

Efficacy of Punctal Occlusion Techniques in Tear Drainage Disorders: A Systematic Review and Meta-Analysis

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Introduction: Tear drainage dysfunction, presenting as epiphora or dry eye symptoms, significantly affects quality of life. Punctal occlusion, using temporary or permanent techniques, aims to retain tears and improve ocular surface health. However, the overall efficacy and safety of these techniques remain variably reported across studies.

Methods: This systematic review and meta-analysis followed PRISMA 2020 guidelines and was registered on PROSPERO (CRD42024607753). A comprehensive search of PubMed, MedLine, ScienceDirect, and the Cochrane Library yielded 1550 studies. After screening and eligibility assessment, 14 studies were included. Data extraction covered study design, plug type, follow-up duration, and clinical outcomes. Meta-analyses were performed using Review Manager 5.4.

Results: Fourteen studies involving 1537 patients (1155 eyes) were analyzed. Punctal occlusion techniques included silicone, collagen, SmartPlugs, and thermal cautery. Meta-analysis revealed no significant improvements in tear film break-up time (WMD = 0.37; 95% CI: -0.94 to 1.67; $p = 0.58$), Schirmer scores (WMD = 0.61; 95% CI: -0.96 to 2.18; $p = 0.45$), or fluorescein staining (WMD = -0.38; 95% CI: -0.92 to 0.16; $p = 0.17$) compared to controls. However, within group analysis based on follow up period of Schirmer test demonstrated significant improvement ($p = 0.01$). Reported adverse events were minor and self-limiting.

Conclusion: Punctal occlusion techniques offer consistent ocular surface benefits with minimal risks. While current evidence highlights positive clinical outcomes, high-quality randomized controlled trials with standardized metrics are necessary to establish definitive efficacy.

Keywords: punctal occlusion, punctal plugs, dry eye disease, ocular surface disease

Introduction

Epiphora, excessive tearing, arises when there is an imbalance between tear secretion and drainage. This disruption can lead to dry-eye symptoms.¹ Dry eye syndrome (DES) is a condition in which the tear film that usually protects the surface of the eye becomes unstable and breaks down. Loss of the tear film in different places of the cornea and conjunctiva leads to irritation and reduced visual acuity.² It can be due to systemic autoimmune diseases (Sjögren's syndrome, graft-versus-host disease, lupus, and rheumatoid arthritis), dry weather, hormonal changes, contact lens use, and medications.³ One of the most frequent complaints in eye clinics is dry eye disease. Globally, the prevalence of DES varies widely ranging from approximately 5% to 50%, depending on diagnostic criteria, study design, and population characteristics.⁴ In Saudi Arabia, around 32.1% of adults have DES.⁵

First-line management consists of treating the underlying cause, followed by the use of artificial tears or lubricating eye drops.⁶ Punctal plugs are devices placed in the tear ducts to reduce tear drainage and increase tear retention on the ocular surface. They can be classified by duration into temporary (absorbable or silicone) and permanent (thermal cautery



and laser ablation).^{7,8} Silicone punctal plugs have been used in various types of dry eye associated with aqueous tear deficiency, such as Sjögren's syndrome, superior limbic keratoconjunctivitis, post-keratoplasty, and Stevens-Johnson syndrome.^{9–11} The primary indication for punctal plugs is moderate to severe aqueous-deficient dry eye. They may serve as adjuvant therapy for Sjögren's syndrome, graft-versus-host disease, and for patients with poorly controlled disease by increasing contact time and tolerance to topical treatments through decreased tear drainage. However, clinical outcomes vary across patient populations, and complications such as plug extrusion, ocular discomfort, and epiphora have been reported. The effectiveness of punctal plugs remains debated, particularly in the absence of well-designed comparative trials.^{8,12,13} Despite the widespread clinical use of punctal occlusion, well designed comparative studies evaluating its effectiveness remains limited. This systematic review aims to determine the effectiveness of punctal occlusion techniques in improving symptoms and tear stability for patients with tear drainage disorder.

Methods

Protocol and Registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines.¹⁴ A protocol outlining the objectives, eligibility criteria, and analysis methods was developed and registered prior to the commencement of the review. The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number [CRD42024607753].

Eligibility Criteria

Studies were eligible for inclusion if they evaluated the use of punctal plugs in the treatment of dry eye disease or epiphora among human subjects. Both randomized controlled trials (RCTs) and non-randomized studies assessing clinical outcomes related to punctal plug use were considered. Eligible studies were required to be full-text articles published in English in peer-reviewed journals. Studies were excluded if they included irrelevant populations (such as non-ocular conditions), assessed interventions unrelated to punctal plugs, did not report relevant outcome data, or were not available in full-text English.

Information Sources

A comprehensive literature search was conducted across four electronic databases: PubMed, ScienceDirect, MedLine, and the Cochrane Library. The search retrieved 226 records from PubMed, 899 from ScienceDirect, 372 from MedLine, and 53 from the Cochrane Library. No publication date restrictions were applied, and the search included all literature available up to the date of screening.

Search Strategy and Study Selection

The search strategy combined Medical Subject Headings (MeSH) and relevant free-text terms such as “punctal plugs”, “dry eye”, “epiphora”, “lacrimal occlusion”, “ocular surface”, “punctal occlusion”, “tear drainage disorders”, “dry eye syndrome”, “efficacy”, “symptoms relief”, “tear stability”, and “ocular surface health”. Boolean operators (AND, OR) were employed to combine search terms, and the strategy was adapted according to each database's indexing system. Because punctal occlusion is clinically used to modify tear retention and drainage, studies evaluating its use in both dry eye disease and epiphora were considered eligible despite the differing underlying pathophysiology of these conditions. 1550 articles were screened by title and abstract resulting in the exclusion of 1515 records. Full-text versions of 35 articles were retrieved for further assessment, and 14 studies met the inclusion criteria and were included in the final review. Two reviewers independently conducted the screening and selection process, resolving any discrepancies through discussion and consensus.

Data Collection

Data extraction was carried out independently by two reviewers using a standardized data collection form. The extracted information included the author's name, year of publication, country, study design (RCT or non-randomized), sample size, patient demographics (age and gender), details of comparison groups, indications for punctal plug use (dry eye or epiphora), type and material of the plug, duration of follow-up, and measured outcomes such as symptom improvement, tear film parameters, plug retention, and adverse events. When reported, the number of eyes rather than the number of participants was used as the unit of analysis.

Risk of Bias Assessment and Critical Appraisal

The risk of bias in randomized controlled trials was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool, which evaluates five domains: the randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results ([supplementary Figure1](#)).¹⁵ For non-randomized studies, the ROBINS-I tool was used to assess bias across seven domains: confounding, participant selection, intervention classification, deviations from intended interventions, missing data, outcome measurement, and selective reporting ([supplementary Figure2](#)).¹⁶ For case-series, Joanna Briggs Institute's (JBI) Critical appraisal checklist was used ([supplementary Table1](#)).¹⁷ Each study was independently evaluated by two reviewers, and any conflicts were resolved through discussion or with the involvement of a third reviewer.

Synthesis and Statistical Analysis

Quantitative data were analyzed using Review Manager (RevMan) version 5.4 (Cochrane Collaboration). Meta-analyses were conducted using a random-effects model to account for potential heterogeneity among studies. Statistical significance was determined at the $P < 0.05$, threshold, and pooled outcomes were presented with 95% confidence intervals (CIs). Heterogeneity was assessed using the I^2 statistic; values exceeding 50% indicate moderate to substantial heterogeneity. Forest plots were generated using the number of eyes as the unit of analysis, in line with the reporting in the included studies. Subgroup analyses were performed where data permitted; however, their interpretation was limited due to the small number of studies in certain categories, a limitation discussed further in the Discussion section.

Results

Systematic search initially identified 1550 potential studies across four databases: PubMed (n=226), ScienceDirect (n=899), MEDLINE (n=372), and the Cochrane Library (n=53). After a thorough process of removing duplicate papers and a rigorous eligibility assessment, 1515 studies were deemed ineligible for inclusion, leading to the final inclusion of 14 studies in accordance with the predetermined criteria ([Figure 1](#)).

Study Characteristics

The final set of included studies consisted of a diverse range of study designs, encompassing six randomized controlled trials (RCTs), four retrospective cohort studies, and four prospective or interventional case series. In total, these studies incorporated a collective sample of 1537 participants and 1155 eyes. In several studies, clinical outcomes were reported per eye rather than per participant, meaning that both eyes from some participants were included in the analysis. This approach may introduce inter-eye correlation, and therefore the results were interpreted with caution. The reported number of analyzed eyes may also represent an underestimate, as two included studies, Louis Tong et al and Rohan Bir Singh et al, did not clearly specify whether outcomes were reported for one eye or both eyes of enrolled participants, nor did they provide the exact number of eyes analyzed.¹⁰⁻¹⁸ Consequently, the precise unit of analysis could not be fully determined for these studies. This limitation has been acknowledged and considered. Among these, the majority underwent punctal plug implantation, with silicone and collagen plugs being the most commonly used types ([Table 1](#)).

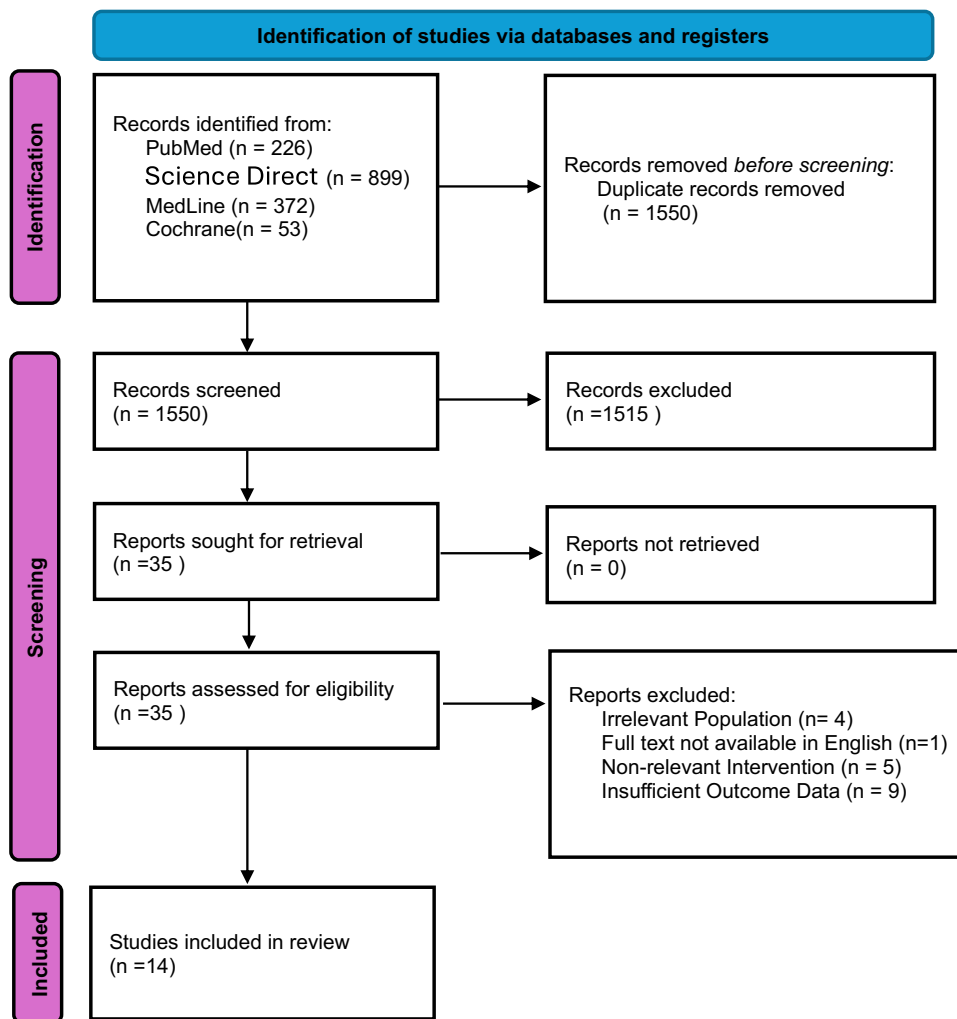


Figure 1 PRISMA for screening and selection of included studies.

Tear Film Break-Up Time (TFBUT)

Four studies reported comparative data on tear film break-up time between punctal plug groups and control groups and were included in the meta-analysis (Figure 2). Where reported in the original studies, control groups consisted of either contralateral untreated eyes or separate control participants. However, not all studies have specified the structure of the control group. The pooled analysis demonstrated no statistically significant difference between the punctal plug and control groups (WMD = 0.37; 95% CI: -0.94 to 1.67; $p = 0.58$). However, substantial heterogeneity was observed among studies ($I^2 = 85\%$). The subgroup analysis based on follow-up duration revealed no statistically significant difference at either less than 3 months (WMD = 1.20; 95% CI: -1.23 to 3.64; $p = 0.33$) or after 3 months follow-up (WMD = -0.24; 95% CI: -0.97 to 0.49; $p = 0.53$) (Figure 3).

In addition to the comparative data, six studies provided within group, pre and post punctal plug data on TFBUT (Table 2). These studies consistently reported statistically significant improvements following punctal plug insertion. For instance, S. Yaguchi et al (2012) reported an increase in TFBUT from 2.6 ± 1.2 seconds at baseline to 8.1 ± 2.8 seconds post-intervention ($p = 0.002$).²² Similarly, Emii Ohba et al (2011) observed an improvement from 1.3 ± 1.1 seconds to 4.6 ± 2.4 seconds ($p < 0.0001$), and Ricardo Holzchuh et al (2011) reported an increase from 1.19 ± 1.68 to 2.49 ± 1.98 seconds ($p = 0.006$).^{21,28}

Table 1 Study Characteristics

Study ID	Study Type	Sample Size			Number of Eyes		
		Punctal	Comparator	Total	Punctal	Comparator	Total
MINI BALARAM (2001) ¹⁹	Retrospective cohort	50	NR	50	100	NR	100
Justin C Sherwin MPhil FRANZCO (2018) ²⁰	Randomized controlled trial	48	48	48	96	96	96
Ricardo Holzchuh (2011) ²¹	Non comparative interventional case series	19	NR	19	37	NR	37
S Yaguchi (2012) ²²	Interventional case series study	10	NR	10	14	NR	14
Yvonne Wang (2021) ²³	Retrospective cohort	80	NR	80	171	NR	171
Rohan Bir Singh (2020) ¹⁰	Retrospective cohort	864	NR	864	NR	NR	NR
Dieter Franz Rabensteiner (2013) ²⁴	Prospective, randomized, single blind, clinical study	15	15	30	30	30	60
Ming-Cheng Tai (2001) ²⁵	Retrospective cohort	153	NR	153	203	NR	203
Yang Hao Yung (2012) ⁹	Prospective	9	9	18	13	15	28
Louis Tong (2016) ¹⁸	Prospective Randomized Trial	29	NR	29	58	NR	NR
Kazunori Miyata (2006) ²⁶	Prospective noncomparative interventional case series	28	NR	28	52	NR	52
Rana Altan-Yaycioglu (2005) ²⁷	Prospective Randomized Trial	11	13	24	22	26	48
Emih Ohba (2011) ²⁸	Prospective, interventional case series	28	NR	28	44	NR	44
Packer et al (2024) ²⁹	Prospective double-masked RCT	103	54	156	198	104	302

Schirmer Test

Three studies provided comparative data on Schirmer test scores and were included in the meta-analysis (Figure 4). The pooled analysis showed no statistically significant difference between punctal plug and control groups (WMD = 0.61;

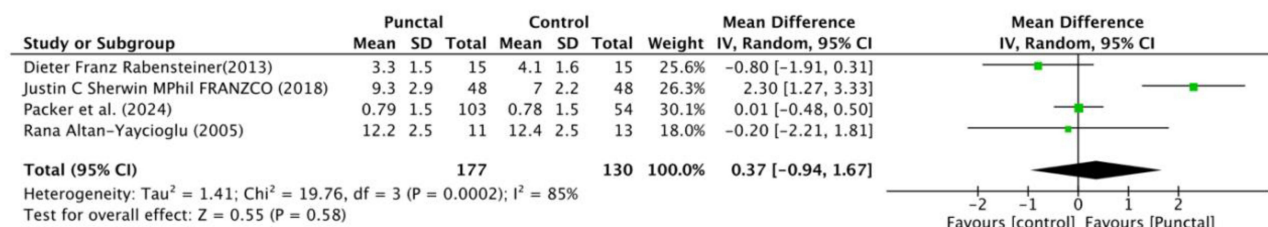


Figure 2 Forest plot for Tear film break up time (TFBUT). Forest plot comparing the mean change in TFBUT between the intervention and the control group. Each green square represents the effect estimate for an individual study, and the size of the square reflects the weight assigned to that study in the meta-analysis. Horizontal lines indicate the 95% confidence intervals (CIs). The vertical line represents no effect between groups. The pooled overall effect (fixed/random effects model) demonstrated a significant improvement in TFBUT in the intervention group compared with the control group. Statistical heterogeneity among studies was assessed using the Chi² test and I² statistic.

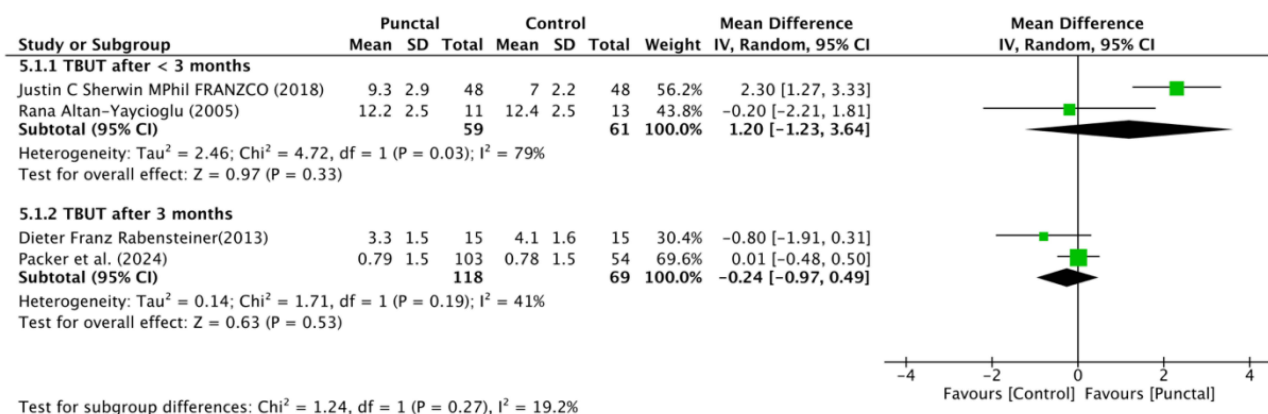


Figure 3 Forest plot for Tear film break up time (subgroup analysis). Subgroup analysis evaluating the effect of the intervention on TFBUT at different follow-up time points. Studies were grouped according to follow-up duration. Each square represents an individual study and the pooled effect within each subgroup is shown as a diamond. The analysis allows comparison of treatment effects across different follow-up periods and helps assess the consistency of the intervention effect over time.

Table 2 Tear Film Break up Time (TFBUT)

Study ID		TFBUT (sec)		P value
		Baseline	Post Punctal Plug	
Ricardo Holzchuh (2011) ²¹	Non oGVHD oGVHD	1.19± 1.68	2.49± 1.98	P = 0.006
S Yaguchi (2019) ²²		2.6± 1.2	8.1± 2.8	P = 0.002
Rohan Bir Singh (2020) ¹⁰		4.42± 4.13	6.54± 4.15	P = 0.0014
Louis Tong (2016) ¹⁸		3.75± 1.94	4.95± 0.72	P = 0.018
Kazunori Miyata (2006) ²⁶		2.2± 0.6	2.42± 0.76	Non significant
Emii Ohba (2011) ²⁸		2.4± NR	3.8± NR	P < 0.0001
		1.3± 1.1	4.6± 2.4	P < 0.0001

Abbreviations: oGVHD, Ocular Graft-Versus-Host Disease; NR, Not reported.

95% CI: -0.96 to 2.18; p = 0.45). Subgroup analyses based on different follow-up duration showed no significant differences at less than 3 months (WMD = -0.19; 95% CI: -0.84 to 0.46; p = 0.57) and at 3 months it showed a borderline improvement favoring punctal plugs, though this did not reach statistical significance (WMD = 1.72; 95% CI: -0.04 to 3.48; p = 0.05). However, a statistically significant improvement favoring punctal plug insertion was observed at 6 months follow-up (WMD = 2.00; 95% CI: 0.32 to 3.68; p = 0.02), moderate heterogeneity was noted (Figure 5).

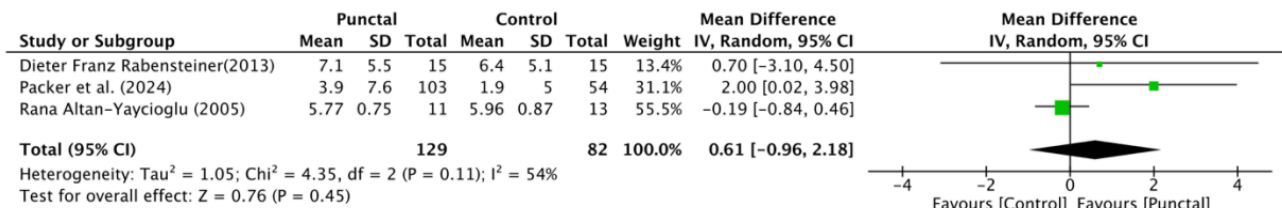


Figure 4 Forest plot for Schirmer test. Forest plot comparing the mean change in Schirmer test results between intervention and control groups. Each green square indicates the mean difference for an individual study with its corresponding weight in the meta-analysis. Horizontal lines represent the 95% confidence intervals. The diamond represents the pooled mean difference with its 95% CI. The pooled analysis indicates an overall improvement in tear production in the intervention group compared with the control group. Heterogeneity among studies was evaluated using the Chi² test and the I² statistic.

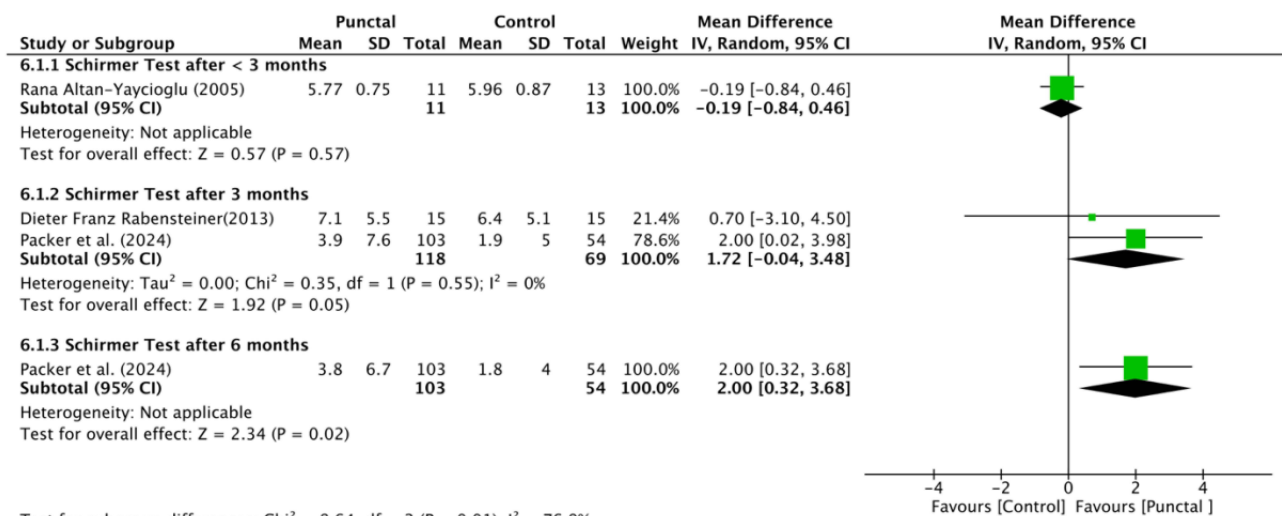


Figure 5 Forest plot for Schirmer test (subgroup analysis). Forest plot showing subgroup analysis of Schirmer test outcomes according to follow-up duration. Individual study results are presented as squares with corresponding 95% confidence intervals. The pooled estimates within each subgroup are represented by diamonds, illustrating the overall effect at different follow-up time points.

Table 3 Schirmer Test Score

Study ID		Schirmer Test (mm)		P value
		Baseline	Post Punctal Plug	
Ricardo Holzchuh (2011) ²¹	Non oGVHD oGVHD	2.7± 2.55	8.92± 7.2	P < 0.0001
S Yaguchi (2019) ²²		1.9± 2.1	6.3± 2.6	P = 0.002
Rohan Bir Singh (2020) ¹⁰		5.41± 4.96	6.59± 2.35	P = 0.014
Louis Tong (2016) ¹⁸		NR	NR	NR
Emii Ohba (2011) ²⁸		5.1± 2.8	6.3± 5.11	Non significant
		2.6± 3.9	6± 5.3	P = 0.0003

Abbreviations: oGVHD, Ocular Graft-Versus-Host Disease; NR, Not reported.

Additionally, significant improvements in tear production were consistently observed following punctal plug placement in five studies (Table 3). Ricardo Holzchuh et al (2011) reported a significant increase from 2.7 ± 2.55 mm at baseline to 8.92 ± 7.2 mm post-intervention ($p < 0.0001$).²¹ Similarly, S. Yaguchi et al (2019) documented improvement from 1.9 ± 2.1 mm to 6.3 ± 2.6 mm ($p = 0.002$), while Emii Ohba et al (2011) showed an increase from 2.6 ± 3.9 mm to 6 ± 5.3 mm ($p = 0.0003$).^{22,28}

Corneal Fluorescence Staining

Two studies reported comparative data on corneal fluorescein staining scores and were included in the meta-analysis. The pooled analysis showed no statistically significant difference between groups (WMD = -0.38 ; 95% CI: -0.92 to 0.16 ; $p = 0.17$). (Figure 6).

Six studies have showed significant results after punctal plug insertion (Table 4). Ricardo Holzchuh et al (2011) reported a significant decrease in corneal staining scores from 4.08 ± 2.53 at baseline to 2.73 ± 0.074 post intervention ($p = 0.003$).²¹ S. Yaguchi et al (2019) observed a reduction from 6.1 ± 1.1 to 1.3 ± 0.8 ($p = 0.002$), and Emii Ohba et al (2011) showed improvement from 4.5 ± 2.8 to 1.1 ± 1.7 ($p < 0.0001$).^{22,28}

Rose Bengal Staining

The pooled analysis demonstrated no statistically significant difference between the two groups (WMD = -0.18 ; 95% CI: -0.75 to 0.40 ; $p = 0.55$). (Figure 7).

Three studies provided reported a significant decrease in staining after punctal insertion (Table 5). Ricardo Holzchuh et al (2011) showed a decrease in staining from 4.95 ± 2.73 at baseline to 3.16 ± 1.8 post-intervention ($p = 0.0002$).²¹ Similarly, S. Yaguchi et al (2019) observed a reduction from 5.6 ± 1.5 to 2.1 ± 2.0 ($p = 0.002$), and Emii Ohba et al (2011) reported an improvement from 4.4 ± 2.7 to 2.4 ± 1.6 ($p = 0.02$).²⁸

Adverse Events

Adverse events associated with punctal plug insertion were reported in five studies (Table 6). The most frequently reported complications included ocular discomfort ($n = 778$), ocular redness ($n = 221$), ocular pain ($n = 112$), blurred vision ($n = 101$), and plug extrusion (total extrusion, $n = 103$; partial extrusion, $n = 5$). Other reported complications

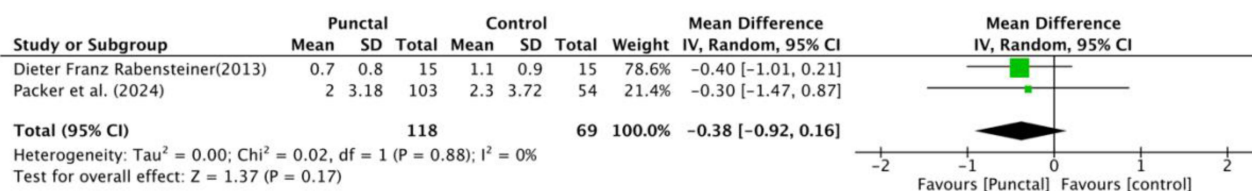


Figure 6 Forest plot for corneal Fluorescence Staining. Forest plot illustrating the comparison of fluorescein staining scores between the intervention and control groups. Each square corresponds to the effect size from an individual study, while the horizontal lines indicate the 95% confidence intervals. The pooled effect estimate suggests a reduction in fluorescein staining scores in the intervention group, indicating improvement in ocular surface integrity. The overall pooled effect and heterogeneity statistics are presented.

Table 4 Corneal Fluorescein Staining

Study ID		Corneal Fluorescein Staining		P value	
		Baseline	Post Punctal Plug		
Ricardo Holzchuh (2011) ²¹	Non oGVHD	4.08± 2.53	2.73± 0.074	P = 0.003	
S Yaguchi (2019) ²²		6.1± 1.1	1.3± 0.8	P = 0.002	
Rohan Bir Singh (2020) ¹⁰		5.99± 3.64	4.02 ± 2.87	P < 0.0001	
Emii Ohba (2011) ²⁸		oGVHD	7.29± 2.15	5.71 ± 1.36	P = 0.0035
Ming-Cheng Tai (2001) ²⁵		4.5± 2.8	1.1± 1.7	P < 0.0001	
Louis Tong (2016) ¹⁸		2.7± 0.1	1.3± 0.1	P < 0.01	
	Central	1.0± 1.0	0.57± 0.73	P < 0.01	
	Nasal	0.7± 0.9	0.41± 0.84	P < 0.01	
	Temporal	0.7± 1.0	0.36± 0.74	P < 0.01	
	Superior	0.6± 0.9	0.48± 0.62	P < 0.01	
	Inferior	1.3± 1.0	1.22 ±0.85	P = 4.42	

Abbreviations: oGVHD, Ocular Graft-Versus-Host Disease.

included epiphora, subconjunctival hemorrhage, conjunctival erosion, temporary eyelid pain, blepharitis, procedural pain, temporary swelling, and plug fragmentation. Most adverse events were mild and resolved spontaneously or required minimal intervention.

Discussion

This systematic review of 14 studies involving 1567 participants, punctal occlusion (via silicone or collagen plugs, SmartPlugs, or thermal/surgical cautery) demonstrated variable outcomes across standard dry eye metrics.

Comparative meta-analyses revealed no significant improvements in tear film break-up time (TFBUT) or Schirmer test values compared with control groups, reflecting high inter-study heterogeneity, small sample sizes, and inconsistent protocols. However, within-group pre–post analyses consistently showed significant enhancements in both TFBUT and tear production, indicating potential individual-level benefits. These within-group improvements should nonetheless be interpreted with caution, as they are susceptible to placebo effects, regression to the mean, and the influence of concomitant treatments, all of which may contribute to apparent gains independent of the intervention itself. In contrast, corneal fluorescein staining scores were markedly improved in patients receiving punctal occlusion (mean difference ≈ -0.47; p < 0.00001), with substantial reductions documented at both short- and longer-term follow-up. This supports the notion that punctal occlusion meaningfully enhances ocular surface integrity. Although pooled analysis of Rose Bengal staining did not demonstrate significant changes, descriptive pre- and post-data consistently suggested clinical benefits that may not be captureable in aggregated metrics.

The observations align with previous reviews: Ervin et al concluded that evidence for plug efficacy remains inconclusive due to study limitations, although some ocular surface improvements were noted,³⁰ and the more recent review by Chen et al (2025) reported moderate-to-high certainty evidence supporting substantial gains in TFBUT, Schirmer scores, symptom relief, and staining, with high retention and low heterogeneity.³¹ Notably, punctal

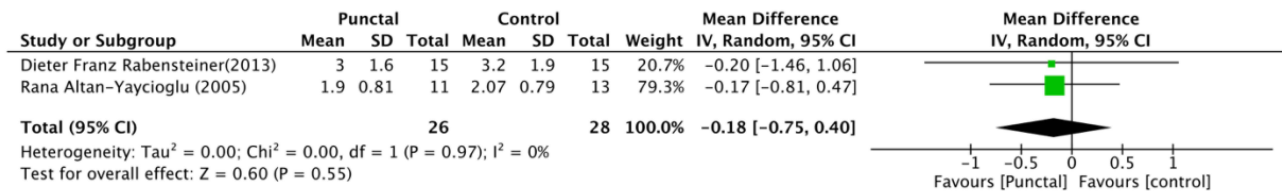


Figure 7 Forest plot for Rose bengal staining. Forest plot comparing Rose Bengal staining scores between intervention and control groups. Each green square represents the mean difference for an individual study, and the size reflects the relative study weight. Horizontal lines indicate the 95% confidence intervals. The pooled diamond shows the overall effect estimate. The analysis suggests a decrease in staining scores in the intervention group compared with the control group, indicating improvement in ocular surface damage.

Table 5 Rose Bengal Staining

Study ID	Rose Bengal Staining		P value
	Baseline	Post Punctal Plug	
Ricardo Holzchuh (2011) ²¹	4.95± 2.73	3.16± 1.8	P =0.0002
S Yaguchi (2019) ²²	5.6± 1.5	2.1± 2.0	P = 0.002
Emii Ohba (2011) ²⁸	4.4± 2.7	2.4± 1.6	P = 0.02

Table 6 Summary of Adverse Events

Study ID	Sample Size	Adverse Events Event (n)
Yvonne Wang (2021) ²³	80	Temporary pain and swelling (3)
Rohan Bir Singh (2020) ¹⁰	864	Ocular discomfort (778)
		Blurred vision (101)
		Ocular redness (221)
		Ocular pain (112)
Ming-Cheng Tai (2001) ²⁵	153	Total extrusion (103)
		Partial extrusion (5)
		Epiphora (12)
		Subconjunctival hemorrhage (4) Conjunctival erosion (3) Fragmentation of plug (1)
Emii Ohba (2011) ²⁸	28	Epiphora (1)
Packer et al (2024) ²⁹	157	Eyelid pain (6)
		Epiphora (11)
		Blepharitis (3)
		Procedural pain (10)

cautery, especially with high-heat devices, has shown low recanalization (<2%) and robust improvements in objective and subjective outcomes, as in Ohba et al (2011)²⁸ and Yaguchi et al (2012) demonstrated positive outcomes in chronic GVHD patients.²² A broader review of thermal/surgical methods further confirmed gains in tear volume and stability, with recanalization rates up to 39%.³²

Adverse events were generally mild and transient, including ocular discomfort, redness, pain, blurred vision, and plug extrusion without serious or vision-threatening complications reported, which is consistent with findings from Ervin et al.³⁰

Limitations of this review include the predominance of nonrandomized, small-scale, and open-label designs; inconsistent definitions of outcomes; substantial heterogeneity in interventions and patient populations; and reliance on pre-post studies lacking controls. These factors limit the ability to draw definitive conclusions about comparative efficacy. Clinically, punctal occlusion appears to offer ocular surface benefits and symptomatic relief, particularly for moderate-to-severe aqueous-deficient dry eye (eg, Sjögren's, GVHD), and may serve as a valuable adjunct to conventional therapies. Permanent cautery may be preferable in cases of recurrent plug extrusion.

Conclusion

Though comparative meta-analysis did not show statistically significant improvements in tear production or film stability, punctal occlusion, especially thermal/surgical approaches, demonstrated consistent ocular surface and symptomatic benefits when assessed within individuals and had favorable safety profiles. Permanent cautery provides durable occlusion with low recanalization rates, though recanalization remains a risk even with single-use devices. Future research should prioritize large-scale, blinded RCTs with standardized interventions and outcomes, including robust patient-reported measures and long-term follow-up.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article.

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Disclosure

The authors declare that have no competing interest in this work.

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