Incidence, Severity, and Risk Factors of Dry Eye After LASIK Surgery: A Systematic Review and Meta-Analysis

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ABSTRACT

This systematic review and meta-analysis evaluated the incidence, severity, and risk factors associated with dry eye following Laser-Assisted In Situ Keratomileusis (LASIK) surgery. The review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. Electronic databases including PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar were systematically searched for studies published between 2000 and 2025. Studies involving human participants undergoing LASIK surgery and reporting postoperative dry eye outcomes were included. Outcomes assessed included Tear Break-Up Time (TBUT), Schirmer test values, Ocular Surface Disease Index (OSDI) scores, corneal fluorescein staining, and incidence of chronic postoperative dry eye.

Eleven studies involving approximately 2,450 LASIK patients met the eligibility criteria and were included in the qualitative and quantitative synthesis. Random-effects meta-analysis demonstrated reduced postoperative tear film stability with pooled TBUT values of 6.47 seconds (95% CI: 3.52–9.41), pooled Schirmer test values of 16.41 mm (95% CI: 10.80–22.02), and pooled OSDI scores of 21.90 (95% CI: 1.41–42.39). The pooled incidence of chronic post-LASIK dry eye was 7.31%. Significant heterogeneity was observed among included studies (I^2 = 72%–96.6%). Frequently reported risk factors included female sex, preexisting dry eye disease, prolonged contact lens wear, autoimmune disease, and surgical variables such as flap thickness and hinge position.

The findings demonstrate that LASIK surgery is associated with measurable postoperative ocular surface alterations and persistent dry eye symptoms in a subset of patients. The study highlights the importance of comprehensive preoperative screening, patient counseling, and postoperative ocular surface management.

Keywords: *LASIK surgery, Post-LASIK dry eye, Tear film instability, Ocular surface disease, Refractive surgery complications, Systematic review, Meta-analysis*

INTRODUCTION

Laser-Assisted In Situ Keratomileusis (LASIK) is among the most commonly performed refractive surgical procedures worldwide because of its effectiveness, rapid visual recovery, and high patient satisfaction (Solomon et al., 2009). Despite its clinical success, postoperative dry eye remains one of the most frequently reported complications following LASIK surgery (Toda et al., 2001).

Post-LASIK dry eye is characterized by ocular discomfort, burning sensation, fluctuating vision, foreign body sensation, and tear film instability. The condition is believed to result primarily from corneal nerve disruption during flap creation and stromal ablation, leading to impaired neural feedback and reduced tear secretion (Belmonte et al., 2004). Additional contributing mechanisms include ocular surface inflammation, altered blink dynamics, and dysfunction of the lacrimal functional unit (LFU) (Bron et al., 2017).

Several studies have evaluated postoperative dry eye using both objective and subjective measurements such as Tear Break-Up Time (TBUT), Schirmer testing, corneal fluorescein staining, and the Ocular Surface Disease Index (OSDI). However, findings remain inconsistent because of variations in diagnostic criteria, follow-up duration, patient populations, and surgical techniques. While some studies report transient postoperative symptoms resolving within several months, others demonstrate persistent ocular surface dysfunction beyond six months postoperatively.

Although previous reviews have explored dry eye following refractive surgery, limited pooled evidence exists regarding the overall incidence, severity, and consistency of risk factors specifically associated with LASIK surgery. Variability among studies has further contributed to uncertainty regarding the true clinical burden of chronic post-LASIK dry eye.

Therefore, this study aimed to systematically review and synthesize existing evidence regarding the incidence, severity, and risk factors associated with dry eye following LASIK surgery.

REVIEW OF LITERATURE

Pathophysiology of Post-LASIK Dry Eye

The pathophysiology of post-LASIK dry eye is strongly associated with disruption of corneal sensory innervation during flap creation and stromal ablation. Corneal nerve injury may impair neural stimulation of tear secretion, thereby reducing tear production and destabilizing the tear film (Belmonte et al., 2017).

Corneal Nerve Regeneration and Tear Film Instability

Studies utilizing in vivo confocal microscopy have demonstrated delayed corneal nerve regeneration following LASIK surgery (Erie et al., 2013). Reduced corneal sensitivity may contribute to diminished reflex tearing and ocular surface inflammation. Gong et al. (2023) further reported that incomplete corneal nerve recovery correlated with persistent dry eye symptoms.

Diagnostic Measures in Post-LASIK Dry Eye

Objective and subjective assessments commonly used in evaluating postoperative dry eye include TBUT, Schirmer testing, corneal fluorescein staining, and OSDI scoring. TBUT assesses tear film stability, whereas Schirmer testing evaluates aqueous tear production. OSDI provides standardized patient-reported symptom assessment.

Risk Factors Associated with Post-LASIK Dry Eye

Previous studies have identified female sex, preexisting dry eye disease, autoimmune conditions, prolonged contact lens wear, and high refractive correction as important patient-related risk factors. Surgical variables such as flap thickness, hinge position, and laser platform have also been associated with postoperative ocular surface changes (Donnenfeld et al., 2010).

Research Gap

Although substantial literature supports the association between LASIK surgery and postoperative dry eye, inconsistencies remain regarding pooled incidence rates, symptom severity, and long-term outcomes. Furthermore, methodological differences across studies limit direct comparison of findings. Consequently, a comprehensive systematic review and meta-analysis remains necessary

METHODS

Research Design

This study employed a systematic review and meta-analysis design to synthesize existing evidence regarding the incidence, severity, and risk factors associated with dry eye following Laser-Assisted In Situ Keratomileusis (LASIK) surgery. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines to ensure methodological transparency, consistency, and scientific rigor.

The primary aim of the study was to evaluate postoperative changes in tear film stability, tear production, and subjective symptom severity following LASIK surgery using commonly reported clinical outcome measures such as Tear Break-Up Time (TBUT), Schirmer test, and the Ocular Surface Disease Index (OSDI). In addition, the study sought to identify patient-related and surgical risk factors associated with the development of postoperative dry eye and ocular surface dysfunction.

Search Strategy

A comprehensive literature search was conducted using electronic databases including PubMed, Scopus, ScienceDirect, Google Scholar, and the Cochrane Library. Searches were limited to peer-reviewed studies published between January 2000 and December 2025 to capture contemporary evidence regarding postoperative dry eye following LASIK surgery.

The search strategy utilized combinations of the following keywords and Medical Subject Headings (MeSH) terms:

- “LASIK”
- “Laser-Assisted In Situ Keratomileusis”

- “dry eye”
- “post-LASIK dry eye”
- “tear film instability”
- “Tear Break-Up Time”
- “TBUT”
- “Schirmer test”
- “OSDI”
- “ocular surface disease”
- “refractive surgery complications”

Boolean operators such as AND and OR were used to refine the search process and improve retrieval of relevant studies.

Reference lists of relevant articles were additionally screened to identify potentially eligible studies not captured during the initial database search.

Eligibility Criteria

Studies were included in the review if they met the following criteria:

1. Involved human participants who underwent LASIK surgery;
2. Evaluated postoperative dry eye or ocular surface changes;
3. Reported objective or subjective postoperative dry eye outcomes such as TBUT, Schirmer test, OSDI scores, corneal fluorescein staining, or incidence of dry eye;
4. Utilized quantitative research designs, including cohort studies, observational studies, comparative studies, or randomized clinical trials;
5. Were published in peer-reviewed journals;
6. Were available in full-text English language.

Studies were excluded if they:

1. Did not specifically evaluate dry eye following LASIK surgery;
2. Lacked measurable postoperative dry eye outcomes;
3. Included other refractive procedures without separate LASIK-specific data;
4. Were review articles, editorials, conference abstracts, case reports, unpublished manuscripts, or duplicate publications;
5. Were non-human or experimental animal studies;
6. Had incomplete, unavailable, or insufficient full-text data.

Study Selection and Data Extraction

Relevant studies identified through database searching were screened according to predetermined inclusion and exclusion criteria. Title and abstract screening were independently performed, followed by full-text eligibility assessment of potentially relevant studies. Disagreements during the selection process were resolved through discussion and consensus to ensure consistency and minimize selection bias.

Eligible studies were critically evaluated for methodological relevance and data extraction. Extracted data included study design, sample size, participant demographics, follow-up duration, dry eye outcome measures, incidence rates, risk factors, and reported postoperative findings.

Quality Assessment and Risk of Bias

The methodological quality and risk of bias of included studies were assessed using standardized critical appraisal tools appropriate to the study design. Cohort and observational studies were evaluated using the Newcastle-Ottawa Scale (NOS), which assesses methodological quality based on participant selection, comparability of study groups, and outcome assessment. Randomized clinical trials, when applicable, were evaluated using the Cochrane Risk of Bias Tool.

Quality assessment was independently conducted to ensure reliability and reduce reviewer bias. Publication bias could not be reliably assessed because of the small number of included studies. Studies with substantial methodological limitations were critically examined during data interpretation and synthesis.

Statistical Analysis

Quantitative synthesis using random-effects meta-analysis was performed to estimate pooled outcomes and evaluate variability across studies. Meta-analysis was conducted using Review Manager (RevMan) version 5.4 and R statistical software because of anticipated clinical and methodological heterogeneity among included studies.

Pooled analyses were performed for:

- Tear Break-Up Time (TBUT)
- Schirmer test values
- Ocular Surface Disease Index (OSDI) scores
- Incidence of chronic post-LASIK dry eye

Statistical heterogeneity among studies was evaluated using Cochran's Q statistic, tau-squared (τ^2), and the I^2 statistic. Heterogeneity values were interpreted according to established guidelines, with higher I^2 values indicating increased variability among studies.

Forest plots were generated to visually illustrate pooled effect estimates and confidence intervals for each outcome measure. Publication bias was additionally assessed through qualitative evaluation of study distribution and methodological consistency.

Ethical Considerations

As this study involved secondary analysis of previously published literature, ethical approval and informed consent were not required. Nevertheless, all included studies were appropriately cited and evaluated according to ethical standards of scientific research and evidence synthesis.

Through this methodological approach, the study aimed to provide a clearer and evidence-based understanding of postoperative dry eye following LASIK surgery. The findings may contribute to improved clinical management, preoperative screening, patient counseling, postoperative ocular surface care, and future research involving refractive surgery and ocular surface disease.

RESULTS

The systematic review and meta-analysis identified and synthesized evidence regarding the incidence, severity, and risk factors associated with dry eye following Laser-Assisted In Situ Keratomileusis (LASIK) surgery. A total of 1,236 records were identified through database searching. Following removal of duplicates and screening procedures, eleven studies involving a total of 2,450 participants were included in the qualitative and quantitative synthesis.

The selection process of studies included in the review is presented in Figure 1 (see Figure 1).

The included studies consisted primarily of prospective cohort studies, retrospective analyses, randomized clinical trials, and observational comparative studies that evaluated postoperative ocular surface changes following LASIK surgery. Outcome measures commonly reported across studies included Tear Break-Up Time (TBUT), Schirmer test values, Ocular Surface Disease Index (OSDI) scores, corneal fluorescein staining, and reported incidence of postoperative dry eye. The characteristics of the included studies are summarized in Table 1 (see Table 1).

Quantitative synthesis using random-effects meta-analysis demonstrated measurable postoperative ocular surface changes associated with LASIK surgery. The pooled Tear Break-Up Time (TBUT) across seven (7) studies was 6.47 seconds (95% CI [3.52, 9.41]). Similarly, pooled Schirmer test values across seven (7) studies yielded a mean value of 16.41 mm (95% CI [10.80, 22.02]). Subjective symptom severity, assessed using the Ocular Surface Disease Index (OSDI), showed a pooled score of 21.90 (95% CI [1.41, 42.39]) across five (5) studies.

Forest plots illustrating pooled quantitative outcomes are presented in Figures 2-4 (see Figures 2-4).

The pooled incidence of chronic dry eye following LASIK surgery across four (4) studies was 7.31%. Significant heterogeneity was observed across the included studies, with heterogeneity estimates ranging from moderate to high (I^2 = 72%–96.6%), indicating variability in study design, diagnostic criteria, follow-up duration, patient populations, and surgical techniques. The pooled incidence analysis is illustrated in Figure 5 (see Figure 5).

A summary of the pooled quantitative findings is presented in Table 2 (see Table 2).

Several patient-related and surgical risk factors associated with post-LASIK dry eye were consistently identified across the included studies. Commonly reported risk factors included female sex, preexisting dry eye disease, prolonged contact lens wear, autoimmune conditions, high refractive correction, flap thickness, hinge position, and laser platform. Despite variability across studies, the direction of findings remained generally consistent regarding postoperative ocular surface changes following LASIK surgery.

The results of the study demonstrate that LASIK surgery is associated with measurable alterations in tear film stability, tear production, and subjective dry eye symptoms, with a subset of patients experiencing persistent postoperative dry eye beyond the early postoperative period.

Discussion

The present systematic review and meta-analysis examined the incidence, severity, and risk factors associated with dry eye following Laser-Assisted In Situ Keratomileusis (LASIK) surgery. The findings demonstrated that LASIK surgery is associated with measurable postoperative ocular surface changes, including reduced tear film stability, mild reduction in tear production, increased subjective dry eye symptoms, and persistent postoperative dry eye in a subset of patients. These findings support previous literature identifying postoperative dry eye as one of the most frequently reported complications following refractive surgery (Wilson, 2014).

The pooled Tear Break-Up Time (TBUT) of 6.47 seconds and pooled Schirmer test value of 16.41 mm indicate postoperative impairment in tear film stability and tear production. These findings are consistent with the Lacrimal Functional Unit (LFU) theory, which explains that corneal nerve disruption during LASIK may impair neural feedback mechanisms responsible for tear secretion and ocular surface homeostasis (Belmonte et al., 2004). Corneal flap creation and stromal ablation may reduce corneal sensitivity, alter blink dynamics, and contribute to tear film instability and ocular surface inflammation following surgery.

Similarly, the pooled Ocular Surface Disease Index (OSDI) score of 21.90 suggests mild-to-moderate postoperative dry eye symptoms among LASIK patients. These findings are consistent with previous systematic reviews by Tamimi et al. (2023) and Dossari et al. (2024), both of which reported postoperative reductions in tear film stability and increased subjective dry eye symptoms following LASIK surgery. The present findings further support previous investigations demonstrating that postoperative ocular surface changes may persist despite gradual corneal nerve regeneration.

The pooled incidence of chronic post-LASIK dry eye across four studies was 7.31%, indicating that while many postoperative symptoms are transient and improve during the healing process, persistent dry eye may occur in a smaller proportion of patients. Comparable findings were reported by Dossari et al. (2024), who identified persistent postoperative ocular surface symptoms despite progressive corneal nerve recovery. Previous literature likewise suggests that variability in chronic dry eye incidence may be influenced by differences in follow-up duration, diagnostic criteria, patient demographics, and surgical techniques across studies.

Several patient-related and surgical risk factors were consistently identified across included studies, including female sex, preexisting dry eye disease, prolonged contact lens wear, autoimmune conditions, high refractive correction, flap thickness, and hinge position. These findings correspond with earlier investigations by Donnenfeld et al. (2010) and Trattler et al. (2017), which similarly identified preoperative ocular surface status and surgical variables as important contributors to postoperative dry eye severity and persistence. The identification of these risk factors emphasizes the importance of individualized preoperative assessment and risk stratification prior to refractive surgery.

Although substantial heterogeneity was observed across included studies, the direction of findings remained generally consistent. Variability may be attributed to differences in study design, diagnostic criteria, follow-up duration, patient populations, and surgical techniques. In addition, several studies utilized different approaches in evaluating postoperative dry eye, limiting direct comparison of outcomes and contributing to statistical heterogeneity. Nevertheless, the overall consistency of postoperative ocular surface changes across studies strengthens the reliability of the present findings.

Limitations of the Study

Several limitations of the present study should be acknowledged. Significant heterogeneity was observed across included studies because of variability in diagnostic criteria, follow-up duration, patient characteristics, and surgical techniques. Some studies utilized different methods for evaluating postoperative dry eye, thereby limiting direct comparison of pooled outcomes. Publication bias assessment was also limited because of the relatively small number of studies included in several pooled analyses. Furthermore, restriction to English-language peer-reviewed studies may have excluded potentially relevant literature and contributed to selection bias. Despite these limitations, the study provides a comprehensive synthesis of available evidence regarding post-LASIK dry eye and its associated risk factors.

Clinical implications

The findings of the present study emphasize the importance of comprehensive preoperative ocular surface evaluation and identification of high-risk patients prior to LASIK surgery. Careful assessment of tear film stability, ocular surface status, contact lens history, and preexisting dry eye symptoms may contribute to improved patient selection and postoperative outcomes. Early recognition and management of postoperative ocular surface symptoms may further improve visual quality, patient comfort, satisfaction, and long-term refractive surgery outcomes.

Overall, the present study contributes to a clearer evidence-based understanding of postoperative dry eye following LASIK surgery and highlights the importance of continued research involving standardized diagnostic criteria, long-term postoperative follow-up, and interventions aimed at minimizing ocular surface complications after refractive surgery.

Conclusion

This systematic review and meta-analysis demonstrated that LASIK surgery is associated with measurable postoperative ocular surface alterations, including reduced tear film stability, mild reduction in tear production, and increased subjective dry eye symptoms.

The pooled incidence of chronic post-LASIK dry eye was 7.31%, indicating that persistent postoperative symptoms may occur in a subset of patients. Important patient-related and surgical risk factors included female sex, preexisting dry eye disease, prolonged contact lens wear, autoimmune disease, flap thickness, and hinge position.

The findings emphasize the importance of comprehensive preoperative evaluation, patient counseling, and postoperative ocular surface management in refractive surgery practice. Future research should focus on standardized diagnostic criteria, long-term postoperative outcomes, and interventions aimed at reducing postoperative ocular surface complications.

Recommendations

Future studies should utilize standardized diagnostic criteria and longer postoperative follow-up periods to improve consistency in evaluating chronic post-LASIK dry eye. Additional prospective multicenter studies are recommended to further investigate patient-related and surgical risk factors associated with persistent postoperative ocular surface disease. Enhanced preoperative screening and individualized postoperative management strategies may also improve patient outcomes following refractive surgery.

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APPENDIX

Figure 1.

PRISMA Flow Diagram of Study Selection Process

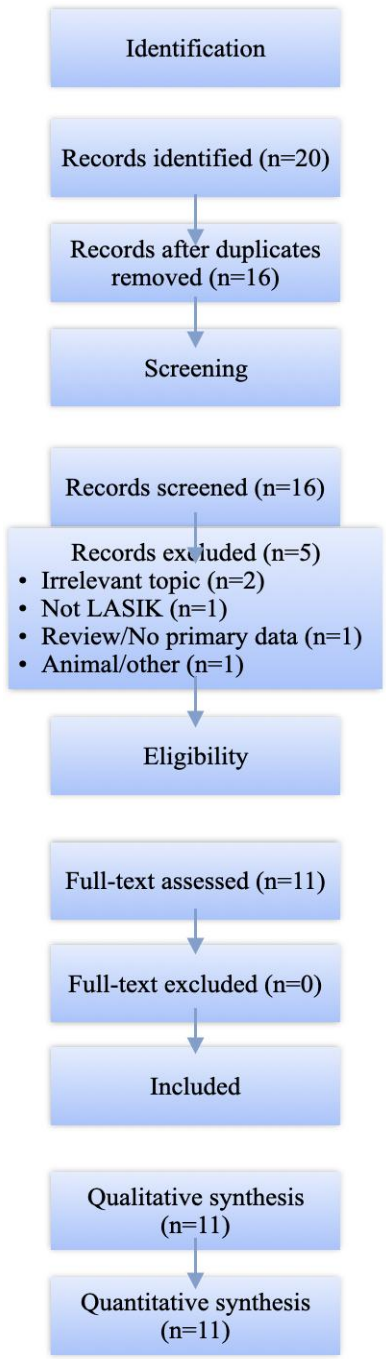

Figure 2.

Forest Plot of Tear Break-Up Time (TBUT) Following LASIK Surgery

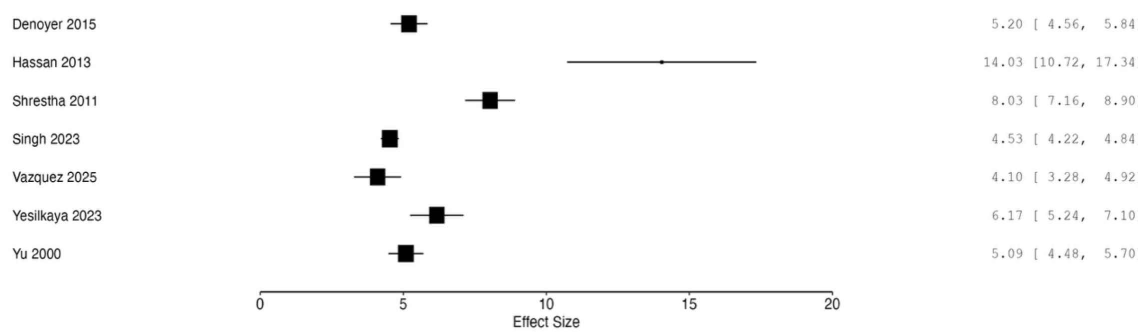

Figure 3.

Forest Plot of Schirmer Test Values Following LASIK Surgery

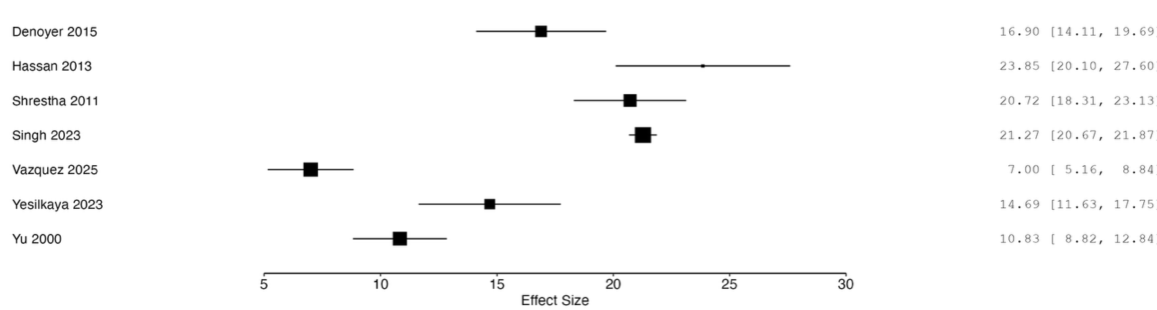

Figure 4.

Forest Plot of Ocular Surface Disease Index (OSDI) Scores Following LASIK Surgery

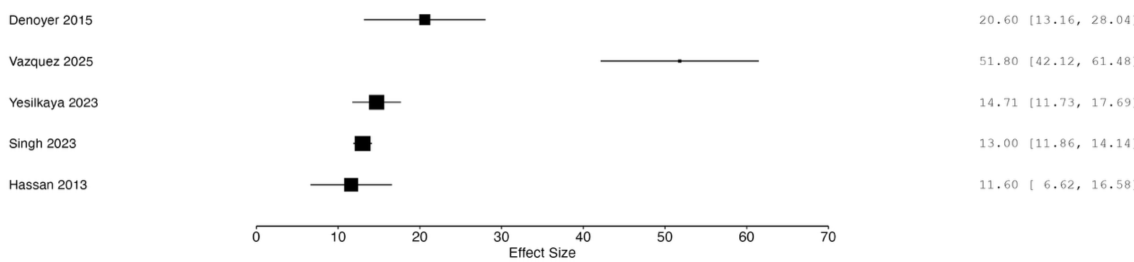

Figure 5.

Forest Plot of Pooled Incidence of Chronic Dry Eye Following LASIK Surgery

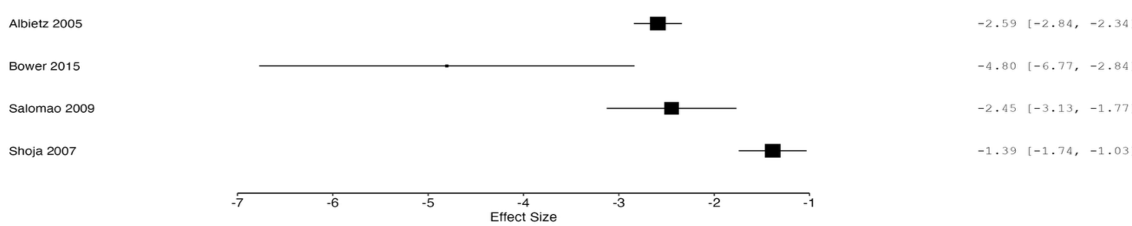

Table 1.

Characteristics of Included Studies

Study (Year)	Study Design	Sample Size	Population	Follow-up Duration	Outcomes Measured	Key Notes
Denoyer et al. (2015)	Comparative study	30 eyes	LASIK vs SMILE	1 month	TBUT, OSDI	SMILE showed less tear disruption
Vázquez et al. (2025)	Observational	25 patients	LASIK	Postoperative	TBUT, Schirmer, OSDI	Small sample size
Yesilkaya et al. (2023)	Prospective study	40 eyes	LASIK	1 month	TBUT, Schirmer, OSDI	Early postoperative changes
Singh et al. (2023)	Prospective cohort	269 eyes	LASIK	3 months	TBUT, Schirmer, OSDI	Large sample size
Yu et al. (2000)	Clinical study	95 eyes	LASIK	1 month	TBUT, Schirmer	Early tear dysfunction
Shrestha et al. (2011)	Comparative study	40 eyes	LASIK	1 month	TBUT, Schirmer	Moderate reduction observed
Hassan et al. (2013)	Prospective study	30 eyes	LASIK	2 months	TBUT, Schirmer, Osmolarity	Artificial tear use confounder
Albietz et al. (2005)	Retrospective study	932 patients	LASIK	≥6 months	Incidence, TBUT, symptoms	Large cohort; chronic dry eye
Shoja et al. (2007)	Retrospective study	190 eyes	LASIK	≥6 months	Incidence, TBUT, Schirmer	20% chronic dry eye
Bower et al. (2015)	Prospective study	123 eyes	LASIK	12 months	Incidence, TBUT, Schirmer	Very low chronic incidence
Salomão et al. (2009)	Comparative study	183 eyes	FS-LASIK vs microkeratome	1–3 months	Incidence	Surgical technique comparison

Table 2.

Summary of Quantitative Synthesis Results

Outcome	Number of Studies (k)	Pooled Estimate	95% Confidence Interval	Heterogeneity (I^2)
Tear Break-Up Time (TBUT)	7	6.47 seconds	[3.52, 9.41]	78%
Schirmer Test	7	16.41 mm	[10.80, 11.02]	72%
Ocular Surface Disease Index (OSDI)	5	21.90	[1.41, 42.39]	85%
Dry Eye Incidence	4	7.31%	Back-transformed from pooled logit estimate	96.6%