

Outcomes of Nd:YAG Laser Posterior Membranotomy in the Treatment of Macular Preretinal Hemorrhage: A Systematic Review and Meta-Analysis

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Abstract

Purpose: To examine the success rate of neodymium-doped yttrium aluminum garnet (Nd:YAG) laser posterior membranotomy as a treatment option to facilitate drainage of macular preretinal hemorrhage into the vitreous cavity. **Methods:** A literature search was conducted using the PubMed, Embase, and Scopus databases for studies describing the use of Nd:YAG laser for a posterior membranotomy in the setting of macular preretinal hemorrhages. The main outcome of interest was drainage of the hemorrhage into the vitreous cavity without need for subsequent vitrectomy. A meta-analysis of proportions measured the pooled success rate of the procedure due to any etiology. Additional meta-analyses evaluated success rates of the procedure for Valsalva retinopathy and proliferative diabetic retinopathy (PDR). Secondary outcomes of interest included complications and reasons for failure. **Results:** Twenty-three studies with 291 eyes were included. The pooled success rate of Nd:YAG laser posterior membranotomy was 93.7% (95% CI, 89.3%-97.3%). Additional meta-analyses identified a success rate of 97.9% (95% CI, 91.9%-100%) with Valsalva retinopathy and 90.8% (95% CI, 77.8%-99.2%) with PDR. Reasons for a failed procedure included failure of drainage secondary to a clotted hemorrhage and nonclearing vitreous hemorrhage that necessitated vitrectomy. Reported complications included 1 macular hole, 2 epiretinal membranes, 2 retinal detachments, and 3 instances of metamorphopsia. **Conclusions:** Nd:YAG laser posterior membranotomy is a safe treatment option for macular preretinal hemorrhages. Drainage of the hemorrhage into the vitreous facilitates absorption and can restore a patient's vision.

Keywords

premacular hemorrhage, subhyaloid hemorrhage, Nd:YAG laser posterior hyaloidotomy, Nd:YAG laser posterior membranotomy

Introduction

Large, macular preretinal subhyaloid or sub-internal limiting membrane (ILM) hemorrhages are visually debilitating posterior segment bleeds that can occur secondary to various etiologies. The localized hemorrhagic detachment of the posterior hyaloid or ILM occurs following vascular rupture from conditions such as Valsalva retinopathy, retinal artery macroaneurysm, proliferative diabetic retinopathy (PDR), leukemic retinopathy, or branch or central retinal vein occlusions.¹ The blood accumulates superficial to the macula at the vitreoretinal interface in a circumscribed, dome-shaped configuration.¹ Spontaneous resorption of the entrapped hemorrhage can occur slowly over months.² The density of the hemorrhage precludes appropriate transmission of light to the macula, leading to patients presenting with an incapacitating loss of vision. In patients who depend on binocular vision for their vocations, or in those with preexisting vision loss in the fellow eye, this loss of sight can be devastating and costly.

Treatment approaches vary depending on the size and etiology of the hemorrhage, and patient-specific characteristics

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and preferences. The preretinal hemorrhage can be managed conservatively, which may take several months and lead to prolonged contact of the macula with hemoglobin and iron. Toxic exposure to these products may lead to irreversible damage to the macula.³ In patients with dense preretinal hemorrhages secondary to PDR or a retinal artery macroaneurysm, this can lead to formation of a fibrotic epiretinal membrane with subsequent macular traction.^{3,4} Therapeutic options that expedite visual recovery and reduce toxic exposure of the macula to blood contents include pneumatic displacement of the hemorrhage with tissue plasminogen activator and gas, pars plana vitrectomy (PPV), and neodymium-doped yttrium aluminum garnet (Nd:YAG) laser puncture of the posterior hyaloid or ILM.^{3,5-7}

Using noninvasive Nd:YAG laser posterior membranotomy, the previously entrapped blood can be rapidly drained into the large vitreous cavity, where it may gravitate away from the visual axis and be absorbed more quickly. This enables rapid visual recovery using an efficient, inexpensive, clinic-based procedure that offers a treatment alternative to vitrectomy.⁷ Several primary, individual studies have evaluated the effectiveness, success rates, and complications associated with performing a laser puncture of the posterior membrane enclosing a circumscribed macular preretinal hemorrhage.⁷⁻²⁹ However, there is no higher level of evidence available. To our knowledge, this is the first meta-analysis to pool data on the outcomes of Nd:YAG laser posterior membranotomy for the treatment of macular subhyaloid or sub-ILM hemorrhages.

Methods

Design

A systematic review in line with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement guidelines on searching was performed.³⁰ The study protocol was prospectively submitted to an online database for systematic reviews, the international prospective register of systematic reviews (PROSPERO ID: CRD42024507325). Ethical approval was not sought for the present study as it was a meta-analysis with no human subjects or use of private information. Informed consent was not sought as we used existing, published studies that obtained informed consent from their respective participants.

Search Strategy

Three databases, PubMed, Scopus, and Embase, were searched on January 28, 2024, with no constraints. Variations of the following words were used in the search: “subhyaloid,” “sub-internal limiting membrane (sub-ILM),” “hemorrhage,” “premacular,” “hyaloidotomy,” and “Nd:YAG.” Supplemental Table 1 shows a complete description of the search strategy.

Article Selection

Two Authors (M.B., D.Z.) independently screened and reviewed articles in 2 phases: (1) title and abstract screening and (2)

full-text screening. During the title and abstract screening phase, articles were included if they reported on the success rates of Nd:YAG laser posterior membranotomy, which was defined as a puncture through either the posterior hyaloid or ILM for the treatment of premacular hemorrhage secondary to any etiology. These articles proceeded to phase 2 of the article selection process. If the content of the article was unclear based on the title or abstract, the study was selected for full-text screening.

During phase 2, the independent authors screened full-text articles based on predetermined inclusion and exclusion criteria. Inclusion criteria are as follows: (1) the article reported the outcomes of Nd:YAG laser posterior membranotomy in a minimum of 5 eyes; (2) full-text publication; (3) English language; (4) clinical trial, cohort, case-control, case series. Exclusion criteria were as follows: (1) case reports, conference proceedings, letters, commentaries, reviews/meta-analyses; (2) animal or laboratory studies; (3) duplicate literature of duplicate data. Disagreements were resolved via consensus and with a third reviewer (G.J.).

The PRISMA flowchart of this meta-analysis is shown in Figure 1. Using the search strategy described (Supplemental Table 1), we obtained 458 results that were then imported into Covidence, a systematic review manager. Covidence merged any duplicates, consolidating the number to 218 results. After screening the titles and abstracts, the number of results was reduced to 55. In the full-text screening phase, 32 studies were excluded (Supplemental Table 2). A total of 23 studies remained, from which data were extracted.

Quality Assessment

Risk of bias was assessed by 2 authors (M.B. and G.J.) using the National Institutes of Health (NIH) quality assessment tool for case-series studies. Supplemental Table 3 depicts the criteria and subdomains for each study. The Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework was used by 2 authors (M.B. and D.Z.) to assess the overall quality of evidence.³¹

Data Extraction

Three authors (M.B., D.Z., G.J.) reviewed the 23 studies in the data extraction process, and disagreements were resolved through consensus. Data points collected included first author's name, year of publication, country, sample size, age, follow-up duration, etiology of the hemorrhage, success rates of the procedure, number of complications, and reasons for a failed procedure. For the purposes of this study, success was defined as drainage of the hemorrhage from the premacular space into the vitreous cavity without the need for future vitrectomy secondary to a nonclearing hemorrhage.

Statistical Analysis

To evaluate the success rate of the procedure, a meta-analysis of proportions was conducted using R software, version 4.2.3

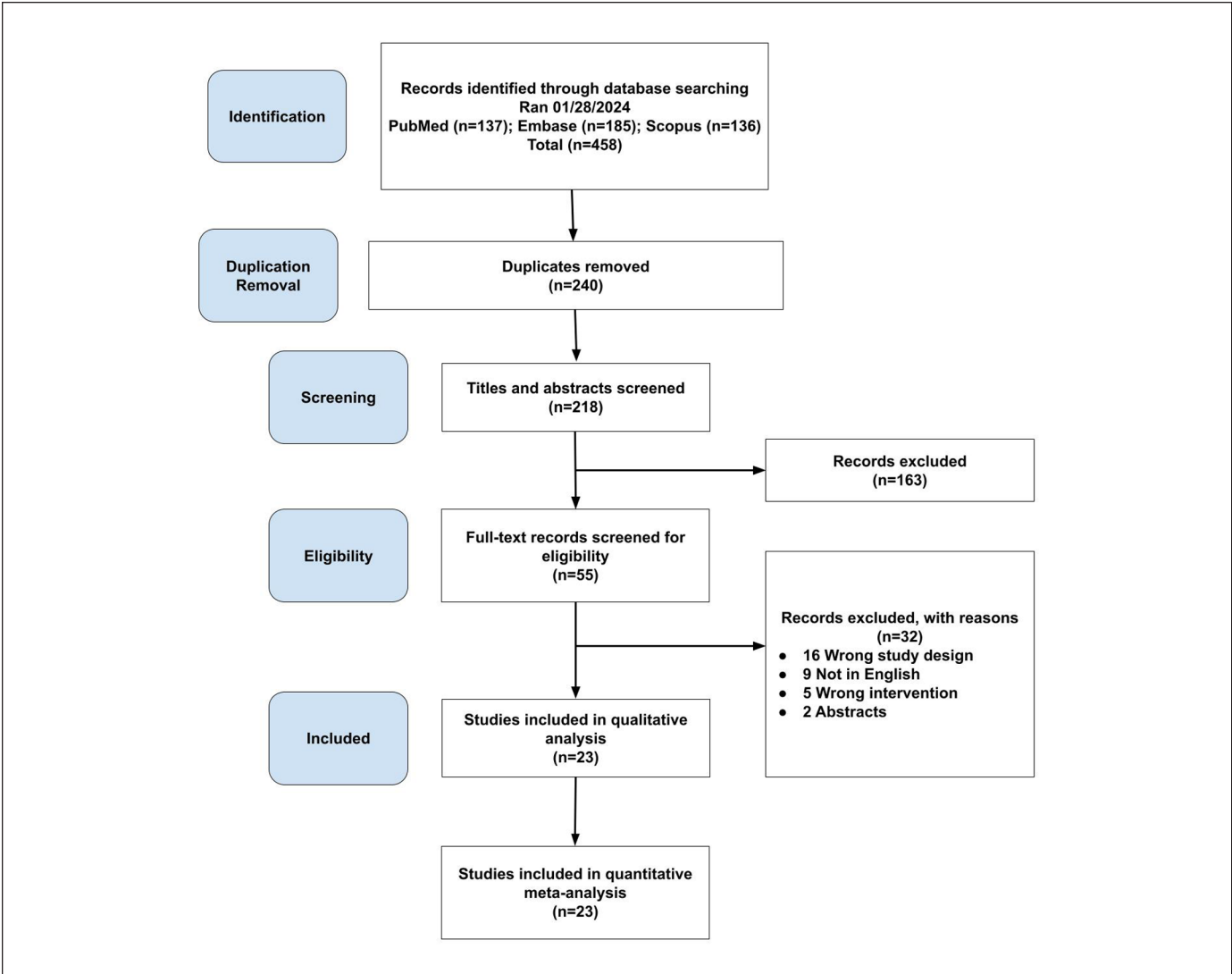


Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flowchart.

(R Foundation for Statistical Computing), specifically using the metafor and meta packages. The random-effects model (DerSimonian and Laird method) was chosen due to anticipated heterogeneity secondary to variations in the protocols, follow-up durations, and etiologies of premacular hemorrhages among the included studies. Additional etiology-specific meta-analyses were conducted if a minimum of 3 studies reported on at least 3 eyes for that etiology. The summary effect measure and 95% CIs were represented using forest plots. Heterogeneity was assessed using Cochran Q and Higgins I^2 . Significant heterogeneity was defined as a Cochran Q $P < .1$ and an $I^2 > 40\%$.

Publication Bias

To assess publication bias, the Begg funnel plot and a linear regression test of funnel plot asymmetry were used. These analyses were conducted using R software version 4.2.3.

Results

Study Characteristics

Twenty-three studies published between 1995 and 2023 were included in the meta-analysis, with sample sizes ranging from 5 to 37 eyes. The characteristics of the studies are provided in Table 1. The published studies were conducted in 11 countries. Of the included studies, 14 were retrospective case series, and the remainder were prospective case series. All studies reported on the success rate and complications of Nd:YAG laser posterior membranotomy.

Quality Assessment

In this meta-analysis, the US National Institutes of Health quality assessment tool for case series studies was used. Consensus was achieved in cases where there were disagreements between

Table 1. Summary of Included Studies.

Source	Year	Country	Study Design	Age (y)	Follow-Up Time (mo)	No. of Eyes ^a	Success Rate of Nd:YAG Posterior Membranotomy
AhmadAbadi et al.	2009	Iran	RCS	34.13 ^b	38.5 ^b	16	14/16
Allam et al.	2019	Saudi Arabia	PCS	46.63 ^b	14 ^b	8	8/8
Alsulaiman et al.	2014	Saudi Arabia	RCS	17 ^b	2.2 ^b	5	3/5
Celebi et al.	2001	Turkey	PCS	39.7 ^b	26.3 ^b	6	6/6
Dulger et al.	2021	Turkey	RCS	46.9 ^b	42.8 ^b	10	8/10
Durukan et al.	2008	Turkey	PCS	28.13 ^b	24	16	16/16
Ezra et al.	1996	England	PCS	50 ^b	19.1 ^b	9	9/9
Farvardin et al.	2005	Iran	PCS	48.25 ^b	3	13	11/13
Goel et al.	2011	India	PCS	30.43 ^b	6	7	7/7
Iijima et al.	1998	Japan	RCS	74.4 ^b	11.8 ^b	6	5/6
Khadka et al.	2016	Nepal	PCS	41.68 ^b	6	22	19/22
Khadka et al.	2012	Nepal	RCS	11.5 ^b	3	9	9/11
Khan et al.	2008	Pakistan	RCS	40.9 ^b	6	11	11/11
Khan et al.	2019	Pakistan	RCS	18-60	1.5	37	31/37
Murtaza et al.	2014	Pakistan	PCS	32.57 ^b	1.5	30	28/30
Nili-Ahmadabadi et al. ^c	2004	Iran	RCS	52.44 ^b	24.5 ^b	9	9/9
Puthalath et al.	2003	India	PCS	39.91 ^b	18	12	12/12
Qureshi et al.	2008	Pakistan	RCS	Not reported	Not reported	8	8/8
Raymond et al.	1995	USA	RCS	Not reported	20 ^b	6	5/6
Rennie et al.	2001	England	RCS	14.33 ^b	58.7 ^b	6	6/6
Su et al.	2021	China	RCS	51.19 ^b	2 ^d	16	16/16
Ulbis et al.	1998	Germany	RCS	46.43 ^b	22 ^b	16	16/21
Wang et al.	2016	China	RCS	37.7 ^b	20.5 ^b	6	5/6

Abbreviations: Nd:YAG, neodymium-doped yttrium aluminum garnet; PCS, prospective case series; RCS, retrospective case series.

^aNumber of eyes that underwent Nd:YAG laser posterior membranotomy.

^bReported mean.

^cThis study included 3 patients with Valsalva retinopathy used in a previous study that were excluded from the analysis.

^dReported median.

reviewers. The analysis demonstrated an overall low risk of bias regarding participant selection, description of interventions, and length of follow-up; defining outcome measures and portrayal of results were deemed moderate-risk. Supplemental Table 3 shows the grading of each study. The quality of evidence for the overall success rate and success rates for PDR and Valsalva retinopathy were assessed using the GRADE framework and were determined to be low-risk, as depicted in Supplemental Table 4.

Overall Success Rate of Nd:YAG Laser Posterior Membranotomy

Meta-analysis of the data extracted from 23 studies with 291 eyes found the success rate of Nd:YAG laser posterior membranotomy for the treatment of macular pre-retinal hemorrhages to be 93.7% (95% CI, 89.3%-97.3%). There was no significant heterogeneity detected ($I^2 = 20\%$; $P = .20$). The overall forest and funnel plot is shown in Figure 2. A linear regression test of funnel plot asymmetry did not detect any significant publication bias ($P = .529$).

Success Rates of Nd:YAG Laser Posterior Membranotomy for Specific Etiologies

Many studies evaluated the success rate of the procedure for premacular hemorrhages secondary to various etiologies. Different etiologies included PDR, Valsalva retinopathy, retinal artery macroaneurysm, central or branch retinal vein occlusion, Eales disease, Terson syndrome, leukemic retinopathy, high-altitude retinopathy, laser-induced maculopathy, choroidal neovascular membrane, trauma, and blood dyscrasia. Additional meta-analyses were performed for etiologies in which at least 3 studies reported on a minimum of 3 patients for that etiology. Valsalva retinopathy and PDR were etiologies that met these criteria. These analyses identified a success rate in patients with Valsalva retinopathy, with 89 total eyes, to be 97.9% (95% CI, 91.9%-100%) and in patients with PDR, with 47 total eyes, to be 90.8% (95% CI, 77.8%-99.2%). No heterogeneity was detected in either of these analyses (Valsalva $I^2 = 0\%$, $P = .61$; PDR $I^2 = 0\%$, $P = .50$). Linear regression tests of funnel plot asymmetry did not detect any publication bias (Valsalva $P = .967$; PDR $P = .365$). Figures 3 and 4 show the forest and funnel plots for Valsalva retinopathy and PDR, respectively.

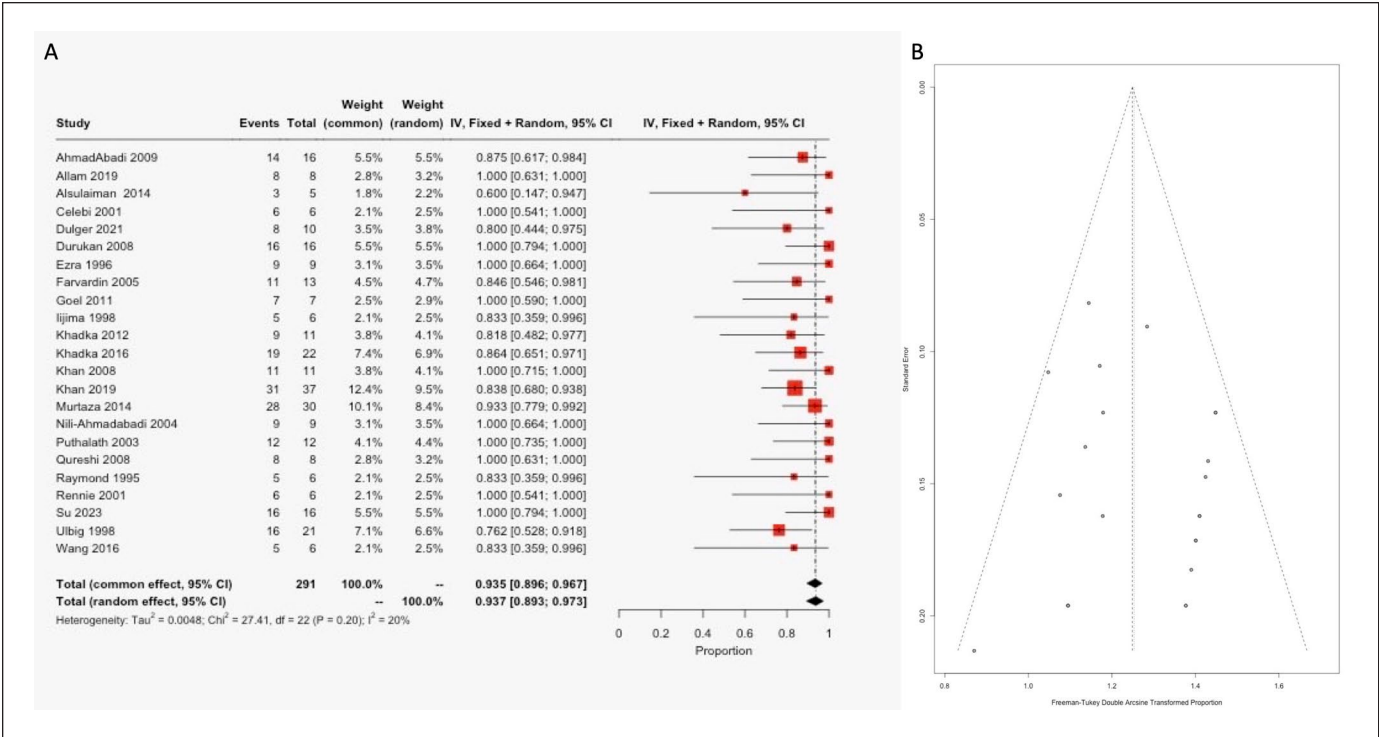


Figure 2. (A) Forest plot meta-analysis of proportions of the pooled success rates of neodymium-doped yttrium aluminum garnet (Nd:YAG) laser posterior membranotomy for premacular hemorrhage due to any etiology. Each study is shown by the last name of the first author and the proportion with 95% CIs. Summary proportions with 95% CIs are also shown. (B) Funnel plot of the studies included in the meta-analysis. Abbreviation: IV, inverse variance.

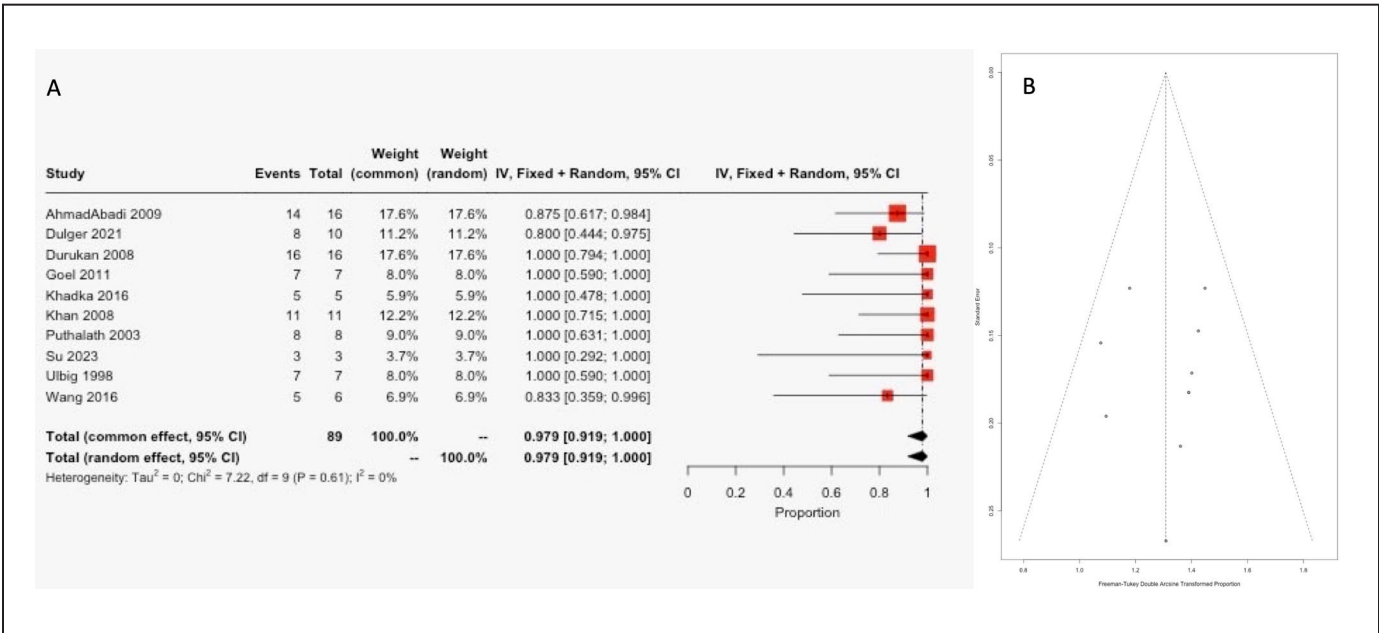


Figure 3. (A) Forest plot meta-analysis of proportions of the pooled success rates of neodymium-doped yttrium aluminum garnet (Nd:YAG) laser posterior membranotomy for premacular hemorrhage due to do Valsalva retinopathy. Each study is shown by the last name of the first author and the proportion with 95% CIs. Summary proportions with 95% CIs are also shown. (B) Funnel plot of the studies included in the meta-analysis. Abbreviation: IV, inverse variance.

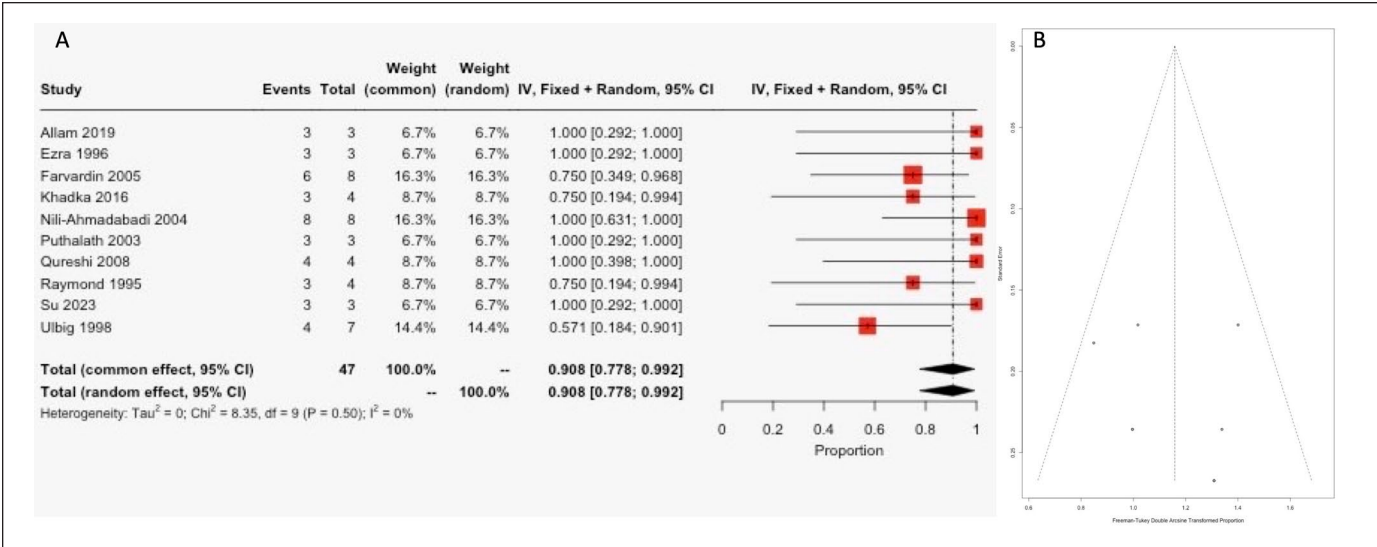


Figure 4. (A) Forest plot meta-analysis of proportions of the pooled success rates of neodymium-doped yttrium aluminum garnet (Nd:YAG) laser posterior membranotomy for premacular hemorrhage due to do proliferative diabetic retinopathy. Each study is shown by the last name of the first author and the proportion with 95% CIs. Summary proportions with 95% CIs are also shown. (B) Funnel plot of the studies included in the meta-analysis. Abbreviation: IV, inverse variance.

Complications of Nd:YAG Laser Posterior Membranotomy

Overall complications associated with the procedure were minimal. Among 291 performed procedures, reported complications included 1 macular hole, 2 epiretinal membranes, 2 retinal detachments, and 3 reports of post-procedure metamorphopsia.

Reasons for a Failed Procedure

The most common reasons for an unsuccessful procedure were failure of drainage secondary to a clotted hemorrhage, and non-clearing vitreous hemorrhage that necessitated vitrectomy for removal. Studies presumed a clotted hemorrhage as the cause of failure whenever a successful puncture of the posterior hyaloid membrane was not followed by subsequent drainage of the hemorrhage into the vitreous cavity. No patients without a pre-existing retinal vascular disorder such as PDR or vein occlusion required vitrectomy secondary to a nonclearing vitreous hemorrhage. For example, Ahmadabadi et al⁸ attributed their 2 failed procedures in patients with Valsalva retinopathy secondary to a clotted hemorrhage. Ulbig et al²⁸ reported on 3 failed procedures in patients with PDR secondary to a nonclearing vitreous hemorrhage, and 2 failed procedures in patients with a branch retinal vein occlusion, secondary to a vitreous hemorrhage in 1 patient and a clotted hemorrhage in the other. Khadka et al¹⁸ attributed 1 failed procedure to a nonclearing vitreous hemorrhage in a patient with PDR, and 2 other failed procedures secondary to a clotted hemorrhage in patients with a branch retinal vein occlusion and Eales disease.

Timing of the Procedure

To prevent the macular preretinal hemorrhage from clotting and leading to failure of mobile drainage into the vitreous, studies recommended performing the procedure as early as possible.^{11,13–15,18,20,24,25,27–29} Some advocated for treatment within 2 weeks of hemorrhage onset, and no longer than 28 days.^{13–15}

Location of Puncture and Size of Hemorrhage

To minimize the risk of retinal damage, studies created the puncture near the inferior edge of the hemorrhage, away from the fovea and retinal vessels but where there still remained a sufficient thickness of blood to shield the underlying retina.^{9,11–20,22,25,26,28,29} Creating an opening at the inferior edge facilitates gravity-induced drainage.^{4,9,13,15,26,28} The procedure was typically performed in hemorrhages with a size of at least 3 disc diameters, which provides additional protection against inadvertent damage to the retina or choroid via the photo disruptive effects of the laser.^{8,11,13,15,16,18,22,29}

Laser Power

Aside from preferred location and size of the hemorrhage, the amount of laser energy required to perforate the posterior hyaloid membrane was also deemed important. Studies advocated for beginning the procedure with lesser amounts of energy and gradually increasing power until success was achieved.^{7,9,11,13,16,18,19,27–29} Celik Dulger et al¹² began puncturing the posterior hyaloid

membrane with an energy level of 1 mJ and increased power gradually in 0.5 mJ intervals as necessary, up to 10 mJ. Theoretically, an excessive amount of laser energy can lead to inadvertent damage to the underlying retina and choroid.²⁸ While all studies promoted use of less energy, studies often omitted the total power used, the energy used per laser pulse, or the starting energy settings. Because of this, it was not possible to create a distinct comparison between studies.

Conclusions

In this meta-analysis of 291 eyes from 23 studies, Nd:YAG laser posterior membranotomy had a success rate of 93.7%. This procedure offers an inexpensive, noninvasive, effective, and safe method for quickly resolving acute loss of vision secondary to a large macular preretinal hemorrhage.^{13,14,18,29} It enables drainage of the hemorrhage into the vitreous, which facilitates the absorption of blood and provides clearance of the previously obstructed macula.^{7,14} When successfully performed, the procedure allows early assessment of the underlying retina following the rapid drainage of hemorrhage, and by extension, it provides a quick restoration of visual function.^{13,18,22,26,29} With appropriate visualization of the previously obscured macula, any ischemic, edematous, or vascular abnormalities can be properly addressed.^{14,26,28}

Using the minimum amount of energy required for perforation, a safely performed procedure creates an opening at the inferior edge of a hemorrhage at least 3 disc diameters in size.^{9,11–20,22,25,26,28,29} While most studies used the traditional Q-switched Nd:YAG laser, which emits a near-infrared ray of 1064 nm, some groups evaluated the use of different Nd:YAG laser designs. Su et al used the Ultra Q reflex (Ellex Medical Pty Ltd), a Q-switched Nd:YAG laser with continuously variable laser energy, on 16 patients. In addition to achieving a success rate of 100%, none of their subjects had any energy-related retinal or choroidal damage.²⁷ Puthalath et al²⁴ used the frequency-doubled Nd:YAG laser (emits at 532 nm), which has greater inherent energy per photon unit, and also achieved a 100% success rate with no complications. However, even with the traditional Q-switched Nd:YAG laser, there were minimal complications appreciated in those studies.

To avoid a failed procedure secondary to a clotted hemorrhage, studies advocated for performing the posterior membranotomy as early as possible.^{11,13–15,18,20,24,25,27–29} With time, the degeneration of hemoglobin results in the hemorrhage assuming a yellowish color. This typically coincides with the blood being viscous and clotted, at which point it becomes more difficult for the hemorrhage to drain into the vitreous despite successful membranotomy.²⁸ Aside from improving the rate of success of the procedure, early intervention may also prevent toxic injury to the retina from prolonged contact with hemoglobin and iron.^{3,4} In longstanding cases of large preretinal hemorrhages secondary to diabetic retinopathy, formation of a fibrous epiretinal membrane and tractional detachment of the macula can eventually follow.³ When there is traction from the posterior hyaloid in eyes with

macular fibrovascular disease such as PDR, the friable and diseased vessels can rupture. Without clearing this subsequent preretinal hemorrhage, the underlying fibrovascular membrane can continue to evolve, eventually leading to further traction and ERM formation. With this in mind, allowing for spontaneous resolution of hemorrhage may not be without its own risks. While this risk is not as relevant in those without vascular disease, early intervention with quick restoration of vision still benefits those individuals who either require binocular vision for their occupation or in monocular patients now affected by the macular preretinal hemorrhage.

In this study, a failed procedure was defined as either a failure of the blood to drain into the vitreous cavity, or a need for further intervention, including PPV. Failed procedures were most frequently seen in patients with a predisposing retinal condition leading to the preretinal hemorrhage. This was especially true for patients requiring a vitrectomy for nonclearing vitreous hemorrhage, most of whom had retinal vascular disease such as PDR or retinal vein occlusion.^{19,21,28} In all studies included, there were no reported cases of nonclearing vitreous hemorrhage following posterior membranotomy in patients without a predisposing retinal vascular disease. In these patients, a failed procedure was typically secondary to failure of drainage, secondary to a clotted hemorrhage. Clotted hemorrhages are likely not a factor of the etiological state of the premacular hemorrhage, but rather secondary to delayed intervention following the onset of vision loss.

Complications encountered in this study were minimal. Because of bias against publishing complications, it is possible that this procedure is not as safe as suggested by the literature in this systematic review. Khadka et al identified 2 total complications in their study of 22 eyes: 1 formation of an epiretinal membrane and 1 tractional retinal detachment, both occurring in eyes with Eales disease. The authors of that study state, however, that rather than being a direct complication from the Nd:YAG laser, these pathologic occurrences were a result of the natural disease processes related to regression of fibrovascular bands.¹⁸ Ulbig et al²⁸ identified 2 total complications in their study of 21 eyes: 1 retinal detachment and 1 macular hole. The retinal detachment occurred in a patient with bilateral myopia and retinal breaks found in both eyes, making it difficult to attribute the laser as the cause of the detachment. The macular hole occurred in a patient in whom a laser was used, despite the size of the preretinal hemorrhage only being 1 disc diameter. Such small hemorrhages lack the ability to dampen the disruptive effects of the laser. Many of the studies used the 3-disc diameter cutoff based on this observation. Among those with preretinal hemorrhage secondary to Valsalva retinopathy, there were no reported complications resulting in direct retinal or choroidal injury across the studies analyzed.^{12,13,16,18,20,29}

Another complication observed was metamorphopsia.^{16,22} Goel et al found that all of their patients treated with posterior membranotomy had a hyporeflexive, convex dome-shaped premacular cavity that persisted until the end of their 6-month follow-up. Despite successful drainage and absorption of the

hemorrhage, they believed that this persistent cavity was the source of the metamorphopsia, which 2 of the 7 patients they treated experienced.¹⁶

Given the variety of different etiologies included in the studies analyzed, we did not report a standardized mean difference in visual acuity before and after membranotomy. It should still be noted, however, that all studies reported an improved visual acuity following a successful procedure unless otherwise impeded by preexisting intraretinal or subretinal disease.^{7-9,11-13,15-20,22-29} Those without an underlying pathology, such as preretinal hemorrhage secondary to Valsalva retinopathy, fared best.^{4,11-13,18,20,24,27-29} Durukan et al,¹³ in their treatment of premacular hemorrhages with Nd:YAG laser for patients with Valsalva retinopathy, found that 14 of 16 eyes treated had a visual acuity of 20/20 as soon as 1 week following treatment. Prior to treatment, visual acuity ranged from counting fingers to hand motions in all patients. This dramatic improvement is not surprising as the clearance of blood from an enclosed space covering the macula allows appropriate visualization of the fovea soon after performing the procedure. However, the persistence of hemorrhage in the vitreous can be a barrier to achieving initial baseline visual acuity in a timely manner. Celik Dulger et al¹² reported on 10 eyes that were successfully treated with Nd:YAG laser for Valsalva retinopathy, where 6 of the patients achieved a visual acuity of 20/20 after 1 month, but 4 had not achieved an acuity of 20/20 until the 2-month period due to persistent hemorrhage in the vitreous. Nonetheless, these patients still demonstrated a more expedited visual recovery than those managed conservatively with observation. This is further exemplified in a study from Ahmadabadi et al: in 16 patients with Valsalva retinopathy treated with Nd:YAG membranotomy, trapped blood was released into the vitreous cavity and absorbed in a mean period of 14.5 days. In contrast, 5 patients treated conservatively demonstrated spontaneous absorption of the trapped blood an average of 47.2 days after presentation.⁸

Studies did not regularly distinguish between true subhyaloid and sub-ILM hemorrhages when evaluating the effectiveness the procedure. For example, in a case series of patients with premacular hemorrhages secondary to a variety of etiologies, Khadka et al¹⁸ note that most of the subjects with Valsalva retinopathy had sub-ILM bleeds. Nonetheless, these patients were all included in the same analysis. It is therefore difficult to make any notable evidence-based distinction as to the effectiveness of this procedure and how it may vary between true subhyaloid vs sub-ILM bleeds.

Unfortunately, studies did not specify whether there was a significant degree of fibrosis and traction in cases in which the etiological cause of the hemorrhage was fibrovascular in nature, such as in PDR. While a successful posterior membranotomy would result in resolution of the premacular hemorrhage, patients with significant tractional detachments of the macula would likely still require a PPV. In such cases, it would be best to pursue surgical intervention as the initial treatment. It is also not possible to comment on how different noninvasive, adjunct therapies may have influenced the results of this analysis. For instance, studies did not typically specify whether

patients received intravitreal antivascular endothelial growth factor injections or panretinal photocoagulation as a primary or adjunct therapeutic regimen in patients with hemorrhage secondary to vascular proliferative disease. If performing a membranotomy, it is recommended to either initiate or continue the relevant treatment to curb the vasoproliferative driving forces in those with vascular disease.

Based on the results of this meta-analysis, Nd:YAG laser posterior membranotomy can safely be considered in relatively new, large, macular preretinal hemorrhages due to any etiology. The best outcomes can be expected in patients with Valsalva retinopathy. The overall pooled success rates of the procedure highlight its ability to be a viable option that may help patients avoid the need for vitrectomy in the long-term. Further prospective, randomized controlled trials that compare deferral of treatment, vitrectomy, and Nd:YAG laser posterior membranotomy for large premacular hemorrhages could potentially elucidate the best course of action for patients with this condition.

Ethical Approval

Ethical approval was not sought for the present study because this study was a meta-analysis with no human subjects or use of private information.

Statement of Informed Consent

Informed consent was not sought for the present study due to its use of existing published studies that had obtained informed consent from their respective participants.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of the article.

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Supplemental Material

Supplemental material is available online with this article.

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