Molecular Vision 2015; 21:893-900 <http://www.molvis.org/molvis/v21/893>
Received 4 May 2015 | Accepted 19 August 2015 | Published 21 August 2015

Clinical outcomes of 23-gauge vitrectomy may be better than 20-gauge vitrectomy for retinal detachment repair

Fei Xia,[1] Ya-Qin Jiang[2]

[1]Department of Ophthalmology, the Affiliated Hospital of Weifang Medical University, Weifang, P.R. China; [2]Department of Ophthalmology, Weifang Eye Hospital, Weifang, P.R. China

Objective: This study compared the clinical outcomes between 23-gauge (23-G) vitrectomy and 20-gauge (20-G) vitrectomy for the repair of retinal detachment (RD).

Methods: A retrospective comparative analysis of 135 RD patients was conducted between January, 2013 and September, 2014 in the Ophthalmology Department of the Affiliated Hospital of Weifang Medical College. The clinical outcomes of RD patients who underwent 23-G vitrectomy (n = 65) and 20-G vitrectomy (n = 70) were compared. A logistic regression analysis was used for prognostic factors in RD patients. A meta-analysis was performed using the comprehensive Meta-Analysis version 2.0 software.

Results: Baseline characteristics of RD patients between the 23-G group and the 20-G group were not significantly different (all $p>0.05$). The postoperative wound closure time was obviously shorter, and postoperative intraocular pressure (IOP; mmHg) and the incidence of macular holes (MH) were evidently lower in the 23-G group than in the 20-G group (all $p<0.05$). However, no statistical significances in the postoperative retinal reattachment rate or visual acuity improvement in the logarithm of the minimum angle of resolution (logMAR) were detected between the 23-G group and the 20-G group (both $p>0.05$). The meta-analysis further confirmed a shorter postoperative wound closure time, as well as a lower postoperative IOP and incidence of MH in the 23-G group than in the 20-G group (all $p<0.05$), while neither the postoperative retinal reattachment rate nor the visual acuity improvement in the logMAR showed statistical significance (all $p>0.05$).

Conclusions: Our retrospective comparative study of RD surgery using 20-G or 23-G techniques revealed a shorter postoperative wound closure time, as well as a lower postoperative IOP and incidence of MH in the 23-G group than in the 20-G group, confirming the superiority of 23-G vitrectomy over 20-G vitrectomy. This study provided a better option of 23-G vitrectomy for clinically managing RD.

Retinal detachment (RD) is a disorder of the eye where the retina detaches away from its underlying layer of support tissue [1,2]. Initial detachment may be localized or broad, but without rapid treatment within 24–72 h, the entire retina may detach, leading to permanent vision loss and blindness, negatively affecting the life quality of patients [3,4]. RD is characterized by a subretinal accumulation of fluid underlying the retinal pigment epithelium and the neurosensory retina at the level of the photoreceptor cells [5]. Annually, approximately 10.5/100,000 adults are diagnosed with RD [6]. In comparison, RD in children is rarer, with 0.001% of all children aged between 0 to 17 years diagnosed with this condition [7]. Risk factors for RD include severe myopia, retinal tears, trauma, male gender, family history, smoking, and complications from cataract surgery [8,9]. There are several methods of treating RD, each of which depends on finding and closing the breaks that have formed in the retina, including cryopexy, laser photocoagulation, scleral buckle surgery, pneumatic retinopexy and vitrectomy [10-12].

Vitrectomy consists of transconjunctival sutureless vitrectomy, such as 23-gauge (23-G) vitrectomy, and conventional pars plana vitrectomy, such as 20-G vitrectomy [13]. The introduction of vitrectomy has offered the potential for considerable benefits to RD patients [14]. The 'gold-standard' for RD treatment, 20-G vitrectomy, was widely popularized in the last two decades of the 20th century [15], and 20-G instruments are versatile for a broad spectrum of vitreoretinal surgeries and for gaining access to the tissues through scleral incision or sclerotomy after conjuctival periotomy, though it requires sutures at the end of the procedure [16]. Alternatively, 23-G vitrectomy was originally reported by Hilton in 1995 as a two-sclerotomy technique and it was subsequently developed by Eckardt in 2005 as a three-way primary pars plana vitrectomy technique [17,18]. More recently, improved visual outcomes and superior anatomic benefits were reported with 23-G vitrectomy in different vitreoretinal disorders, such as RD, macular holes (MH), proliferative diabetic retinopathy, epiretinal membranes (ERM), and vitreous hemorrhage [19]. Previous published studies demonstrated the strong

Correspondence to: Fei Xia, Department of Ophthalmology, the Affiliated Hospital of Weifang Medical University, No. 2428 Yuhe Road, Kuiwen District, Weifang 261031, P.R. China; Phone: +8605368270543; email: xiafei1011@163.com

advantages of 23-G vitrectomy over 20-G vitrectomy, but several other studies noted complications, such as increased incidences of postoperative hypotony, endophthalmitis, and MH, using the 23-G system [20-23]. In view of the ambiguous data from different studies regarding the comparative clinical efficacies of 23-G vitrectomy and 20-G vitrectomy in the repair of RD, we performed this study to systematically compare the clinical outcomes between 23-G vitrectomy and 20-G vitrectomy using the following parameters: wound closure time, intraocular pressure (IOP), incidence of MH, retinal reattachment rate, and visual acuity improvement, for the management of RD.

METHODS

Ethics statement: The study was approved by the ethics committee of the Affiliated Hospital of Weifang Medical College. Written informed consent was provided by each eligible patient or the patient's next of kin and the study conformed to the Declaration of Helsinki [24].

Subjects: A retrospective comparative analysis of 135 patients who underwent vitrectomy for RD repair was conducted between January, 2013 and September, 2014 in the Ophthalmology Department of the Affiliated Hospital of Weifang Medical College. Among them, 65 patients (male, 38, female, 27; age range, 40–60 years; mean age, 50.29±5.99 years) underwent 23-G vitrectomy (23-G group); and 70 patients (male, 45, female, 25; age range, 40–64 years; mean age, 52.27±6.61 years) underwent 20-G vitrectomy (20-G group). All patients were confirmed as having RD by a color Doppler-type ultrasonic diagnostic apparatus or CT/MRI scanning. Diagnostic criteria of RD were as follows: (1) retinoschisis, formed by cystoid degeneration and fusion, occurs under the peripheral fundus, presenting a hemispherical bulge; (2) the inner wall of the split retina is thin and transparent, and pigmentation is observed near the edge of the outer wall of the split retina; (3) the area of retinoschisis presents an absolute scotoma and is inactive, without subretinal fluid [25]. All patients had no history of retinal laser treatment, RD surgeries, or ophthalmic drug administration. The exclusion criteria were as follows: (1) patients having received vitrectomy, retinal operation, or cataract surgery; (2) patients with diabetic retinopathy; (3) patients with aphakia; (4) patients with grade C proliferative vitreoretinopathy (PVR) before the surgery; (5) patients needing silicone oil intraocular tamponade; and (6) pregnant and lactating women. All eligible patients included in the study first had a color Doppler ultrasound examination for the diagnosis of RD, and they were then examined by the eyelid method. Before vitrectomy, with all patients in the supine position and eyes closed, eyelids and periorbital skin were scrubbed with the coupling agent, and the observation of retinal location and morphology was performed with multisection scanning of the eyeball by a high-frequency probe lying on the eyelid skin. Whether there is membranous echogenicity in the vitreous body, a relationship between the initiation site of the intraocular membrane and the optic papilla and the wall of eyeball during oculogyration, or movement of the eyeball were observed. Blood flow in lesions was observed by color Doppler flow imaging. If there is a blood flow signal, spectrum characteristics were analyzed.

Surgical procedures: The 23-G group underwent vitrectomy by using the 23-G trocar-cannula system (Alcon Laboratories, Inc., Fort Worth, TX). The conjunctiva and sclera were penetrated by a trocar 3.5 mm posterior to and in parallel with the limbus, depending on the lens status, at an angle between 20° and 30° with the bevel up, while inserting the cannula into the scleral incision. Once the trocar sleeve was reached, the cannula was rotated perpendicular to the eyeball toward the posterior pole. The cannula was held in place with forceps and the trocar was removed. The 20-G group underwent vitrectomy by using the standard 20-G vitrectomy system. The scleral incision was made by inserting a 20-G vitreoretinal blade. The intraoperative technologies used mainly included the stripping of membranes, intraocular diathermy, laser photocoagulation, trans-scleral cryotherapy, gas-fluid exchange, and gas/silicone oil tamponade.

Outcome measures: Baseline characteristics of all patients, including gender, age, the number of the cases of rhegmatogenous retinal detachment (RRD), the number of the cases of traction retinal detachment (TRD), and the number of the cases of traumatic RD, were recorded. All patients received a follow-up of 6 to12 months. During the follow-up, postoperative wound closure time, postoperative IOP, postoperative incidence of MH, postoperative retinal reattachment rate, and postoperative visual acuity improvement in the logMAR were observed and recorded.

Statistical analysis: The SPSS 18.0 statistical software was used for data analysis. Measurement data were presented as mean ± standard deviation (x±s). The *t* test was applied to compare the data between two groups, and the q test was applied to compare enumeration data. An unconditional logistic regression analysis was performed for prognostic factors in RD patients. A $p<0.05$ was considered statistically significant.

Computerized databases [PubMed, China National Knowledge Infrastructure (CNKI).] were used to search papers published before September 2014 that assessed 23-G vitrectomy in treating RD compared with 20-G vitrectomy

Table 1. Baseline characteristics of patients in the 23- and the 20-gauge vitrectomy groups.

Characteristics	23-G vitrectomy (n=65)	20-G vitrectomy (n=70)	*P*
Gender (Male/Female)	38/27	45/25	0.487
Age (year, x± s)	50.29±5.99	52.27±6.61	0.071
RRD (n, %)	53 (81.5%)	56 (80.0%)	0.941
TRD (n, %)	9 (13.8%)	8 (11.4%)	0.709
Traumatic RD (n, %)	3 (4.7%)	6 (8.6%)	0.389

23-G vitrectomy: 23-gauge vitrectomy. 20-G vitrectomy: 20-gauge vitrectomy. RRD: rhegmatogenous retinal detachment. TRD: traction retinal detachment. Traumatic RD: traumatic retinal detachment.

using selected common keywords ("retinal detachment," "RD," "rhegmatogenous retinal detachment," "PRD," "23-gauge vitrectomy," "23-G vitrectomy," "20-gauge vitrectomy," "20-G vitrectomy," "vitreous surgery," "ophthalmic surgery," "efficacy," etc.). The comprehensive Meta-Analysis version 2.0 software (CMA 2.0, Biostat Inc., Englewood, New Jersey, USA) was used to perform the statistical meta-analysis. The standard mean differences (SMD) or odds ratios (ORs) with 95% confidence intervals (CI) were calculated by applying a fixed-effects model (Mantel-Haenszel method) or a random-effects model (DerSimonian and Laird method) to evaluate the difference in clinical efficacy between 23-G vitrectomy and 20-G vitrectomy in the treatment of RD. The Z test was used to examine pooled effect size [26], and the forest plot was used to compare the SMD or OR with a 95% CI between groups.

RESULTS

Baseline characteristics: One hundred and thirty-five patients underwent vitrectomy for RD repair. Seventy patients received the 20-G system treatment, and 65 patients received the 23-G system. The baseline characteristics recorded for the patients are summarized in Table 1. No significant differences in baseline characteristics were apparent between the 23-G and 20-G groups (all p>0.05).

Clinical outcomes: Postoperative follow-up revealed the postoperative wound closure time (months) was obviously shorter, and the postoperative IOP (mmHg) and incidence of MH were evidently lower in the 23-G group than in the 20-G group (postoperative wound closure time, 3.35±1.56 months versus 9.07±2.45 months, p<0.01; postoperative IOP, 8.42±3.13 mmHg versus 12.24±3.93 mmHg, p<0.01; postoperative incidence of MH, 29.2% versus 57.1%, p = 0.039). There was no statistical significance in the postoperative retinal reattachment rate and postoperative visual acuity improvement in the logMAR between the 23-G group and the 20-G group (both p>0.05; Table 2, Table 3).

Logistic regression analysis for prognostic factors in RD patients: A dualistic logistic regression analysis was performed with the operation method in RD patients as the dependent variable, and age, gender, postoperative wound closure time, postoperative IOP, and postoperative incidence of MH were used as independent variables. The results revealed that both postoperative wound closure time and postoperative IOP were prognostic factors for RD (postoperative IOP: OR = 0.621, 95% CI = 0.434–0.890, p = 0.009; postoperative wound closure time: OR = 0.118, 95% CI = 0.032–0.434, p = 0.001; Table 4).

Comparison of clinical outcomes of 23-G and 20-G vitrectomy for RD by meta-analysis: In total, 13 clinical studies met our inclusion criteria for this meta-analysis [13,19,27-37]. A total of 3,235 RD patients were involved in this

Table 2. Wound closure time, intraocular pressure (IOP) and visual acuity improvement in logarithm of the minimum angle of resolution (LogMAR) after 23-gauge vitrectomy and 20-gauge vitrectomy (x± S).

Indicators	23-G vitrectomy (n=65)	20-G vitrectomy (n=70)	*P*	t	95%CI
Postoperative wound closure time (months)	3.35±1.56	9.07±2.45 #	<0.001	16.04	5.015~6.425
Postoperative IOP (mmHg)	8.42±3.13	12.24±3.93 #	<0.001	6.22	2.605~5.035
Postoperative visual acuity improvement in LogMAR	0.25±0.21	0.27±0.21	0.581	0.55	−0.052~0.092

23-G vitrectomy: 23-gauge vitrectomy. 20-G vitrectomy: 20-gauge vitrectomy. #, compared to 23-G vitrectomy group, p<0.01; IOP: intraocular pressure. LogMAR: logarithm of the minimum angle of resolution. 95%CI:95% confidence intervals.

Table 3. Incidence of macular hole (MH) and retinal reattachment rate after 23-gauge vitrectomy and 20-gauge vitrectomy.

Indicators	23-G vitrectomy (n=65)	20-G vitrectomy (n=70)	*P*	OR	95%CI
Postoperative incidence of MH (%)	19 (29.2%)	40 (57.1%) *	0.039	0.512	0.269~0.972
Postoperative retinal reattachment rate (%)	62 (95.4%)	66 (94.3%)	0.963	1.012	0.624~1.641

23-G vitrectomy: 23-gauge vitrectomy. 20-G vitrectomy: 20-gauge vitrectomy. *, compared to 23-G vitrectomy group, p<0.05; OR: odd ratios. 95%CI:95% confidence intervals.

meta-analysis, including 1,738 patients undergoing 23-G vitrectomy and 1,497 patients undergoing 20-G vitrectomy. Four included studies, which reported the difference in postoperative wound closure time between the 23-G group and the 20-G group, revealed the postoperative wound closure time in the 23-G group was shorter than that in the 20-G group (SMD = -1.608, 95% CI = -3.206–-0.010, p = 0.049; as seen in Figure 1A). Three included studies, which reported the difference in postoperative IOP between the 23-G group and the 20-G group, demonstrated that postoperative IOP in the 23-G group was lower than that in the 20-G group (SMD = -0.748, 95% CI = -1.478–-0.018, p = 0.045; Figure 1B). Seven included studies that compared the postoperative incidence of MH of 23-G vitrectomy and 20-G vitrectomy showed that the postoperative incidence of MH in the 23-G group was obviously lower than that in the 20-G group (OR = 0.386, 95% CI = 0.245–0.606, p<0.001; Figure 1C). Five included studies compared the retinal reattachment rate after 23-G and 20-G vitrectomy and implied no observably statistical significance of postoperative incidence of retinal reattachment between the 23-G group and the 20-G group (OR = 0.938, 95% CI = 0.366–2.404, p = 0.894; Figure 2A). Additionally, six included studies assessed the visual acuity improvement in the logMAR after 23-G and 20-G vitrectomy, and no statistical significant in the visual acuity improvement in the logMAR was detected between the 23-G group and the 20-G group (SMD = -0.066, 95% CI = -0.396–0.264, p = 0.697; Figure 2B).

DISCUSSION

In this present study, the clinical outcomes between 23-G vitrectomy and 20-G vitrectomy were evaluated in patients with RD, and we focused on five primary parameters after the operation, including wound closure time, IOP, incidence of MH, retinal reattachment rate, and visual acuity improvement. The validation of a new technique, here 23-G vitrectomy, in a selected indication should first refer to the capacity of obtaining at least the same rate of functional and anatomic results and an acceptable rate of adverse events when compared to the standardized technique, here 20-G vitrectomy [19]. The most important findings in our study demonstrated that 23-G vitrectomy was superior to 20-G vitrectomy in managing RD, with a shorter wound closure time, lower IOP, and lower incidence of MH in the 23-G vitrectomy group, suggesting 23-G vitrectomy is a safe and reproducible technique for the management of RD. Similarly, there is previous evidence showing 23-G vitrectomy has the advantage of accelerated wound recovery over 20-G vitrectomy: (1) in the study of Yanyali et al., the sclerotomy size in 23-G vitrectomy is just 0.6 mm compared to 0.89 mm in 20-G vitrectomy; thus, a minimally invasive wound with a protective drivepipe that can prevent the wound from damage in 23-G vitrectomy may explain the shorter wound closure time in 23-G vitrectomy [38]; (2) the 23-G vitrectomy instruments are characterized by greater stiffness and edge stability, reducing the risk of retinal impairment in vascular membrane fiber tissue segmentation, which may be another reason for the shorter wound closure time in 23-G vitrectomy

Table 4. Logistic regression analysis of prognostic factors for retinal detachment.

Variable	B	SEM	Wald	df	Sig.	Exp (B)	95% CI
Age	−0.038	0.064	0.356	1	0.551	0.963	0.850 ~1.090
Gender	−0.245	0.884	0.077	1	0.781	0.782	0.138 ~4.422
Wound closure time	−2.135	0.664	10.345	1	0.001	0.118	0.032 ~0.434
Postoperative IOP	−0.476	0.183	6.748	1	0.009	0.621	0.434 ~0.890
Incidence of MH	−1.285	0.916	1.970	1	0.160	0.277	0.046 ~1.665

B: Regression coefficient value; SEM: standard error of the mean; Wald: Wald Chi square value. df: degrees of freedom. Sig: p value; Exp (B): adjusted odds; IOP: intraocular pressure. MH: macular hole. 95%CI:95% confidence interval.

[39]. Consistent with our results, Sandali et al. and Pielen et al. reported that 23-G vitrectomy reduced operating time, improved patient comfort, accelerated wound healing and visual recovery, and reduced postoperative astigmatism [21,33].

In addition, Kusuhara et al. documented that in their gas-filled eyes, the mean overall IOP on postoperative day 1 was significantly lower in the 23-G group than in the 20-G group and the incidence of postoperative hypotony was 8.5% after 23-G vitrectomy and 0% after 20-G vitrectomy [29]. Previous reports suggested that transient postoperative hypotony is caused by unsutured sclerotomies [40,41]. The relatively lower postoperative IOP in the present study could be because of surgical indication. In RD cases, the extensive intraocular manipulation during the thorough removal of peripheral vitreous gel causes wound extension, thus contributing to the larger number of unsealed sclerotomies [29].

In addition, postoperative complications after small-incision, sutureless 23-G vitrectomy is rare, with a lower incidence of MH compared to 20-G vitrectomy. The reason for the lower incidence of MH in 23-G vitrectomy is unclear. One possible explanation is that the lower cutter

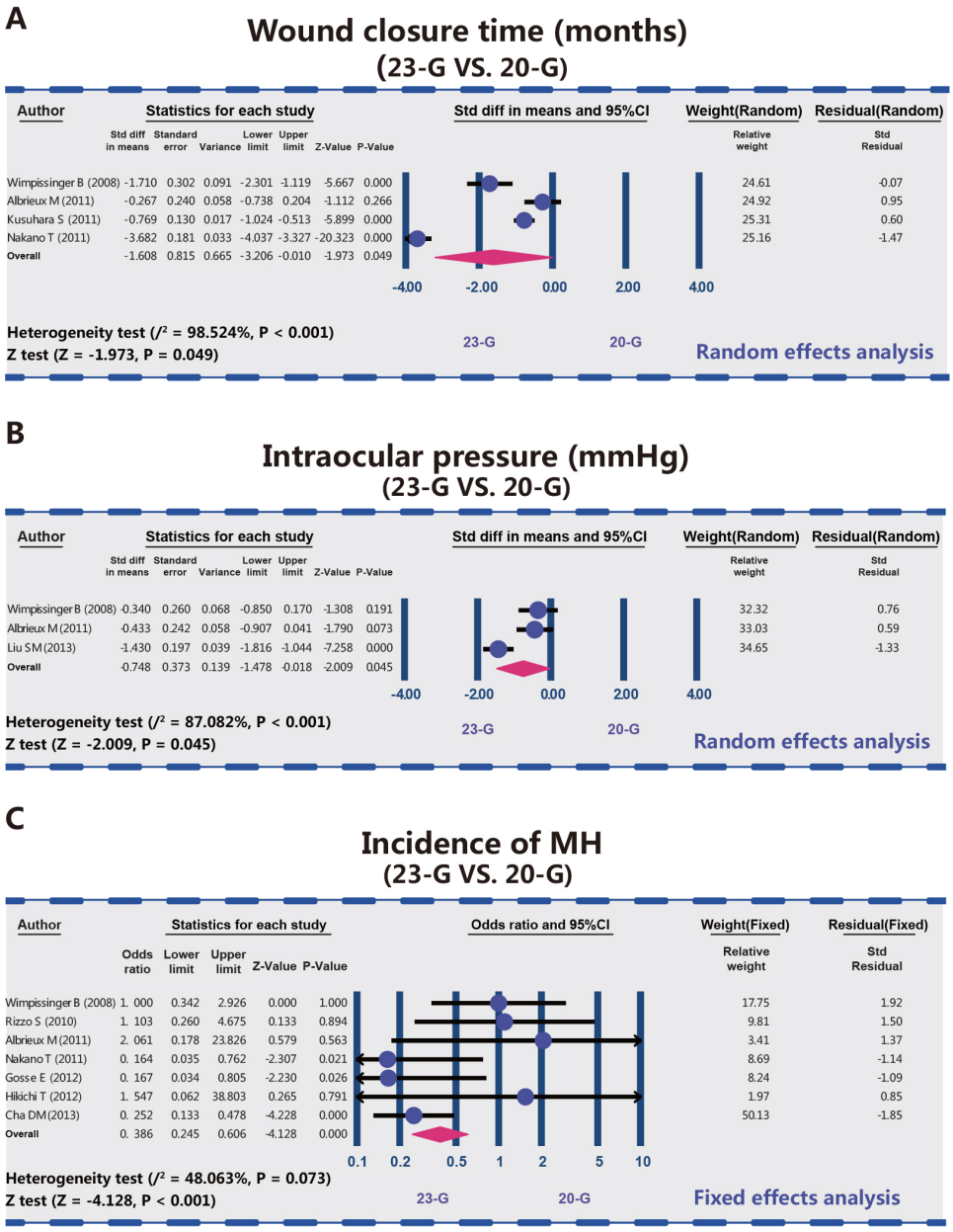

Figure 1. Comparison of wound closure time and IOP after 23-G vitrectomy and 20-G vitrectomy for RD. **A**: Comparison of wound closure time after 23-G vitrectomy and 20-G vitrectomy for RD in enrolled studies showed that four included studies revealing the post-operative wound closure time in the 23-G group was shorter than that in the 20-G group. **B**: Comparison of IOP after 23-G vitrectomy and 20-G vitrectomy for RD in enrolled studies showed that three included studies demonstrating that postoperative IOP in the 23-G group was lower than that in the 20-G group. **C**: Comparison of the incidence of MH after 23-G vitrectomy and 20-G vitrectomy for RD in enrolled studies showed that seven included studies presenting that the post-operative incidence of MH in the 23-G group was obviously lower than that in the 20-G group; 23-G vitrectomy, 23-gauge vitrectomy; 20-G vitrectomy, 20-gauge vitrectomy; RD, retinal detachment; IOP, intraocular pressure; MH, macular hole.

efficiency of small-G cutters in 23-G vitrectomy leads to less damage to the macular area. Because the instruments are smaller, the aspiration rates are lower than those achieved with 20-G instrumentation [30]. Scartozzi et al. compared the incidence of sclerotomy-related retinal breaks between the 20-G and 23-G vitrectomy systems for macular pucker and MH, and they found a trend toward slightly lower rates of retinal breaks with the 23-G system compared with the 20-G system [42]. No observably statistical difference in the postoperative incidence of retinal reattachment or the amount of improvement in logMAR visual acuity between the 23-G group and the 20-G group was found in our current study. However, there were improvements in the visual acuity and better reattachment rates resulting from 23-G vitrectomy and 20-G vitrectomy, respectively. Koh et al. conducted a study to explore the effectiveness and safety of 23-G vitrectomy, revealing the preoperative and postoperative mean logMAR visual acuity was 0.06±0.15 and 0.54±0.31, respectively; that is, the mean logMAR visual acuity was improved by 23-G vitrectomy [43]. A study by Narayanan et al. demonstrated the primary reattachment rate was 83.3% in the 23-G group and 86.8% in 20-G group, and the visual acuity at the last visit was improved in both the 23-G and 20-G groups [33]. In conclusion, our retrospective comparative study of RD surgery using the 20-G or 23-G techniques revealed a shorter postoperative wound closure time, lower postoperative IOP, and lower incidence of MH in the 23-G group than in the 20-G group. This confirmed the superiority of 23-G vitrectomy over 20-G vitrectomy; however, it also showed the results of both techniques are not significantly different in terms of the incidence of retinal reattachment or the logMAR visual outcome. This study provided a better option of 23-G vitrectomy for clinically managing RD. However, with our own limitations, such as our inclusion and exclusion criteria of the meta-analysis, may be incomplete, which may result in the omission of relevant high-quality literature and potential complications that this present study did not assess. Further prospective studies are required to evaluate the expected increase in the quality of life after 23-G vitrectomy.

ACKNOWLEDGMENTS

We would like to acknowledge the reviewers for their helpful and timely comments on this paper. We would also like to thank the participants and attendees of the previous workshops for the enlightening presentations and discussions.

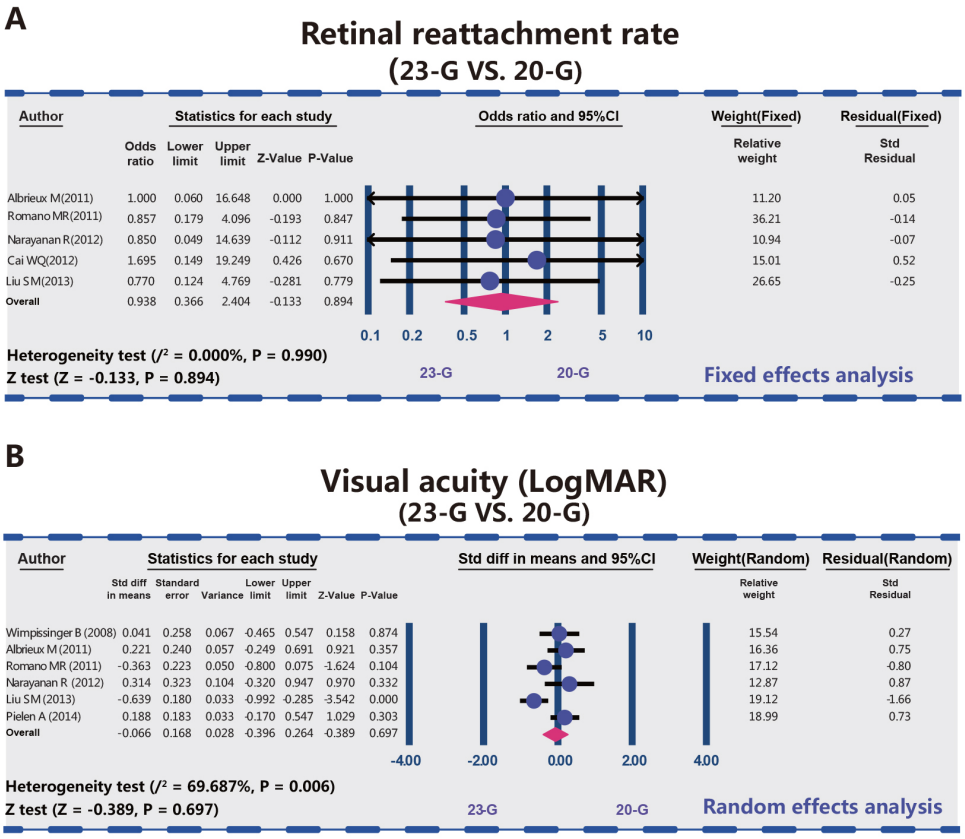

Figure 2. Comparison of retinal reattachment rate and visual acuity improvement in the logMAR after 23-G vitrectomy and 20-G vitrectomy for RD. **A**: Comparison of retinal reattachment rate after 23-G vitrectomy and 20-G vitrectomy for RD in enrolled studies showed that five included studies implying no observably statistical significance of postoperative incidence of retinal reattachment between the 23-G group and the 20-G group. **B**: Comparison of visual acuity improvement in the logMAR after 23-G vitrectomy and 20-G vitrectomy for RD in enrolled studies showed that six included studies presenting that no statistical significant in the visual acuity improvement in the logMAR was detected between the 23-G group and the 20-G group; 23-G vitrectomy, 23-gauge vitrectomy; 20-G vitrectomy, 20-gauge vitrectomy; RD, retinal detachment; LogMAR, logarithm of the minimum.

REFERENCES

1. Schwartz SG, Flynn HW Jr, Mieler WF. Update on retinal detachment surgery. Curr Opin Ophthalmol 2013; 24:255-61. [PMID: 23429600].
2. Ahrens MB, Li JM, Orger MB, Robson DN, Schier AF, Engert F, Portugues R. Brain-wide neuronal dynamics during motor adaptation in zebrafish. Nature 2012; 485:471-7. [PMID: 22622571].
3. Woo TT, Li SY, Lai WW, Wong D, Lo AC. Neuroprotective effects of lutein in a rat model of retinal detachment. Graefes Arch Clin Exp Ophthalmol 2013; 251:41-51. [PMID: 22899456].
4. Mitry D, Chalmers J, Anderson K, Williams L, Fleck BW, Wright A, Campbell H. Temporal trends in retinal detachment incidence in Scotland between 1987 and 2006. Br J Ophthalmol 2011; 95:365-9. [PMID: 20610474].
5. Delyfer MN, Raffelsberger W, Mercier D, Korobelnik JF, Gaudric A, Charteris DG, Tadayoni R, Metge F, Caputo G, Barale PO, Ripp R, Muller JD, Poch O, Sahel JA, Leveillard T. Transcriptomic analysis of human retinal detachment reveals both inflammatory response and photoreceptor death. PLoS ONE 2011; 6:e28791-[PMID: 22174898].
6. Mitry D, Charteris DG, Fleck BW, Campbell H, Singh J. The epidemiology of rhegmatogenous retinal detachment: geographical variation and clinical associations. Br J Ophthalmol 2010; 94:678-84. [PMID: 19515646].
7. Haargaard B, Andersen EW, Oudin A, Poulsen G, Wohlfahrt J, la Cour M, Melbye M. Risk of retinal detachment after pediatric cataract surgery. Invest Ophthalmol Vis Sci 2014; 55:2947-51. [PMID: 24713483].
8. Haug SJ, Bhisitkul RB. Risk factors for retinal detachment following cataract surgery. Curr Opin Ophthalmol 2012; 23:7-11. [PMID: 22081033].
9. Bringmann A, Pannicke T, Biedermann B, Francke M, Iandiev I, Grosche J, Wiedemann P, Albrecht J, Reichenbach A. Role of retinal glial cells in neurotransmitter uptake and metabolism. Neurochem Int 2009; 54:143-60. [PMID: 19114072].
10. Seider MI, Naseri A, Stewart JM. Cost comparison of scleral buckle versus vitrectomy for rhegmatogenous retinal detachment repair. Am J Ophthalmol 2013; 156:661-6. [PMID: 23876865].
11. Cheng HC, Lee SM, Lee FL, Liu JH, Kuan CH, Lin PK. Short-term external buckling with pneumatic retinopexy for retinal detachment with inferior retinal breaks. Am J Ophthalmol 2013; 155:750-6. [PMID: 23317649].
12. Nakashima H, Emi K, Sato T, Iwahashi-Shima C, Bando H, Ikeda T. Long-term prognosis of 5 cases with stage 3A Coats disease after vitrectomy. Nippon Ganka Gakkai Zasshi 2012; 116:560-7. [PMID: 22774595].
13. Gosse E, Newsom R, Lochhead J. The incidence and distribution of iatrogenic retinal tears in 20-gauge and 23-gauge vitrectomy. Eye (Lond) 2012; 26:140-3. [PMID: 22094297].
14. Kim JD, Pham HH, Lai MM, Josephson JW, Minarcik JR, Von Fricken M. Effect of symptom duration on outcomes following vitrectomy repair of primary macula-off retinal detachments. Retina 2013; 33:1931-7. [PMID: 23591530].
15. Hubschman JP, Gupta A, Bourla DH, Culjat M, Yu F, Schwartz SD. 20-, 23-, and 25-gauge vitreous cutters: performance and characteristics evaluation. Retina 2008; 28:249-57. [PMID: 18301030].
16. Avitabile T, Castiglione F, Bonfiglio V, Castiglione F. Trans-conjunctival sutureless 25-gauge versus 20-gauge standard vitrectomy: correlation between corneal topography and ultrasound biomicroscopy measurements of sclerotomy sites. Cornea 2010; 29:19-25. [PMID: 19907299].
17. Hilton GF, Josephberg RG, Halperin LS, Madreperla SA, Brinton DA, Lee SS, Gordon SF. Office-based sutureless transconjunctival pars plana vitrectomy. Retina 2002; 22:725-32. [PMID: 12476098].
18. Eckardt C. Transconjunctival sutureless 23-gauge vitrectomy. Retina 2005; 25:208-11. [PMID: 15689813].
19. Albrieux M, Rouberol F, Bernheim D, Romanet JP, Chiquet C. Comparative study of 23-gauge vitrectomy versus 20-gauge vitrectomy for the treatment of rhegmatogenous retinal detachment. Graefes Arch Clin Exp Ophthalmol 2011; 249:1459-68. [PMID: 21499771].
20. Scott IU, Flynn HW Jr, Acar N, Dev S, Shaikh S, Mittra RA, Arevalo JF, Kychenthal A, Kunselman A. Incidence of endophthalmitis after 20-gauge vs 23-gauge vs 25-gauge pars plana vitrectomy. Graefes Arch Clin Exp Ophthalmol 2011; 249:377-80. [PMID: 20853005].
21. Sandali O, El Sanharawi M, Lecuen N, Barale PO, Bonnel S, Basli E, Borderie V, Laroche L, Monin C. 25-, 23-, and 20-gauge vitrectomy in epiretinal membrane surgery: a comparative study of 553 cases. Graefes Arch Clin Exp Ophthalmol 2011; 249:1811-9. [PMID: 21830061].
22. Von Fricken MA, Kunjukunju N, Weber C, Ko G. 25-Gauge sutureless vitrectomy versus 20-gauge vitrectomy for the repair of primary rhegmatogenous retinal detachment. Retina 2009; 29:444-50. [PMID: 19174723].
23. Haas A, Seidel G, Steinbrugger I, Maier R, Gasser-Steiner V, Wedrich A, Weger M. Twenty-three-gauge and 20-gauge vitrectomy in epiretinal membrane surgery. Retina 2010; 30:112-6. [PMID: 19834355].
24. . M PN. World Medical Association publishes the Revised Declaration of Helsinki. Natl Med J India 2014; 27:56-[PMID: 25403137].
25. Finck S, Lepiece G, Bonnet S. Diagnosis of chronic retinal detachment following the discovery of a crystalline retinopathy. Rev Med Liege 2014; 69:586-9. [PMID: 25796769].
26. Chen H, Manning AK, Dupuis J. A method of moments estimator for random effect multivariate meta-analysis. Biometrics 2012; 68:1278-84. [PMID: 22551393].
27. Wimpissinger B, Kellner L, Brannath W, Krepler K, Stolba U, Mihalics C, Binder S. 23-Gauge versus 20-gauge system for pars plana vitrectomy: a prospective randomised clinical trial. Br J Ophthalmol 2008; 92:1483-7. [PMID: 18703552].

28. Rizzo S, Belting C, Genovesi-Ebert F, di Bartolo E. Incidence of retinal detachment after small-incision, sutureless pars plana vitrectomy compared with conventional 20-gauge vitrectomy in macular hole and epiretinal membrane surgery. Retina 2010; 30:1065-71. [PMID: 20616684].

29. Kusuhara S, Ooto S, Kimura D, Itoi K, Mukuno H, Miyamoto N, Akimoto M, Takagi H. Intraocular gas dynamics after 20-gauge and 23-gauge vitrectomy with sulfur hexafluoride gas tamponade. Retina 2011; 31:250-6. [PMID: 21052036].

30. Nakano T, Uemura A, Sakamoto T. Incidence of iatrogenic peripheral retinal breaks in 23-gauge vitrectomy for macular diseases. Retina 2011; 31:1997-2001. [PMID: 21610562].

31. Romano MR, Angi M, Valldeperas X, Costagliola C, Vinciguerra P. Twenty-three-gauge pars plana vitrectomy, Densiron-68, and 360 degrees endolaser versus combined 20-gauge pars plana vitrectomy, scleral buckle, and SF6 for pseudophakic retinal detachment with inferior retinal breaks. Retina 2011; 31:686-91. [PMID: 21386767].

32. Hikichi T, Kosaka S, Takami K, Ariga H, Ohtsuka H, Higuchi M, Matsushita T, Matsushita R. Incidence of retinal breaks in eyes undergoing 23-gauge or 20-gauge vitrectomy with induction of posterior vitreous detachment. Retina 2012; 32:1100-5. [PMID: 22366906].

33. Narayanan R, Tibra N, Mathai A, Chhablani J, Kuppermann BD. Sutureless 23-gauge versus 20-gauge vitrectomy with silicone oil injection in rhegmatogenous retinal detachment. Retina 2012; 32:1013-6. [PMID: 22366901].

34. Cha DM, Woo SJ, Park KH, Chung H. Intraoperative iatrogenic peripheral retinal break in 23-gauge transconjunctival sutureless vitrectomy versus 20-gauge conventional vitrectomy. Graefes Arch Clin Exp Ophthalmol 2013; 251:1469-74. [PMID: 23504087].

35. Pielen A, Guerra NI, Bohringer D, Junker B, Buhler AD, Stahl A, Agostini HT, Ehlken C. Intra- and postoperative risks and complications of small-gauge (23-G) versus conventional (20-G) vitrectomy for macular surgery. Eur J Ophthalmol 2014; 24:778-85. [PMID: 24706351].

36. Cai WQ, Zheng Z, Li T, Chen FE, Xu X. Analysis of the clinical efficacy of 23-G and 20-G vitrectomy to retinal detachment. Shanghai Medicine. 2012; 151–4.

37. Liu SM, Zhong J, Fan YC. Comparison of the treatments of 20-G and 23-G vitrectomy to retinal detachment Practical Journal of Clinical Medicine 2013; 113–5.

38. Yanyali A, Horozoglu F, Macin A, Bozkurt KT, Aykut V, Acar BT, Nohutcu AF. Corneal topographic changes after transconjunctival 23-gauge sutureless vitrectomy. Int Ophthalmol 2011; 31:277-82. [PMID: 21750946].

39. Meleth AD, Carvounis PE. Outcomes of vitrectomy for tractional retinal detachment in diabetic retinopathy. Int Ophthalmol Clin 2014; 54:127-39. [PMID: 24613889].

40. Romano MR. Re: Primary 23-gauge transconjunctival sutureless vitrectomy for rhegmatogenous retinal detachment. Retina 2009; 29:1547-[PMID: 19898193].

41. Byeon SH, Kwon OW, Kang SY. Short-term outcomes of 23-gauge pars plana vitrectomy. Am J Ophthalmol 2008; 146:789-90. , author reply 90–1. [PMID: 18984086].

42. Scartozzi R, Bessa AS, Gupta OP, Regillo CD. Intraoperative sclerotomy-related retinal breaks for macular surgery, 20- vs 25-gauge vitrectomy systems. Am J Ophthalmol 2007; 143:155-6. [PMID: 17188054].

43. Koh KM, Kim HS, Cho HJ, Lew YJ, Choi MJ, Han JI, Cho SW, Kim CG, Lee TG, Kim JW, Yoo SJ. Surgical outcomes of 23-gauge vitrectomy for the management of lens fragments dropped into the vitreous cavity during cataract surgery. Saudi J Ophthalmol 2014; 28:253-6. [PMID: 25473339].

Articles are provided courtesy of Emory University and the Zhongshan Ophthalmic Center, Sun Yat-sen University, P.R. China. The print version of this article was created on 21 August 2015. This reflects all typographical corrections and errata to the article through that date. Details of any changes may be found in the online version of the article.