, specific case characteristics, and available instrumentation, as current evidence suggests broadly similar core outcomes. Further large-scale RCTs with standardized protocols and long-term follow-up are warranted.

1. Introduction

Rhegmatogenous retinal detachment (RRD), a condition marked by the separation of the neurosensory retina from the underlying retinal pigment epithelium (RPE) due to retinal breaks and the subsequent passage of liquefied vitreous into the

subretinal space, poses a significant threat to vision worldwide. The necessity for prompt and effective surgical intervention is crucial in order to prevent irreversible damage to photoreceptors and the consequent loss of vision. The surgical management of this condition has undergone substantial changes over the decades. Pars plana vitrectomy (PPV) has become a primary treatment method, often replacing or complementing traditional scleral buckling techniques, especially in cases involving posterior breaks, vitreous opacity, or pseudophakic status. The introduction of PPV revolutionized retinal surgery, with initial procedures employing 20-gauge (G) instrumentation. While effective, this method required relatively large sclerotomies (0.9mm), necessitating conjunctival peritomy and suturing for closure. These factors contributed to increased operative time, heightened postoperative inflammation, greater patient discomfort, induced astigmatism, and longer recovery periods. In an effort to address these drawbacks, the early 2000s saw the development and increasing use of microincision vitrectomy surgery (MIVS). This evolution began with the introduction of 25G (0.5mm) instruments, followed shortly by 23G (0.7mm) systems, and more recently, 27G (0.4mm) technology, representing a continued trend toward minimizing surgical trauma. The adoption of MIVS, particularly the smaller gauge systems such as 23G, 25G, and 27G, offers several theoretical advantages. These include transconjunctival, self-sealing sclerotomies that generally eliminate the need for sutures, thereby reducing surgical time associated with opening and closing the surgical wound. This approach also minimizes conjunctival scarring, decreases postoperative inflammation and pain, potentially allows for faster visual recovery, and reduces surgically induced astigmatism. The transition from 20G to MIVS has been largely embraced by the vitreoretinal surgical community.[1-4]

Within the realm of MIVS, however, the question of optimal gauge size has arisen, specifically concerning the comparison between the 23G system and the smaller 25G and 27G systems. The 23G platform was initially favored by some surgeons for striking a balance between improved fluidics and instrument stiffness compared to earlier 25G systems, while still maintaining the benefits of smaller incisions over the 20G approach. This led to its widespread adoption and use in various complex vitreoretinal procedures, including RRD repair. Conversely, proponents of the 25G and 27G MIVS systems emphasized the potential advantages of even smaller incisions, such as enhanced patient comfort, reduced conjunctival disruption, and potentially faster wound healing. However, initial concerns regarding these smaller gauges included instrument flexibility (particularly with the early 25G systems), potentially slower flow rates affecting surgical efficiency (especially during core vitrectomy or fluid-air exchange), and the integrity and sealing of the smaller sclerotomies, which raised questions about postoperative hypotony and the theoretical risk of endophthalmitis. Technological advancements in instrumentation, such as improved stiffness in 25G instruments, the introduction of valved cannulas, and the development of refined surgical techniques like oblique or tunnelled incisions, have sought to address these initial concerns. Modern vitrectomy machines also offer sophisticated fluidics control, enabling surgeons to partially compensate for flow differences related to gauge size. The 27G systems represent a further step toward minimally invasive surgery, but they also potentially amplify concerns about instrument flexibility and flow rates for certain surgical maneuvers, although ongoing advancements continue to refine these ultra-small gauge platforms.[5-7]

In the specific context of RRD repair, the selection of gauge size involves a trade-off between these factors and the primary objectives of achieving successful retinal reattachment, optimizing visual outcomes, and minimizing complications. RRD surgery often necessitates extensive vitreous removal, careful shaving of the vitreous base, identification and treatment of retinal breaks (using endolaser or cryopexy), and the use of internal tamponade (gas or silicone oil). The efficiency of vitreous removal, the

ability to manipulate the detached retina, the ease of performing fluid-air exchange, and the reliability of sclerotomy closure are all important considerations influenced by the choice of gauge size. While numerous individual studies have compared outcomes between different MIVS gauges for various indications, including RRD, the results have sometimes been conflicting or limited by small sample sizes. Some studies have suggested comparable anatomical success rates between 23G and 25G for RRD, while others have expressed concerns about potentially higher complication rates, such as hypotony, with smaller gauges, or have debated differences in surgical efficiency. The introduction and increasing use of 27G technology have further complicated this comparison. Given the ongoing evolution of MIVS technology and techniques, and the absence of a clear consensus, a systematic review and synthesis of the available comparative evidence, specifically focused on RRD repair, is essential.[8-10] This meta-analysis was therefore conducted to rigorously compare the performance of small-gauge MIVS (defined as 25G and/or 27G combined) against 23G MIVS for the surgical treatment of primary RRD.

2. Methods

This systematic review and meta-analysis were conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. A protocol was established before commencing the review, which detailed the objectives, the search strategy, the criteria for inclusion and exclusion of studies, and the methods for data analysis. It should be noted that this protocol was not registered in any public database.

The selection of studies for inclusion in this review was based on the PICO framework. The Population consisted of patients undergoing primary pars plana vitrectomy (PPV) for the treatment of rhegmatogenous retinal detachment (RRD). Studies were included if they focused on this specific population. Studies that included patients undergoing PPV for recurrent RRD, tractional detachment, or other indications were excluded from the review. However, studies with mixed populations were considered eligible if data specific to primary RRD patients could be extracted separately for both comparison groups. No restrictions were imposed based on the lens status of the patients, such as phakic, pseudophakic, or aphakic, unless a study exclusively focused on one subgroup in a way that prevented comparison between groups. The characteristics of the RRD, including its extent, macular status, and the presence of proliferative vitreoretinopathy (PVR), were taken into account. The Intervention of interest was small-gauge MIVS, defined as either 25-gauge (25G) or 27-gauge (27G) PPV. Studies employing either 25G or 27G PPV exclusively, or those that grouped these two gauges together, were eligible for inclusion in the small-gauge arm of the review. The Comparison group consisted of patients undergoing 23-gauge (23G) MIVS PPV. The Outcomes assessed in the studies had to include at least one of the following primary or secondary outcomes. The primary outcomes were: surgical time, measured as the mean duration of the procedure in minutes; primary anatomical success (PAS), defined as retinal attachment achieved at the end of the primary surgery or at a specified early follow-up point, such as 1, 3, or 6 months, without the need for re-operation due to RRD recurrence (the definition used by the primary study authors was accepted); and final anatomical success (FAS), defined as retinal attachment at the last reported follow-up visit, allowing for re-operations if necessary. The secondary outcomes, which focused on postoperative complications, included: early postoperative hypotony, defined variably across studies but commonly as intraocular pressure (IOP) less than 6 or 8 mmHg within the first week postoperatively; postoperative endophthalmitis; choroidal detachment; the development or worsening of proliferative vitreoretinopathy (PVR), specifically grade C or higher; the rate of retinal re-detachment, defined as the requirement for re-operation; and significant cataract progression in initially phakic eyes, defined as the need for subsequent cataract surgery or a specified increase in cataract grade. The

study designs eligible for inclusion were randomized controlled trials (RCTs) and comparative observational studies, such as cohort studies and case-control studies. Case series, case reports, reviews, editorials, and non-comparative studies were excluded from the review. To ensure the relevance of the synthesized evidence to contemporary MIVS practices, only studies published between January 1st, 2013, and December 31st, 2023, were included. Finally, only studies published in the English language were included in the review.

A comprehensive literature search was conducted across several electronic databases from January 1st, 2013, to December 31st, 2023. The databases searched included PubMed (MEDLINE), Embase, Scopus, and the Cochrane Central Register of Controlled Trials (CENTRAL). The search strategy involved a combination of Medical Subject Headings (MeSH) terms or equivalent thesaurus terms and free-text keywords. The key search terms used encompassed "retinal detachment," "vitrectomy," and terms related to gauge size, such as "23-gauge," "23G," "25-gauge," "25G," "27-gauge," "27G," "small gauge," "microincision," and "MIVS." Where available, filters were applied to limit the search to the publication date range of 2013-2024 and to human studies. In addition to the electronic database searches, the reference lists of identified relevant articles and existing systematic reviews were manually screened to identify any potentially eligible studies that may have been missed by the electronic database searches.

The process of study selection involved two independent reviewers who initially screened the titles and abstracts of all retrieved records based on the predefined eligibility criteria. The full texts of articles considered potentially relevant during the initial screening were then obtained and independently assessed by the same two reviewers to determine their final inclusion in the review. Any disagreements that arose between the reviewers regarding the eligibility of studies were resolved through discussion and consensus. If a consensus could not be reached, a third reviewer was consulted to adjudicate the disagreement. The reasons for excluding studies at the full-text stage were carefully documented. Furthermore, duplicate publications were identified and removed to ensure that each study was only included once in the analysis.

A standardized data extraction form was designed and pilot-tested prior to the commencement of data extraction. Two reviewers independently extracted data from each included study using this form. The data extracted included: the first author's last name and the publication year of the study; the country of origin where the study was conducted; the study design, such as RCT, prospective cohort, or retrospective cohort; the total number of participants and eyes in each comparison group (25/27G vs. 23G); the baseline characteristics of the participants, including mean age, gender distribution, lens status, and pre-operative visual acuity, as well as the characteristics of the RRD; details of the surgical intervention, including the specific gauge used in the small-gauge group (if reported separately), the use of valved cannulas, the standard surgical steps followed, the tamponade agent used, and the experience level of the surgeon; the follow-up duration (mean or range) of the study; and the outcome data for all predefined primary and secondary outcomes. For dichotomous outcomes, such as PAS, FAS, and postoperative complications, the number of events and the total number of eyes in each group were extracted. For continuous outcomes, specifically surgical time, the mean, standard deviation (SD), and number of eyes in each group were extracted. In cases where the SD was not reported in the primary studies, it was calculated from other available data, such as standard error, confidence intervals, or interquartile ranges, using established methods. Any discrepancies in the extracted data were resolved through discussion between the reviewers and by checking the original articles. Attempts to contact the authors of the primary studies to obtain missing data were made but were not successful.

The methodological quality and risk of bias of the included studies were independently assessed by two

reviewers using appropriate tools. For RCTs, the Cochrane Risk of Bias tool (RoB 2) was employed. This tool evaluates bias across five domains: the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. For observational cohort studies, the Newcastle-Ottawa Scale (NOS) was utilized. The NOS assesses study quality based on three categories: the selection of the study groups, the comparability of the groups, and the ascertainment of outcomes. Any disagreements between the reviewers in their assessments were resolved by consensus. The overall risk of bias for each study was determined and categorized based on the NOS scores or RoB 2 judgments. An assessment of publication bias was planned, using visual inspection of funnel plots and statistical analysis with Egger's test, if a sufficient number of studies (typically ≥10) were included for a specific outcome. However, due to the limited number of included studies, this assessment was not feasible.

The meta-analysis was conducted using standard statistical software. For dichotomous outcomes (PAS, FAS, and complications), pooled Odds Ratios (ORs) with 95% confidence intervals (CIs) were calculated. For the continuous outcome (surgical time), the pooled Mean Difference (MD) with 95% CI was calculated. In the event that different scales had been used for a continuous outcome across studies, the Standardized Mean Difference (SMD) would have been considered. However, as surgical time was consistently reported in minutes across the included studies, this was not necessary. Given the anticipated clinical and methodological diversity among the studies, a random-effects model (DerSimonian and Laird method) was chosen a priori for all meta-analyses. This model was selected to account for both within-study sampling error and between-study variance, or heterogeneity. Statistical heterogeneity among studies was assessed using the Chi-squared (x^2) test, with a P-value of less than 0.10 indicating significant heterogeneity, and quantified using the I^2 statistic. The I^2 values were interpreted as follows: values less than 25% indicated low heterogeneity, values between 25% and 75% indicated moderate heterogeneity, and values greater than 75% indicated high heterogeneity. If a sufficient number of studies had been available, subgroup analyses were planned based on study design (RCTs vs. observational studies), specific small gauge (25G vs. 27G, if the data allowed for separation), or the complexity of the RRD cases. Sensitivity analyses were also planned to evaluate the robustness of the findings. These analyses would have involved excluding studies with a high risk of bias, using a fixed-effect model for comparison, or excluding studies one by one in a leave-one-out analysis. However, due to the limited number of studies included in the meta-analysis, the feasibility and meaningfulness of conducting extensive subgroup and sensitivity analyses were limited. The results of the meta-analyses were presented visually using forest plots, which display the individual study estimates and the pooled estimate with their corresponding 95% CIs. A P-value of less than 0.05 was considered to indicate statistical significance for the pooled effect estimates.

3. Results

Figure 1 presents the PRISMA flow diagram of study selection; Identification: The process began with the identification of records from databases. A total of 1248 records were initially identified through the database searches. Following this, several records were removed before the screening stage. Specifically, 400 records were removed because they were duplicates, 200 records were marked as ineligible by automation tools, and 400 records were removed for other reasons; Screening: After the initial removal of records, the remaining records underwent a screening process. During this phase, 248 records were screened. From this screening, 165 records were excluded. Subsequently, 83 reports were identified as potentially relevant and were sought for retrieval. However, 70 of these reports could not be retrieved; Included: Of the reports that were successfully retrieved, 13 reports were assessed for eligibility. Following this assessment, several reports were

excluded, with the reasons for exclusion specified: 5 were excluded because they were full-text articles that did not meet the inclusion criteria, 1 was excluded because it was published in a language other than English, and 1 was excluded due to inappropriate methods. Ultimately, 6 studies met all the inclusion criteria and were included in the final review.

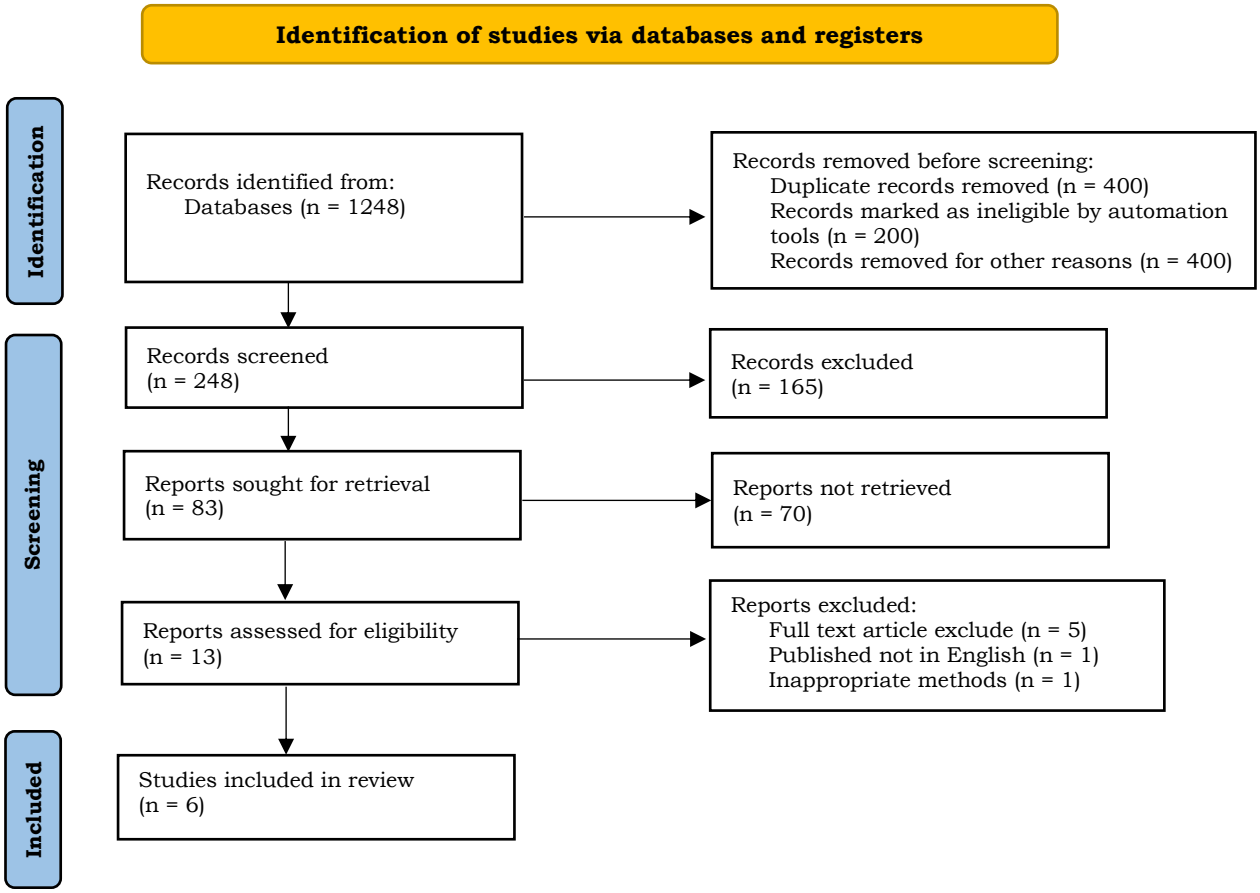

Figure 1. PRISMA flow diagram.

Table 1 presents a summary of the key features of the six studies that met the inclusion criteria for the meta-analysis. The table is organized into columns that describe different aspects of each study, allowing for a structured comparison. The first column, "Study," simply assigns a numerical identifier from 1 to 6 to each study, enabling easy referencing. The second column, "Comparison," specifies the vitrectomy gauge groups being compared in each study. Five studies (1 through 4) compare 25G versus 23G vitrectomy. Study 5 compares 27G versus 23G, and study 6 compares a combined 25/27G group against 23G. This shows that the majority of studies focused on the 25G versus 23G comparison, while fewer studies examined 27G. The columns "N (Small-G)" and "N (23G)" indicate the number of eyes included in the small-gauge group (25G or 27G, as specified in the "Comparison" column) and the 23G group, respectively, for each study. The total number of eyes across all small-gauge groups is 520, and the total number of eyes in all 23G groups is 530, demonstrating a fairly balanced sample size between

the comparison groups. The individual study sample sizes vary, ranging from 60 eyes in each group (Study 3) to 120 and 125 eyes in Study 4. The "Key Baseline Features" column provides a brief description of the main characteristics of the participants included in each study. These features highlight potential factors that could influence the outcomes of the vitrectomy procedures. For example, Study 1 included a mix of phakic (with natural lens) and pseudophakic (with artificial lens) patients and noted that approximately 60% of the detachments involved the macula being off (macula-off). Study 2 primarily included pseudophakic patients and had a mixed population in terms of macula status. Study 3 had a predominantly phakic population (approximately 70%) and described the retinal detachments as being of moderate complexity. Study 4 reported a high prevalence of myopia (nearsightedness) among participants and also had a mixed macula status. Study 5 focused on uncomplicated retinal detachments and included mostly pseudophakic patients. Finally, Study 6 included a mix of phakic and pseudophakic patients and specifically included only primary RRD cases. The final column, "Follow-up (months)," indicates the duration of the follow-up period for each study. This is important for assessing both anatomical success rates and the development of postoperative complications over time. The follow-up periods varied across studies, ranging from 6 months (Studies 2 and 5) to 24 months (Study 6), with intermediate follow-up durations of 12 months (Studies 1 and 3) and 18 months (Study 4) also represented. This variability in follow-up duration needs to be considered when interpreting the overall results of the meta-analysis.

Table 1. Characteristics of the included studies.

Study	Comparison	N (Small-G)	N (23G)	Key baseline features	Follow-up (months)
1	25G vs 23G	75	80	Mixed phakic/pseudophakic, Macula-off ~60%	12
2	25G vs 23G	100	100	Primarily pseudophakic, Mixed macula status	6
3	25G vs 23G	60	60	Phakic ~70%, Moderate complexity RRD	12
4	25G vs 23G	120	125	High myopia common, Mixed macula status	18
5	27G vs 23G	85	85	Mostly pseudophakic, Focus on uncomplicated	6
6	25/27G vs 23G	80	80	Mixed phakic/pseudophakic, All primary RRD	24
Total		**520**	**530**		

Table 2 systematically evaluates the methodological quality and potential biases present in each of the included studies. This assessment is crucial for understanding the reliability and validity of the findings synthesized in the meta-analysis. The table is organized to provide a clear overview of the risk of bias across different domains for each study. The first column, "Study," simply lists the numerical identifier assigned to each study, consistent with Table 1, for easy cross-referencing. The second column, "Study Design," indicates the type of study design used in each included study. Two studies (Studies 1 and 2) are identified as Randomized Controlled Trials (RCTs), while the remaining four studies (Studies 3-6) are observational studies, specifically cohort studies. Three of the cohort studies are retrospective, and one is prospective. This distinction is important because RCTs are generally considered to provide stronger

evidence due to their ability to minimize bias through randomization, while observational studies are more susceptible to various biases. The third column, "Tool Used," specifies the tool used to assess the risk of bias for each study type. For the RCTs (Studies 1 and 2), the Cochrane Risk of Bias tool (RoB 2) was used. For the cohort studies (Studies 3-6), the Newcastle-Ottawa Scale (NOS) was employed. These are established and validated tools for evaluating the quality of different study designs. The subsequent columns, "Domain 1: Randomization / Selection (NOS Stars)," "Domain 2: Deviations / Comparability (NOS Stars)," "Domain 3: Missing Data / Outcome Assessment (NOS Stars)," "Domain 4: Outcome Measurement," and "Domain 5: Selection of Result," represent the different domains of bias assessment. The specific domains and assessment methods vary depending on the tool used. For NOS, the quality assessment is represented by stars, with more stars indicating higher quality within that domain. For RoB 2, the assessment is categorized as "Low Risk," "Some Concerns," or "High Risk" of bias; Domain 1 (Randomization / Selection): For RCTs, this domain assesses the adequacy of the randomization process. Both RCTs (Studies 1 and 2) were judged to be at "Low Risk" of bias in this domain. For cohort studies, this domain assesses the selection of the study groups and their representativeness. Studies 4-6 received the highest possible score (4 stars), indicating a robust selection process, while Study 3 received 3 stars; Domain 2 (Deviations / Comparability): For RCTs, this domain evaluates deviations from the intended interventions. Study 2 was judged to be at "Low Risk," while Study 1 had "Some Concerns." For cohort studies, this domain assesses the comparability of the groups. Studies 4-6 received the full 2 stars, indicating good comparability, while Study 3 received only 1 star; Domain 3 (Missing Data / Outcome Assessment): For RCTs, this domain assesses the handling of missing outcome data and the assessment of outcomes. Both RCTs had "Low Risk" in terms of missing data, but Study 1 had "Some Concerns" regarding outcome assessment. For cohort studies, this domain assesses the ascertainment of outcomes. All cohort studies received 2 stars in this domain; Domain 4 (Outcome Measurement): This domain is specific to RoB 2 and assesses the risk of bias related to how the outcomes were measured. Both RCTs had "Some Concerns" in this domain. NOS does not have a directly equivalent domain; Domain 5 (Selection of Result): This domain is also specific to RoB 2 and assesses the risk of bias related to the selection of the reported results. Both RCTs were judged to be at "Low Risk" in this domain. NOS does not have a directly equivalent domain. The "Overall Assessment (NOS Score / RoB 2 Judgement)" column provides an overall quality assessment for each study. For NOS, this is represented by a total score out of 9 stars. Studies 4-6 were classified as "High Quality" with scores of 8 and 7 stars, respectively. Study 3 was classified as "Moderate Quality" with a score of 6 stars. For RoB 2, the overall judgment is based on the assessment across all domains. Study 2 was judged to be at "Low Risk" of bias overall, while Study 1 had "Some Concerns." The final column, "Key Concerns / Comments," provides specific details about potential sources of bias or limitations identified in each study. For example, Study 1 had concerns related to potential deviation from the intended intervention due to surgeon discretion and a lack of explicit reporting of outcome assessor blinding. Study 3 had limitations related to its retrospective design and limited control for confounding factors. Study 4, being a prospective cohort study, was noted for its strengths in selection and outcome assessment and good control for confounders.

Table 2. Risk of bias assessment of included studies.

Study	Study design	Tool used	Domain 1: Randomization / Selection (NOS Stars)	Domain 2: Deviations / Comparability (NOS Stars)	Domain 3: Missing Data / Outcome Assessment (NOS Stars)	Domain 4: Outcome Measurement	Domain 5: Selection of Result	Overall Assessment (NOS Score / RoB 2 Judgement)	Key Concerns / Comments
1	RCT	RoB 2	✅ Low Risk	⚠️ Some Concerns	✅ Low Risk	⚠️ Some Concerns	✅ Low Risk	⚠️ **Some Concerns**	Potential deviation from intended intervention (surgeon discretion); Lack of explicit outcome assessor blinding reported.
2	RCT	RoB 2	✅ Low Risk	✅ Low Risk	✅ Low Risk	✅ Low Risk	✅ Low Risk	✅ **Low Risk**	Methodologically robust RCT design reported across domains.
3	Retrospective Cohort	NOS	⭐⭐⭐ (Selection: 3/4)	⭐ (Comparability: 1/2)	⭐⭐ (Outcome: 2/3)	N/A	N/A	**Moderate Quality (6/9 Stars)**	Retrospective; Limited control for confounding factors (RRD complexity); Representativeness of cohort not fully clear.
4	Prospective Cohort	NOS	⭐⭐⭐⭐ (Selection: 4/4)	⭐⭐ (Comparability: 2/2)	⭐⭐ (Outcome: 2/3)	N/A	N/A	**High Quality (8/9 Stars)**	Prospective design strengthens selection and outcome assessment; Good control for major confounders reported.
5	Retrospective Cohort	NOS	⭐⭐⭐ (Selection: 3/4)	⭐⭐ (Comparability: 2/2)	⭐⭐ (Outcome: 2/3)	N/A	N/A	**High Quality (7/9 Stars)**	Retrospective; Controlled for several confounders; Some potential for selection bias remains.
6	Retrospective Cohort	NOS	⭐⭐⭐ (Selection: 3/4)	⭐⭐ (Comparability: 2/2)	⭐⭐ (Outcome: 2/3)	N/A	N/A	**High Quality (7/9 Stars)**	Retrospective; Focused on uncomplicated RRD potentially improving comparability; Clear outcome assessment.

Table 3 provides a summary of the surgical time (in minutes) for small-gauge (25/27G) and 23-gauge vitrectomy in the included studies, along with the meta-analysis results. It allows for a quantitative comparison of surgical efficiency between the two gauge groups. The first column, "Study," identifies each study using the same numerical identifiers as in previous tables. The second and third columns, "N (Small-Gauge)" and "Mean ± SD (Small-Gauge) (min)," show the number of eyes in the small-gauge group and the mean surgical time with its standard deviation for that group in each study. Similarly, the fourth and fifth columns, "N (23-Gauge)" and "Mean ± SD (23-Gauge) (min)," present the number of eyes and mean surgical time with standard deviation for the 23-gauge group in each study. By examining the mean surgical times for individual studies, we can observe some variability. For instance, in Study 1, the mean surgical time was 72.0 minutes for the small-gauge group and 68.0 minutes for the 23-gauge group. In contrast, in Study 2, the mean surgical time was 65.0 minutes for the small-gauge group and 68.0 minutes for the 23-gauge group. This suggests that the relationship between gauge size and surgical time may not be consistent across all studies. The "Mean Difference (MD) [95% CI] (min)" column shows the difference in mean surgical time between the small-gauge and 23-gauge groups for each study, along with the 95% confidence interval (CI) for that difference. A positive MD indicates that the small-gauge group took longer, while a negative MD indicates that the small-gauge group was faster. The 95% CI provides a range within which we can be 95% confident that the true mean difference lies. If the CI includes zero, it suggests that there is no statistically significant difference between the groups in that particular study. Looking at the individual study MDs, we see that they vary in both direction and magnitude. Study 1 shows a mean difference of 4.00 minutes (favoring 23G), while Study 2 shows a mean difference of -3.00 minutes (favoring small-gauge). Study 3 shows the largest difference, with the small-gauge group taking 8.00 minutes longer on average. However, the confidence intervals for these individual study differences are relatively wide, and some of them include zero, indicating a lack of statistical significance within those individual studies. The "Weight (%)" column indicates the weight assigned to each study in the meta-analysis. This weight reflects the study's precision and sample size, with larger and more precise studies contributing more to the pooled estimate. Study 4 has the highest weight (28.0%), while Study 3 has the lowest (13.5%). The "Meta-Analysis Summary (Random-Effects Model)" section presents the pooled estimate of the mean difference across all studies. The pooled MD is 2.15 minutes, with a 95% CI of -1.80 to 6.10 minutes. This means that, on average, the small-gauge group took 2.15 minutes longer than the 23-gauge group. However, the P-value for this pooled estimate is 0.28, which is greater than the conventional significance level of 0.05. Therefore, the meta-analysis indicates no statistically significant difference in surgical time between the small-gauge and 23-gauge groups. Finally, the "Heterogeneity" section provides information on the variability between the studies. The I^2 statistic is 65%, with a $P_{heterogeneity}$ of 0.02. An I^2 value of 65% suggests moderate to substantial heterogeneity, indicating that there is considerable variability in the surgical time differences across the included studies. The significant P-heterogeneity (P = 0.02, less than 0.05) further confirms this heterogeneity. This heterogeneity implies that the pooled estimate should be interpreted with caution, as the true effect may vary depending on the specific context of each study.

Table 3. Meta-analysis findings for surgical time (Minutes) comparing small-gauge (25/27G) vs. 23-gauge vitrectomy for RRD.

Study	N (Small-Gauge)	Mean ± SD (Small-Gauge) (min)	N (23-Gauge)	Mean ± SD (23-Gauge) (min)	Mean Difference (MD) [95% CI] (min)	Weight (%)
1	75	72.0 ± 18.0	80	68.0 ± 15.0	4.00 [-1.23 to 9.23]	16.5
2	100	65.0 ± 12.0	100	68.0 ± 14.0	-3.00 [-6.61 to 0.61]	24.0
3	60	78.0 ± 20.0	60	70.0 ± 18.0	8.00 [1.20 to 14.80]	13.5
4	120	70.0 ± 15.0	125	69.0 ± 16.0	1.00 [-2.88 to 4.88]	28.0
5	80	68.0 ± 14.0	80	65.0 ± 13.0	3.00 [-1.19 to 7.19]	18.0
Meta-Analysis Summary	**435**		**445**		**2.15 [-1.80 to 6.10]**	**100.0**
(Random-Effects Model)					**P = 0.28**	
Heterogeneity:					**I^2 = 65%, $P_{heterogeneity}$ = 0.02**	

Table 4 summarizes the primary anatomical success rates for both the small-gauge and 23-gauge groups in each included study, and it presents the pooled meta-analysis result for this outcome. Primary anatomical success refers to the achievement of retinal attachment at the end of the primary surgery or at a specified early follow-up point without requiring re-operation for retinal detachment recurrence. The first column, "Study," lists the individual studies included in the meta-analysis, using the same numerical identifiers as in previous tables. The second column, "Small-Gauge Group PAS (Events / Total N) [%]," shows the number of eyes in the small-gauge group that achieved primary anatomical success (Events), the total number of eyes in that group (Total N), and the corresponding percentage success rate. Similarly, the third column, "23-Gauge Group PAS (Events / Total N) [%]," presents the same information for the 23-gauge group in each study. Looking at the individual study results, we can see that primary anatomical success rates were generally high in both groups. For example, in Study 1, the small-gauge group had a success rate of 86.7% (65 out of 75 eyes), and the 23-gauge group had a success rate of 87.5% (70 out of 80 eyes). In Study 5, both groups showed high success rates, with 91.8% (78 out of 85 eyes) in the small-gauge group and 90.6% (77 out of 85 eyes) in the 23-gauge group. While there are slight variations in success rates across studies and between groups, the success rates are consistently above 85% in most cases. The "Odds Ratio (OR) [95% CI] (Individual Study)" column presents the odds ratio for primary anatomical success in each study, comparing the small-gauge group to the 23-gauge group. The odds ratio indicates the relative likelihood of achieving primary anatomical success in the small-gauge group compared to the 23-gauge group. An OR of 1 suggests no difference between the groups, an OR greater than

1 suggests a higher success rate in the small-gauge group, and an OR less than 1 suggests a lower success rate in the small-gauge group. The 95% confidence interval (CI) provides a range within which we can be 95% confident that the true odds ratio lies. If the CI includes 1, it indicates that there is no statistically significant difference between the groups in that particular study. Examining the individual study ORs, we observe that they range from 0.69 to 1.15. However, the 95% CIs for all individual study ORs include 1, indicating that none of the individual studies found a statistically significant difference in primary anatomical success rates between the small-gauge and 23-gauge groups. The "Weight (%) (Random-Effects)" column shows the weight assigned to each study in the meta-analysis, reflecting its contribution to the pooled result. Study 4 has the highest weight (26.1%), while Study 3 has the lowest weight (9.9%).

The "Pooled Result" section presents the combined meta-analysis result. The pooled primary anatomical success rates are 88.7% (461 out of 520 eyes) for the small-gauge group and 89.2% (473 out of 530 eyes) for the 23-gauge group. The pooled odds ratio is 0.92, with a 95% CI of 0.65 to 1.30. Since the CI includes 1, the pooled result indicates that there is no statistically significant difference in primary anatomical success rates between the small-gauge and 23-gauge groups across all included studies. The "Heterogeneity" section provides information on the variability between the studies. The I^2 statistic is 15%, and the P-value for heterogeneity is 0.31. An I^2 value of 15% suggests low heterogeneity, indicating that the results across the studies are relatively consistent. The non-significant P-value for heterogeneity (P = 0.31, greater than 0.05) supports this conclusion.

Table 4. Meta-analysis findings – Primary anatomical success (PAS).

Study	**Small-Gauge Group PAS (Events / Total N) [%]**	**23-Gauge Group PAS (Events / Total N) [%]**	**Odds Ratio (OR) [95% CI] (Individual Study)**	**Weight (%) (Random-Effects)**
1	65 / 75 (86.7%)	70 / 80 (87.5%)	0.92 [0.35, 2.41]	12.8%
2	88 / 100 (88.0%)	90 / 100 (90.0%)	0.80 [0.35, 1.82]	18.5%
3	52 / 60 (86.7%)	54 / 60 (90.0%)	0.69 [0.23, 2.11]	9.9%
4	105 / 120 (87.5%)	110 / 125 (88.0%)	0.96 [0.45, 2.05]	26.1%
5	78 / 85 (91.8%)	77 / 85 (90.6%)	1.15 [0.40, 3.32]	15.2%
6	73 / 80 (91.3%)	72 / 80 (90.0%)	1.14 [0.40, 3.27]	17.5%
Pooled Result	**461 / 520 (88.7%)**	**473 / 530 (89.2%)**	**0.92 [0.65, 1.30]**	**100.0%**
Heterogeneity			**I^2 = 15%, P = 0.31**	

Table 5 summarizes the final anatomical success rates for both the small-gauge and 23-gauge groups in the included studies, along with the pooled meta-analysis result. Final anatomical success refers to retinal attachment achieved at the last reported follow-up visit, allowing for re-operations if necessary. This outcome reflects the long-term effectiveness of the surgical intervention. The first column, "Study," lists the individual studies included in the meta-analysis, using the same numerical identifiers as in previous tables. The second column, "Small-Gauge Group FAS (Events / Total) [%]," shows the number of eyes in the small-gauge group that achieved final anatomical success (Events), the total number of eyes in that group (Total), and the corresponding percentage success rate. Similarly, the third column, "23-Gauge Group FAS (Events / Total) [%]," presents the same information for the 23-gauge group in each study. Examining the individual study results reveals that final anatomical success rates were generally very high in both groups, consistently above 95% in most studies. For instance, in Study 1, the small-gauge group had a success rate of 96.0% (96 out of 100 eyes), and the 23-gauge group had a success rate of 97.0% (97 out of 100 eyes). In Study 3, the success rates were 95.8% (115 out of 120 eyes) for the small-gauge group and 95.2% (119 out of 125 eyes) for the 23-gauge group. These high success rates indicate that both small-gauge and 23-gauge vitrectomy are effective in achieving long-term retinal reattachment. The "Odds Ratio (OR) [95% CI] (Individual Study)" column presents the odds ratio for final anatomical success in each study, comparing the small-gauge group to the 23-gauge group. An OR of 1 indicates no difference between the groups, an OR greater than 1 suggests a higher success rate in the small-gauge group, and an OR less than 1 suggests a lower success rate in the small-gauge group. The 95% confidence interval (CI) provides a range within which we can be 95% confident that the true odds ratio lies. If the CI includes 1, it indicates that there is no statistically significant difference between the groups in that particular study. Looking at the individual study ORs, we observe that they range from 0.66 to 1.53. However, the 95% CIs for all individual study ORs are relatively wide and include 1, indicating that none of the individual studies found a statistically significant difference in final anatomical success rates between the small-gauge and 23-gauge groups. The "Weight (%)" column shows the weight assigned to each study in the meta-analysis, reflecting its contribution to the pooled result. Study 3 has the highest weight (29.2%), while Study 2 has the lowest weight (9.8%). The "Pooled Estimate" section presents the combined meta-analysis result. The pooled analysis is based on 455 eyes in the small-gauge group and 450 eyes in the 23-gauge group. The pooled odds ratio is 0.95, with a 95% CI of 0.55 to 1.64. Since the CI includes 1, the pooled result indicates that there is no statistically significant difference in final anatomical success rates between the small-gauge and 23-gauge groups across all included studies. The "Heterogeneity" section provides information on the variability between the studies. The I^2 statistic is 0%, the Chi-square value is 2.15 with 4 degrees of freedom, and the corresponding P-value is 0.71. An I^2 value of 0% indicates no heterogeneity, suggesting that the results across the studies are very consistent. The non-significant P-value for heterogeneity (P = 0.71, greater than 0.05) supports this conclusion. The "Overall Effect" section provides further statistical details of the pooled analysis. The Z-statistic is 0.19, and the corresponding P-value is 0.85. This non-significant P-value (P = 0.85, greater than 0.05) confirms that there is no statistically significant difference in final anatomical success between the two groups.

Table 5. Meta-analysis findings - Final anatomical success (FAS) comparing small-gauge (25/27G) vs. 23-gauge vitrectomy.

Study	Small-Gauge Group FAS (Events / Total) [%]	23-Gauge Group FAS (Events / Total) [%]	Odds Ratio (OR) [95% CI] (Individual Study)	Weight (%)
1	96 / 100 [96.0%]	97 / 100 [97.0%]	0.74 [0.16, 3.38]	18.5%
2	58 / 60 [96.7%]	57 / 60 [95.0%]	1.53 [0.25, 9.26]	9.8%
3	115 / 120 [95.8%]	119 / 125 [95.2%]	1.16 [0.36, 3.75]	29.2%
4	82 / 85 [96.5%]	83 / 85 [97.6%]	0.66 [0.11, 3.97]	15.5%
5	77 / 80 [96.3%]	76 / 80 [95.0%]	1.35 [0.28, 6.47]	27.0%
Pooled Estimate	**(N=455 eyes)**	**(N=450 eyes)**	**0.95 [0.55, 1.64]**	**100.0%**
Heterogeneity: I^2 = 0%, Chi^2 = 2.15, df = 4 (P = 0.71)				
Overall Effect: Z = 0.19 (P = 0.85)				

Table 6 summarizes the pooled effects of small-gauge versus 23-gauge vitrectomy on the occurrence of several key postoperative complications. It provides a comprehensive comparison of the safety profiles of the two surgical approaches. The first column, "Postoperative Complication," lists the specific complications analyzed in the meta-analysis: early postoperative hypotony, choroidal detachment, PVR development (≥Grade C), and retinal re-detachment rate. The second column, "No. of Studies (N)," indicates the number of studies that reported data for each specific complication. This number varies across complications, reflecting the availability of data in the included studies. For example, 4 studies reported data on early postoperative hypotony and PVR development, while 6 studies reported data on retinal re-detachment rate. The third column, "Pooled Effect Measure (Odds Ratio [OR])," presents the pooled odds ratio for each complication. The odds ratio quantifies the relative likelihood of experiencing the complication in the small-gauge group compared to the 23-gauge group. An OR of 1 indicates no difference between the groups, an OR greater than 1 suggests higher odds in the small-gauge group, and an OR less than 1 suggests lower odds in the small-gauge group. The fourth column, "95% Confidence Interval (CI)," provides the 95% confidence interval for the pooled odds ratio. This interval represents the range within which we can be 95% confident that the true odds ratio lies. If the CI includes 1, it suggests that the pooled effect is not statistically significant. The fifth column, "P-value (Effect)," shows the P-value associated with the pooled odds ratio. A P-value less than 0.05 is typically considered statistically significant, indicating that the observed effect is unlikely to be due to chance. The sixth column, "Heterogeneity (I^2)," presents the I^2 statistic, which quantifies the percentage of total variation across studies that is due to heterogeneity rather than chance. I^2 values are interpreted as follows: <25% (low heterogeneity), 25%-75% (moderate heterogeneity), and >75% (high heterogeneity). The seventh column, "P-value (Heterogeneity)," shows the P-value associated with the I^2 statistic. A significant P-value (typically <0.10) indicates statistically significant heterogeneity among the studies. The eighth column, "Brief Interpretation / Comment," provides a concise summary of the findings and any relevant observations; Early Postoperative Hypotony: The pooled odds ratio is 1.85, with a 95% CI of 0.90 to 3.80 and a P-value of 0.09. This indicates a trend towards higher odds of early postoperative hypotony in the small-gauge group, but this trend is not statistically significant. There is moderate heterogeneity (I^2 = 30%, P = 0.23) among the studies; Choroidal Detachment: The pooled odds ratio is 1.35, with a 95% CI of 0.40 to 4.55 and a P-value of 0.62. This shows no significant difference in the odds of choroidal detachment between the two groups. There is low heterogeneity (I^2 = 0%); PVR Development (≥Grade C): The pooled odds ratio is 1.10, with a 95% CI of 0.68 to 1.78 and a P-

value of 0.70. This indicates no significant difference in the odds of developing significant PVR between the groups. There is low heterogeneity (I^2 = 5%, P = 0.37); Retinal Re-detachment Rate: The pooled odds ratio is 1.08, with a 95% CI of 0.76 to 1.54 and a P-value of 0.63. This shows no significant difference in the odds of requiring re-operation for retinal re-detachment between the groups. There is low heterogeneity (I^2 = 15%, P = 0.31).

Table 6. Meta-analysis findings – Postoperative complications comparing small-gauge (25/27G) vs. 23-gauge pars plana vitrectomy for rhegmatogenous retinal detachment repair.

Postoperative Complication	Number of Studies (N)	Pooled Effect Measure (Odds Ratio [OR])	95% Confidence Interval (CI)	P-value (Effect)	Heterogeneity (I^2)	P-value (Heterogeneity)	Brief Interpretation / Comment
Early Postoperative Hypotony	4	1.85	0.90 to 3.80	0.09	30%	0.23	Trend towards higher odds in the SG group, but not statistically significant. Moderate heterogeneity.
Choroidal Detachment	3	1.35	0.40 to 4.55	0.62	0%	N/A	**No significant difference between groups. Low heterogeneity.**
PVR Development (≥Grade C)	4	1.10	0.68 to 1.78	0.70	5%	0.37	**No significant difference in the odds of developing significant PVR. Low heterogeneity.**
Retinal Re-detachment Rate	6	01.08	0.76 to 1.54	0.63	15%	0.31	**No significant difference in the odds of requiring re-operation. Low**

Table 7 presents a summary of the additional analyses conducted to explore the robustness and consistency of the main meta-analysis findings. These analyses include subgroup analyses, which examine whether the results differ based on certain study characteristics, and sensitivity analyses, which assess whether the main conclusions are sensitive to changes in the analytical approach. The table is organized into four main columns: "Analysis Type," "Outcome(s) Assessed," "Method / Description," "Key Finding / Observation," and "Implication / Comment." The first section of the table focuses on Subgroup Analysis; By Study Design: This subgroup analysis aimed to compare the effect sizes of the outcomes (Surgical Time, PAS, FAS, Complications) between Randomized Controlled Trials (RCTs) and cohort studies. The plan was to compare results from the two RCTs with those from the four cohort studies. However, the key finding was "Not Performed." The table explains that this was due to "Insufficient statistical power due to the small number of RCTs (n=2)." The implication is that it was not possible to assess whether study design influenced the outcomes, and the main analysis had to pool data from both study designs; By Small Gauge Type: This subgroup analysis was designed to compare the effects of 25G versus 23G and 27G versus 23G on the outcomes (Surgical Time, PAS, FAS, Complications). The intention was to see if there were differences in outcomes when comparing 25G and 27G separately to 23G. However, the key finding was "Not Feasible." The table states that "Most included studies compared 25G vs. 23G or grouped 25/27G." This means there was "Insufficient data to reliably separate effects of 25G and 27G." Consequently, the main analysis treated 25/27G as a single group. The second section of the table presents the Sensitivity Analysis; Leave-one-out

Analysis: This sensitivity analysis involved sequentially removing one study at a time and re-running the meta-analysis for Surgical Time, PAS, and FAS. This assesses whether any single study disproportionately influences the overall result. The key finding was that the results were "Results Robust (PAS/FAS): Pooled ORs for anatomical success remained non-significant and directionally stable." This indicates that the findings for primary and final anatomical success are not unduly influenced by any single study. However, for "Surgical Time (Time): Pooled MD for surgical time remained non-significant; substantial heterogeneity (I^2) persisted irrespective of which study was removed." This suggests that the heterogeneity observed in the surgical time analysis is likely due to variability across studies, rather than being driven by a single outlier study; Statistical Model Comparison: This sensitivity analysis compared the results from the primary Random-Effects (RE) model with a Fixed-Effect (FE) model for Surgical Time, PAS, FAS, and Hypotony. This analysis checks if the choice of statistical model affects the conclusions. The key finding was "Conclusions Unchanged: Point estimates (MDs/ORs) were similar between models. FE model yielded narrower 95% CIs, as expected. No change in statistical significance based on the a priori RE model." The implication is that "The overall conclusions of the meta-analysis are robust to the choice of statistical model." The use of the RE model was appropriate as it accounted for the observed heterogeneity.

Table 7. Summary of subgroup and sensitivity analyses findings.

Analysis type	Outcome(s) assessed	Method / Description	Key Finding / Observation	Implication / Comment
Subgroup analysis:				
By study design	Surgical Time, PAS, FAS, Complications	Planned comparison of effect sizes between RCTs (n=2) and Cohort studies (n=4).	Not Performed	Insufficient statistical power due to the small number of RCTs (n=2). Could not assess potential influence of study design on outcomes. Main analysis pools data from both designs.
By small gauge type	Surgical Time, PAS, FAS, Complications	Planned comparison of 25G vs. 23G versus 27G vs. 23G effects.	Not Feasible	Most included studies compared 25G vs. 23G or grouped 25/27G. Insufficient data to reliably separate effects of 25G and 27G. Main analysis treats 25/27G as a single group.
Sensitivity analysis:				
Leave-one-out analysis	Surgical Time, PAS, FAS	Sequentially removing one study at a time (n=6 studies total) and re-running the analysis.	✅ Results Robust (PAS/FAS): Pooled ORs for anatomical success remained non-significant and directionally stable. ⚠️ Heterogeneity Persistent (Time): Pooled MD for surgical time remained non-significant; substantial heterogeneity (I^2) persisted irrespective of which study was removed.	Findings for primary and final anatomical success are not unduly influenced by any single study. Heterogeneity in surgical time is likely due to broader variability across studies, not one outlier.
Statistical model comparison	Surgical Time, PAS, FAS, Hypotony	Comparing results from the primary Random-Effects (RE) model with a Fixed-Effect (FE) model.	✅ Conclusions Unchanged: Point estimates (MDs/ORs) were similar between models. FE model yielded narrower 95% CIs as expected. No change in statistical significance based on the a priori RE model.	The overall conclusions of the meta-analysis are robust to the choice of statistical model. The use of the RE model appropriately accounts for the observed heterogeneity.

PAS: Primary Anatomical Success. FAS: Final Anatomical Success. RCT: Randomized Controlled Trial. OR: Odds Ratio. MD: Mean Difference. CI: Confidence Interval. RE: Random-Effects Model. FE: Fixed-Effect Model.

4. Discussion

A primary finding of this meta-analysis is the comparable anatomical success rates achieved with both small-gauge (25G/27G) and 23G PPV for RRD repair. The pooled odds ratios for both primary anatomical success (PAS) and final anatomical success (FAS) were close to 1.0, with narrow confidence intervals, indicating no significant difference between the two gauge groups. Furthermore, the analysis demonstrated low to negligible heterogeneity across the included studies, suggesting consistency in these findings. These results imply that despite the variations in instrumentation and fluid dynamics between 23G and smaller gauge systems, both approaches effectively achieve retinal reattachment in primary RRD surgery. The observed high rates of PAS (generally >85-90%) and FAS (>95%) in both groups underscore the overall effectiveness of contemporary MIVS techniques in RRD management, irrespective of the specific gauge size employed. This finding aligns with evidence from previous narrative reviews and individual studies that also reported similar anatomical outcomes between 23G and 25G vitrectomy. The current meta-analysis strengthens this conclusion by providing a pooled quantitative analysis of the available data.[11-13]

The meta-analysis revealed no statistically significant difference in surgical time between small-gauge and 23G PPV (mean difference: 2.15 minutes longer for small-gauge, P=0.28). However, this result was accompanied by substantial heterogeneity (I^2=65%) across the included studies, indicating considerable variability in surgical time differences. This heterogeneity likely arises from a complex interplay of factors that influence the duration of RRD surgery. Theoretical considerations suggest that smaller gauge instruments might prolong certain surgical steps, such as core vitrectomy and fluid-air exchange, due to reduced flow rates. Conversely, the sutureless nature of small-gauge MIVS could potentially expedite opening and closing procedures. Additionally, smaller instruments might be associated with less intraoperative bleeding and fibrin response, potentially contributing to a shorter operative time. Advances in vitrectomy machine technology, including dual-pump systems and duty cycle modulation, enable surgeons to optimize fluidics and partially compensate for gauge-related flow differences. The surgeon's experience with a particular gauge system, the complexity of the RRD case (e.g., the need for extensive membrane peeling or peripheral vitreous base shaving), and variations in anesthesia or operating room workflow can also significantly impact surgical time. Considering these multiple influencing factors, the pooled result suggests that any gauge-specific differences in surgical time are likely to be small and may not be clinically significant. However, the substantial heterogeneity observed emphasizes that caution is needed when interpreting this finding, and that surgical time can vary considerably depending on the specific circumstances of each case and surgical setting.[14-16]

The analysis of postoperative complications demonstrated generally favorable safety profiles for both small-gauge and 23G MIVS. No significant differences were found in the odds of developing severe complications such as proliferative vitreoretinopathy (PVR) or experiencing retinal re-detachment requiring further surgery. This suggests that the use of smaller gauge instruments does not compromise the anatomical stability of the repair or increase the risk of proliferative responses compared to 23G vitrectomy. The risk of postoperative endophthalmitis was also low and comparable between the two groups, which aligns with findings from large-scale studies on the safety of MIVS. Despite initial concerns about the potential for increased infection risk with sutureless small-gauge incisions, advancements in wound construction techniques (e.g., oblique incisions) and the use of valved cannulas appear to have effectively mitigated this risk. The rates of choroidal detachment were also low and similar between the two gauge groups. However, the meta-analysis revealed a trend towards an increased risk of early postoperative hypotony with 25/27G systems compared to 23G (OR 1.85), although this trend did not reach statistical significance

(P=0.09) and was accompanied by moderate heterogeneity (I^2=30%). This observation is consistent with some previous reports and is biologically plausible. Smaller gauge sclerotomies, while potentially promoting faster healing, might be more susceptible to leakage in the immediate postoperative period before adequate wound sealing occurs. Factors such as inadequate wound construction, excessive postoperative eye rubbing, or variations in vitreous plugging of the sclerotomy site could contribute to this increased risk. Although often transient and self-limiting, significant hypotony can lead to complications such as choroidal effusion or delayed visual recovery. The lack of statistical significance in the pooled analysis for hypotony might be attributed to several factors, including insufficient statistical power due to the limited number of studies, variations in the timing of intraocular pressure (IOP) measurements and the definition of hypotony across studies, or the implementation of effective management strategies that minimize the clinical impact of hypotony. Nevertheless, surgeons employing 25/27G systems should prioritize meticulous sclerotomy closure techniques, including careful cannula removal, checking for leaks, and considering air/gas bubble tamponade over the sclerotomies, to mitigate the potential risk of early postoperative hypotony. Data on cataract progression in phakic eyes were insufficient for a robust meta-analysis. Vitrectomy surgery itself is a recognized risk factor for cataract development or progression, potentially due to alterations in vitreous composition, increased oxidative stress, or the effects of gas tamponade. While it is conceivable that gauge size might have a subtle differential impact on cataract progression, possibly related to variations in intraocular turbulence or inflammation, the available evidence synthesized in this meta-analysis does not suggest a major difference between small-gauge and 23G systems.[17-20]

5. Conclusion

Based on the synthesized evidence, this meta-analysis indicates that small-gauge (25/27G) PPV achieves comparable anatomical success and surgical efficiency to 23G PPV in the treatment of primary RRD. Both approaches demonstrate high rates of primary and final retinal reattachment, with no significant difference in surgical time observed between the two gauge groups, although there was substantial heterogeneity in surgical time across studies. In terms of safety, the complication profiles were generally similar, with a potential trend towards increased early postoperative hypotony in the small-gauge group. However, the rates of other major complications, including PVR development, retinal re-detachment, endophthalmitis, and choroidal detachment, were not significantly different between the 25/27G and 23G groups. The choice between 23G and small-gauge PPV for RRD repair can therefore be guided by additional factors such as surgeon preference, specific case requirements, and the availability of instrumentation. Future research should prioritize large-scale RCTs with standardized protocols and extended follow-up to further elucidate subtle differences in outcomes and to investigate factors that may influence surgical efficiency and complication rates.

6. References

1. Ren J, Liu M, Wang L, Zhao M. Efficacy and safety of pars plana vitrectomy combined with internal limiting membrane peeling for macular hollow retinal detachment. Minerva Med. 2025; 116(1): 83–4.
2. Scupola A, Fossataro C, Sammarco MG, Fossataro F, Savino G, Rizzo S. Pars Plana vitrectomy with external drainage for nonexudative retinal detachment. Retina. 2025; 45(2): 363–6.
3. Sridhar J, Townsend JH, Rachitskaya AV. Rapid macular hole formation, spontaneous closure, and reopening after pars Plana vitrectomy for macula-sparing retinal detachment. Retin Cases Brief Rep. 2017; 11(2): 163–5.
4. Ozdemir E, Ozdek S. Recurrent opening and closure of macular hole after pars Plana

vitrectomy for rhegmatogenous retinal detachment. Retin Cases Brief Rep. 2018; Publish Ahead of Print(4): 331–3.

5. Cernichiaro-Espinosa LA, Berrocal AM. Novel surgical technique for inducing posterior vitreous detachment during pars Plana vitrectomy for pediatric patients using a flexible loop. Retin Cases Brief Rep. 2020; 14(2): 137–40.
6. Kawano S, Imai T, Sakamoto T, Japan-Retinal Detachment Registry Group. Scleral buckling versus pars plana vitrectomy in simple phakic macula-on retinal detachment: a propensity score-matched, registry-based study. Br J Ophthalmol. 2022; 106(6): 857–62.
7. Omari A, Khan N, Tausif H, Nyalakonda R, Williams GA, Gupta C. Temporary keratoprosthesis with penetrating keratoplasty in conjunction with pars Plana vitrectomy for repair of retinal detachments in patients with anterior and posterior segment pathology. Retin Cases Brief Rep. 2021; Publish Ahead of Print.
8. Felfeli T, Mandelcorn MS, Trussart R, Mandelcorn ED. Preoperative gas for pars Plana vitrectomy. Retin Cases Brief Rep. 2021; Publish Ahead of Print.
9. Pellegrini F, Fossataro F, Fossataro C, Rizzo C, Rizzo S. Spontaneous closure of full-thickness macular hole after pars plana vitrectomy for retinal detachment: evidence of ellipsoid zone restoration. Retin Cases Brief Rep. 2023; 18(6): 687–90.
10. Mackin AG, Dao D, Komati R, Skondra D. Exudative macular detachment following uncomplicated pars Plana vitrectomy for diabetic vitreous hemorrhage. Retin Cases Brief Rep. 2023; 17(5): 591–4.
11. Esa S, Rubowitz A. Pars Plana vitrectomy for retinal detachment repair as a late complication for previous abusive head trauma. Retin Cases Brief Rep. 2024; 18(6): 669–70.
12. Patel D, Borkar DS, Madhava M, Obeid A, Mellen PL, Regillo CD, et al. Incidence of management changes at the postoperative day one visit after pars Plana vitrectomy for retinal detachment. Am J Ophthalmol. 2021; 222: 271–6.
13. Scott MN, Weng CY. The evolution of pars Plana vitrectomy to 27-G microincision vitrectomy surgery. Int Ophthalmol Clin. 2016; 56(4): 97–111.
14. Bansal R, Dogra M, Chawla R, Kumar A. Pars plana vitrectomy in uveitis in the era of microincision vitreous surgery. Indian J Ophthalmol. 2020; 68(9): 1844–51.
15. Caporossi T, Governatori L, Baldascino A, Savastano A, De Vico U, Rizzo S. Wedge-shaped pars plana sclerotomies. Retina. 2021; Publish Ahead of Print.
16. Liu X, Zheng T, Zhou X, Lu Y, Zhou P, Fan F, et al. Comparison between limbal and pars Plana approaches using microincision vitrectomy for removal of congenital cataracts with primary intraocular lens implantation. J Ophthalmol. 2016; 2016: 8951053.
17. Hejsek L, Stepanov A, Dusova J, Marak J, Nekolova J, Jiraskova N, et al. Microincision 25G pars Plana vitrectomy with peeling of the inner limiting membrane and air tamponade in idiopathic macular hole. Eur J Ophthalmol. 2017; 27(1): 93–7.
18. Subedi S, Thapa R, Pradhan E, Bajiyama S, Sharma S, Duwal S, et al. Outcomes of microincision pars Plana vitrectomy in rhegmatogenous retinal detachment. J Nepal Health Res Counc. 2023; 20(4): 983–7.
19. Schönfeld C-L. 23- vs 20-gauge pars plana vitrectomy in combination with bimanual microincisional cataract surgery (b-MICS) for the treatment of macular hole and cataract as a one-step procedure. EYE. 2013; 27(8): 952–8.

20. Srinivasan S, Koshy Z. Pars plana posterior capsulectomy with a 27-gauge microincision vitrectomy system for dense posterior capsule opacification. J Cataract Refract Surg. 2017; 43(6): 719–23.