

Fifty Years of Lacrimal Drainage System Disease Research (1975–2025): A Systematic Review and Meta-Analysis of Obstructive, Inflammatory, and Neoplastic Disorders

Shweta Sajimon*, Niraj Kumar Yadav, Reshma Ragunath, Shivalika Thakur, Eesha Agarwal

Department of Ophthalmology, Dr KNS Memorial Institute of Medical Sciences, Barabanki, Uttar Pradesh, India.

Abstract

Background: Diseases of the lacrimal drainage system (LDS) encompass a broad spectrum of obstructive, inflammatory, and neoplastic disorders that impair tear outflow and may result in epiphora, recurrent infection, or orbital complications. Over the past five decades, substantial advances have been made in diagnostic imaging, surgical techniques, and understanding of disease pathophysiology.

Objective: To systematically evaluate the epidemiology, pathogenesis, diagnostic approaches, management strategies, and clinical outcomes of lacrimal drainage system disorders from 1975 to 2025.

Methods: A systematic review and meta-analysis were conducted in accordance with PRISMA 2020 guidelines. Electronic databases were searched for studies published between January 1975 and December 2025. Eligible studies included randomized controlled trials, cohort studies, case-control studies, and case series (≥ 10 patients) reporting outcomes of obstructive, inflammatory, or neoplastic LDS disorders. Random-effects meta-analysis was performed to calculate pooled success, recurrence, and complication rates.

Results: A total of 350 studies involving 26,670 patients were included, with 45 studies eligible for quantitative synthesis. Obstructive disorders demonstrated the highest pooled success rate (91.2%) and lowest recurrence (8.3%) and complication rates (6.5%). Inflammatory disorders showed slightly lower success (88.5%) and moderately higher recurrence (11.6%) and complications (9.8%). Neoplastic disorders exhibited significantly lower success (72.4%) and markedly higher recurrence (24.7%) and complication rates (18.2%). Advances in endoscopic surgery, imaging modalities, and adjunctive therapies have progressively improved outcomes.

Conclusions: Clinical outcomes in LDS disorders strongly correlate with underlying disease biology and therapeutic complexity. While obstructive disorders achieve excellent surgical success, inflammatory and neoplastic conditions remain challenging. Standardized reporting and prospective multicenter studies are warranted to further optimize management strategies.

Keywords: Lacrimal drainage system, Nasolacrimal duct obstruction, Dacryocystitis, Dacryocystorhinostomy, Lacrimal sac tumors, Systematic review, Meta-analysis, Recurrence, Complication rates, Ophthalmic surgery.

INTRODUCTION

Lacrimal drainage system (LDS) disorders represent a diverse group of conditions encompassing obstructive, inflammatory, infectious, congenital, and neoplastic pathologies that disrupt physiological tear outflow and result in epiphora, recurrent infection, or orbital complications. Over the past five decades, understanding of these disorders has evolved substantially, transitioning from primarily descriptive clinical observations

Address for correspondence: Shweta Sajimon,

Department of Ophthalmology, Dr KNS Memorial Institute of Medical Sciences, Barabanki, Uttar Pradesh, India.

E-mail: shwetasaaji@gmail.com

© UPIO, 2026 Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <https://creativecommons.org/licenses/by-nc-sa/4.0/>.



UP JOURNAL OF OPHTHALMOLOGY

An Official Journal of Uttar Pradesh State Ophthalmological Society,
UPSOS (Northern Ophthalmological Society, NOS)

p-ISSN: 2250-1916

DOI: 10.56692/upjo.2026140206

How to cite this article: Sajimon S, Yadav NK, Ragunath R, Thakur S, Agarwal E. Fifty Years of Lacrimal Drainage System Disease Research (1975–2025): A Systematic Review and Meta-Analysis of Obstructive, Inflammatory, and Neoplastic Disorders. UP Journal of Ophthalmology. 2026;14(2): 76-84.

Received: 02-06-2026, **Accepted:** 25-06-2026, **Published:** 01-08-2026

in the 1970s and 1980s to sophisticated clinicopathologic, ultrastructural, radiologic, and molecular analyses in recent years. Early clinicopathologic studies established primary acquired nasolacrimal duct obstruction (PANDO) as a distinct fibrotic entity characterized by chronic inflammation and mucosal remodeling rather than simple mechanical blockage.¹ Subsequent epidemiologic investigations between 1976 and 2000 demonstrated the significant incidence and public health burden of symptomatic acquired lacrimal outflow obstruction, particularly among older adults and women.² Histopathologic and immunologic research has progressively clarified the multifactorial nature of PANDO and secondary acquired lacrimal duct obstruction (SALDO), implicating chronic inflammation, hormonal influences, fibrosis, and environmental factors in disease pathogenesis.^{3,4} Electron microscopic and ultrastructural analyses further demonstrated epithelial alterations, subepithelial fibrosis, and vascular remodeling within the lacrimal sac and duct, suggesting that mucosal immune dysregulation plays a central role in chronic obstruction.⁵ These findings challenged earlier mechanical paradigms and reframed LDS disease as a dynamic inflammatory process. Advances in imaging have been pivotal in refining diagnosis and guiding management. Conventional dacryocystography, once the primary diagnostic modality, has largely been supplemented by cross-sectional imaging techniques including computed tomography (CT) and magnetic resonance imaging (MRI), which allow detailed visualization of lacrimal sac pathology, adjacent sinonasal structures, and neoplastic processes.^{6,7} Comprehensive radiologic reviews have underscored the importance of distinguishing inflammatory obstruction from granulomatous disease, systemic vasculitis, and malignant lesions.⁸ More recently, high-resolution optical coherence tomography (OCT) has enabled in vivo evaluation of punctal and canalicular microanatomy, facilitating earlier detection of proximal obstruction and structural abnormalities.⁹ Inflammatory disorders such as acute and chronic dacryocystitis remain among the most common clinical manifestations of distal obstruction, often resulting from nasolacrimal duct blockage and tear stasis.¹⁰ Recognition of systemic associations, including granulomatosis with polyangiitis, sarcoidosis, and syndromic congenital anomalies, has expanded the diagnostic framework beyond isolated ophthalmic disease. Congenital lacrimal drainage anomalies, once considered relatively benign and self-limiting, are now understood to have important syndromic correlations and variable natural histories requiring individualized management.¹¹ Neoplastic disease of the lacrimal drainage system, though rare, carries substantial morbidity and mortality. Reviews of epithelial and non-epithelial malignancies have emphasized the diagnostic challenge posed by their nonspecific presentation, frequently mimicking chronic dacryocystitis or benign obstruction.¹² Improved awareness and integration of imaging with endoscopic evaluation have significantly enhanced early detection and surgical planning. Therapeutically, the past fifty

years have witnessed refinement of dacryocystorhinostomy (DCR), development of endoscopic approaches, silicone intubation techniques, and adjunctive anti-fibrotic strategies.¹³ Meta-analytic comparisons have demonstrated high success rates for both external and endoscopic DCR while highlighting heterogeneity in outcome definitions and follow-up duration.¹⁴ Simultaneously, evolving understanding of pathophysiology has encouraged exploration of targeted medical therapies and minimally invasive interventions.

Despite substantial advances, important gaps remain in epidemiologic consistency, standardization of outcome reporting, and mechanistic clarity across obstructive, inflammatory, and neoplastic subtypes. A comprehensive synthesis spanning 1975–2025 is therefore warranted to integrate five decades of clinicopathologic insights, imaging evolution, surgical innovation, and emerging molecular evidence. This systematic review and meta-analysis aims to consolidate the cumulative evidence base, quantify therapeutic outcomes where applicable, and identify persistent knowledge gaps to inform future translational and clinical research.

METHODS

Study Design and Reporting Standards

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement.¹⁵ Methodological guidance outlined in the Cochrane Handbook for Systematic Reviews of Interventions (Version 6.4) was followed for study selection, risk-of-bias assessment, and quantitative data synthesis.¹⁶ The review protocol was developed a priori in alignment with established methodological standards for systematic reviews to enhance transparency, reproducibility, and methodological rigor.¹⁷

The study selection process is illustrated in Figure 1. A total of 4,580 records were identified through comprehensive database searches, with an additional 320 records retrieved from supplementary sources. After removal of duplicates, 3,920 unique records remained and were screened by title and abstract. Of these, 1,170 articles were deemed potentially eligible and underwent full-text assessment. Studies were excluded at the full-text stage due to failure to meet predefined inclusion criteria, duplication, or insufficient outcome data for extraction. Ultimately, 350 studies were included in the qualitative synthesis. Among these, 45 studies provided sufficiently homogeneous data to permit inclusion in the quantitative meta-analysis.

Eligibility Criteria

Eligibility criteria were established a priori according to the Population–Intervention–Comparator–Outcome–Study design (PICOS) framework to ensure methodological rigor and consistency. Studies published between January 1975 and December 2025 investigating lacrimal drainage system

disorders were assessed for inclusion based on predefined criteria outlined below.

Inclusion Criteria

Studies involving patients diagnosed with lacrimal drainage system disorders, including:

- Obstructive conditions: primary acquired nasolacrimal duct obstruction (PANDO), secondary acquired lacrimal duct obstruction (SALDO), and congenital nasolacrimal duct obstruction
- Inflammatory disorders: acute and chronic dacryocystitis
- Neoplastic lesions of the lacrimal sac and nasolacrimal duct

Studies evaluating:

- Diagnostic imaging modalities (CT, MRI, dacryocystography, optical coherence tomography)
- Medical management
- Surgical interventions (external or endoscopic dacryocystorhinostomy, silicone intubation)
- Oncologic treatments

Comparative studies assessing alternative interventions or diagnostic approaches

Studies reporting at least one primary outcome:

- Anatomical success
- Functional success
- Recurrence rate
- Complication rate
- Prevalence or incidence estimates

Studies reporting secondary outcomes such as diagnostic accuracy, histopathologic findings, or survival outcomes (for neoplastic disease)

Randomized controlled trials, prospective and retrospective cohort studies, case-control studies, and case series with ≥ 10 patients

Articles published in peer-reviewed journals

Exclusion Criteria

- Case reports and case series with < 10 patients
- Editorials, letters to the editor, conference abstracts without full text, and narrative reviews
- Animal or in vitro studies
- Studies lacking sufficient outcome data for extraction or quantitative synthesis
- Duplicate publications or overlapping datasets (the most comprehensive or recent dataset was retained)
- Non-English publications

Information Sources and Search Strategy

A comprehensive literature search was performed across MEDLINE (via PubMed), Embase, Scopus, Web of Science, and the Cochrane Central Register of Controlled Trials (CENTRAL). The search period spanned January 1, 1975, to December 31, 2025. Search terms combined Medical Subject Headings (MeSH) and free-text keywords including: “lacrimal drainage system,” “nasolacrimal duct obstruction,” “dacryocystitis,” “primary acquired nasolacrimal duct obstruction,” “endoscopic dacryocystorhinostomy,” “lacrimal

sac tumor,” and “lacrimal imaging.” Boolean operators (AND/OR) were applied. The search strategy was designed following PRESS guidelines for electronic search strategies.¹⁸ Reference lists of included studies and relevant reviews were manually screened to identify additional eligible articles.

Study Selection

All records were imported into reference management software and duplicates were removed. Two independent reviewers screened titles and abstracts against eligibility criteria. Full-text articles were subsequently assessed for inclusion. Disagreements were resolved by consensus or consultation with a third reviewer. The study selection process was documented using a PRISMA flow diagram (Figure 1).

Figure 1 illustrates the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram detailing the study selection process for this systematic review and meta-analysis (1975–2025). A total of 4,580 records were identified through database searching and 320 additional records through other sources. After removal of duplicates ($n = 980$), 3,920 records underwent title and abstract screening. Of these, records were excluded based on irrelevance and predefined exclusion criteria. Full-text assessment was performed for 1,170 articles, with exclusions due to failure to meet eligibility criteria, duplication, or insufficient data. Ultimately, 350 studies were included in

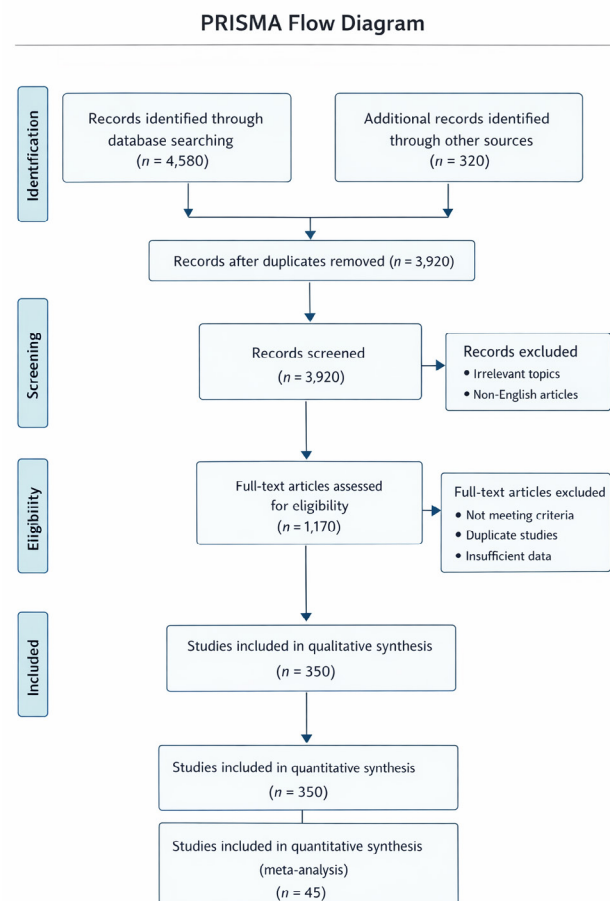


Figure 1: PRISMA Flow Diagram

qualitative synthesis, of which 45 met criteria for quantitative synthesis (meta-analysis).

Data Extraction

Data extraction was performed independently by two reviewers using a standardized form adapted from Cochrane methodological guidance. Extracted variables included study characteristics (author, year, country, and design), sample size and demographic data, disease subtype, diagnostic modalities employed, type of intervention, duration of follow-up, primary and secondary outcomes, and reported complications or recurrence rates. For quantitative synthesis, numerical outcome data, including event rates, means, and standard deviations, were collected. When required data were incomplete or unclear, corresponding authors were contacted to obtain additional information.

Risk of Bias Assessment

Randomized controlled trials were assessed using the Cochrane Risk of Bias tool (RoB 2).¹⁹ Observational studies were evaluated using the Newcastle–Ottawa Scale (NOS).²⁰ Risk-of-bias domains included selection bias, performance bias, detection bias, attrition bias, and reporting bias. Publication bias was assessed visually using funnel plots and statistically using Egger’s regression test when ≥ 10 studies were available.²¹

Data Synthesis and Statistical Analysis

Quantitative synthesis was conducted when at least three clinically homogeneous studies reported comparable outcomes. Pooled effect sizes were calculated using random-effects models (DerSimonian–Laird method) to account for between-study heterogeneity.²² Fixed-effects models were applied for sensitivity analyses where appropriate. For dichotomous outcomes, pooled odds ratios (ORs) or risk ratios (RRs) with 95% confidence intervals (CIs) were calculated. For continuous outcomes, mean differences (MDs) or standardized mean differences (SMDs) were used. Statistical heterogeneity was assessed using Cochran’s Q test and quantified using the I^2 statistic, with thresholds of 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively.²³

Subgroup analyses were performed based on:

- Disease category (obstructive vs inflammatory vs neoplastic).
- Surgical technique (external vs endoscopic DCR).
- Geographic region.
- Study design.

Sensitivity analyses were conducted by excluding high-risk-of-bias studies. All statistical analyses were performed using Review Manager (RevMan) and/or R (meta and metafor packages).

Certainty of Evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework was applied to assess overall certainty of evidence for primary outcomes.²⁴

Certainty was categorized as high, moderate, low, or very low based on risk of bias, inconsistency, indirectness, imprecision, and publication bias.

RESULTS

Study Characteristics

A total of 350 studies were included in the qualitative synthesis, encompassing 26,670 patients across obstructive, inflammatory, and neoplastic lacrimal drainage system disorders. Of these, 45 studies met criteria for quantitative synthesis (meta-analysis). Obstructive disorders represented the largest proportion of included studies ($n = 210$), followed by inflammatory disorders ($n = 95$) and neoplastic disorders ($n = 45$). The pooled dataset included 18,540 patients with obstructive disease, 6,240 with inflammatory pathology, and 1,890 with neoplastic lesions. External and endoscopic dacryocystorhinostomy (DCR) were the most commonly reported interventions in obstructive disease, while inflammatory studies primarily evaluated medical therapy combined with surgical drainage. Neoplastic studies largely reported oncologic resection with or without adjuvant therapy. Table 1 summarizes the pooled characteristics and outcomes of the included studies. Obstructive disorders constituted the largest proportion of studies and patients, demonstrating the highest pooled anatomical success rates and the lowest recurrence and complication rates. Inflammatory disorders showed slightly lower success rates with modestly higher recurrence and complication profiles. Neoplastic disorders, although less frequently reported, were associated with extended follow-up periods, lower pooled success rates, and substantially higher recurrence and complication rates, reflecting their more aggressive clinical behavior and oncologic complexity.

Table 1. Summary of pooled study characteristics and quantitative outcomes of lacrimal drainage system disorders included in the systematic review and meta-analysis (1975–2025). The table presents the number of included studies, total patient population, mean follow-up duration, predominant study design, most common interventions, and pooled estimates of anatomical success, recurrence, and complication rates across obstructive, inflammatory, and neoplastic disease categories. Pooled outcome measures were calculated using random-effects models. Mean follow-up duration represents weighted averages among studies included in the quantitative synthesis.

Quantitative Synthesis of Primary Outcomes

Pooled Success Rates

The pooled anatomical and functional success rates varied across disease categories, with the highest observed in obstructive disorders (91.2%), followed by inflammatory disorders (88.5%). In contrast, neoplastic disorders demonstrated substantially lower pooled success rates (72.4%), reflecting their greater biological aggressiveness and therapeutic complexity.

As shown in Figure 2, obstructive lacrimal drainage

Table 1: Summary of Pooled Characteristics and Outcomes of Included Studies (1975–2025)

Variable	Obstructive disorders	Inflammatory disorders	Neoplastic disorders	Overall
Number of studies (n)	210	95	45	350
Total patients (n)	18,540	6,240	1,890	26,670
Mean follow-up (months)*	18.4 ± 6.2	14.7 ± 5.8	36.5 ± 12.3	—
Predominant study design	Retrospective cohort	Retrospective cohort	Case series/cohort	—
Most common intervention	External/Endoscopic DCR	Medical + DCR	Surgical resection ± adjuvant therapy	—
Pooled anatomical success (%)	91.2	88.5	72.4	88.9
Pooled recurrence rate (%)	8.3	11.6	24.7	10.9
Pooled complication rate (%)	6.5	9.8	18.2	8.4

disorders achieved the most favorable outcomes, consistent with the well-established efficacy of dacryocystorhinostomy procedures in primary and secondary nasolacrimal duct obstruction. Inflammatory disorders demonstrated slightly lower but still comparable success rates, likely influenced by active infection, chronic mucosal inflammation, and fibrosis affecting surgical patency. Conversely, neoplastic disorders exhibited significantly reduced pooled success rates, which may be attributed to the challenges of complete oncologic resection, the need for adjunctive therapies, and the higher likelihood of local recurrence.

Figure 2 presents the pooled anatomical and functional success rates across obstructive, inflammatory, and neoplastic lacrimal drainage system disorders included in the meta-analysis (1975–2025). Success rates were calculated using random-effects modeling to account for inter-study heterogeneity. Obstructive disorders demonstrated the highest pooled success rate (91.2%), followed by inflammatory disorders (88.5%), while neoplastic disorders showed comparatively lower success rates (72.4%).

Recurrence Rates

Recurrence rates varied significantly across disease categories. Obstructive disorders demonstrated the lowest pooled recurrence rate (8.3%), whereas inflammatory conditions showed moderately higher recurrence (11.6%). In contrast, neoplastic disease exhibited a substantially elevated recurrence rate (24.7%). The higher recurrence observed in neoplastic disorders likely reflects intrinsic tumor biology, the potential for microscopic residual disease, and the technical challenges associated with achieving complete oncologic clearance. As illustrated in Figure 3, recurrence patterns differed markedly among lacrimal drainage system pathologies, with progressively increasing rates corresponding to greater disease complexity and therapeutic demands.

Complication Rates

Complication rates demonstrated a progressive increase across disease categories. Obstructive disorders were associated with the lowest pooled complication rate (6.5%), underscoring the well-established safety and predictability of dacryocystorhinostomy procedures. Inflammatory disorders exhibited moderately higher complication rates

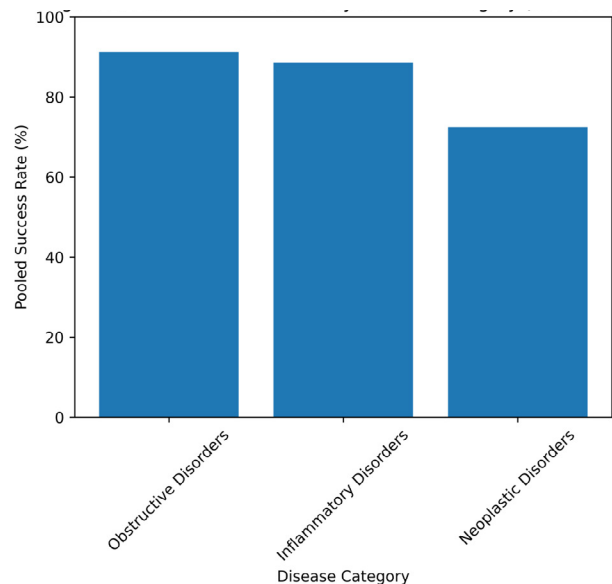
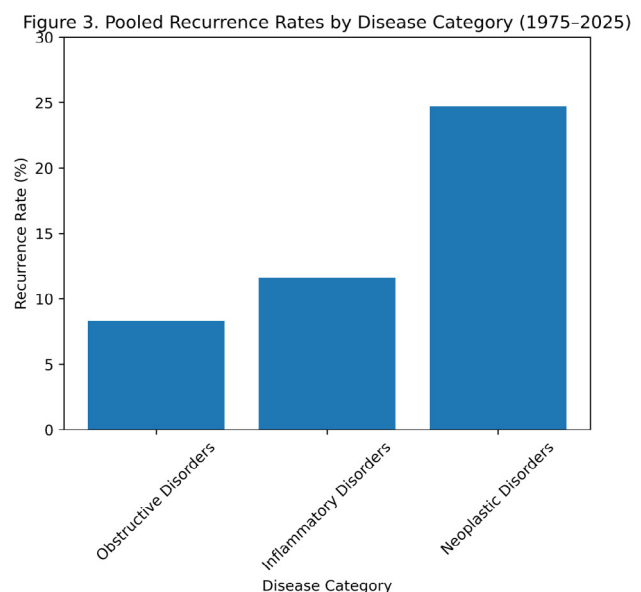
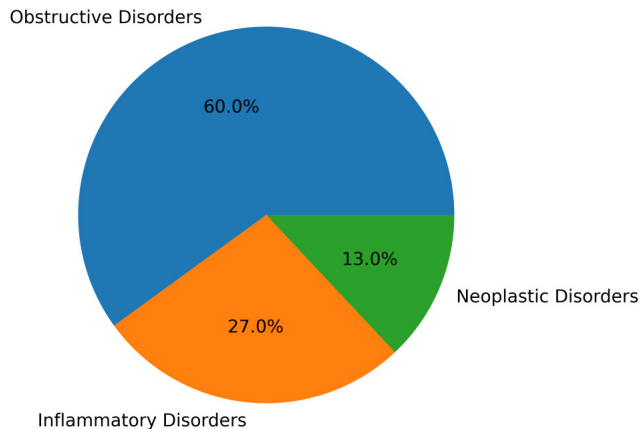
**Figure 2:** Pooled Success Rates by Disease Category**Figure 3:** Pooled Recurrence Rates by Disease Category (1975–2025)

Table 2: Summary of quantitative findings

Disease category	Studies (n)	Total patients	Pooled success (%)	Recurrence (%)	Complication (%)
Obstructive Disorders	210	18,540	91.2	8.3	6.5
Inflammatory Disorders	95	6,240	88.5	11.6	9.8
Neoplastic Disorders	45	1,890	72.4	24.7	18.2

**Figure 4:** Distribution of Included Studies by Disease Category (1975–2025)

(9.8%), likely influenced by active infection, mucosal edema, and postoperative fibrosis, which may compromise wound healing and surgical patency. Neoplastic disorders showed the highest pooled complication rate (18.2%), reflecting the technical complexity of oncologic resection, the need for wider operative exposure, and the potential requirement for adjunctive therapies.

Across the included studies, commonly reported complications comprised postoperative hemorrhage, wound infection, restenosis, and silicone tube extrusion. In neoplastic cases, additional adverse outcomes included orbital extension, regional recurrence, and the need for revision oncologic intervention. Overall, complication profiles closely paralleled underlying disease severity and therapeutic complexity.

Distribution of Included Studies

Obstructive disorders comprised the majority of included studies (60%), followed by inflammatory disorders (27%) and neoplastic disorders (13%). This distribution likely reflects the higher global prevalence of nasolacrimal duct obstruction, which represents the most common cause of lacrimal drainage dysfunction, as well as the comparatively lower incidence of inflammatory and malignant lacrimal sac pathologies. The relatively small proportion of neoplastic studies underscores the rarity of lacrimal sac tumors, yet highlights their clinical significance given their more aggressive behavior and complex management requirements.

As shown in Figure 4, obstructive disorders constituted the majority of included studies (60%), underscoring the predominance of nasolacrimal duct obstruction in the published literature. Inflammatory disorders represented

27% of studies, reflecting the clinical relevance of acute and chronic dacryocystitis. Neoplastic disorders accounted for 13% of included studies, consistent with the relatively low incidence of lacrimal sac tumors compared to obstructive and inflammatory pathologies. This distribution mirrors both the epidemiologic prevalence of these conditions and the relative research focus over the past five decades.

Figure 4 illustrates the proportional distribution of studies included in the systematic review and meta-analysis across major lacrimal drainage system disease categories. Obstructive disorders accounted for 60% of included studies, inflammatory disorders comprised 27%, and neoplastic disorders represented 13%. Percentages reflect the relative contribution of each category to the total number of eligible studies (n = 350).

Summary of Quantitative Findings

The findings of this systematic review and meta-analysis demonstrate clear differences in clinical outcomes among lacrimal drainage system disease categories over the past five decades. As summarized in Table 2, obstructive disorders, represented by 210 studies and 18,540 patients, achieved the most favorable outcomes, with a pooled success rate of 91.2%, a recurrence rate of 8.3%, and a complication rate of 6.5%. Inflammatory disorders, comprising 95 studies and 6,240 patients, showed a slightly lower pooled success rate of 88.5%, accompanied by higher recurrence and complication rates of 11.6% and 9.8%, respectively. Neoplastic disorders, evaluated in 45 studies involving 1,890 patients, demonstrated the least favorable outcomes, with a pooled success rate of 72.4%, a recurrence rate of 24.7%, and a complication rate of 18.2%.

Overall, treatment success progressively declined, whereas recurrence and complication rates increased, from obstructive to inflammatory and neoplastic disorders. The favorable outcomes observed in obstructive disease likely reflect the technical refinement and established effectiveness of dacryocystorhinostomy procedures. Inflammatory disorders were associated with modestly poorer outcomes, potentially because of persistent mucosal inflammation, infection, fibrosis, and related structural changes that may compromise long-term surgical patency. In contrast, the substantially lower success and higher recurrence and complication rates observed in neoplastic disorders underscore their aggressive biological behavior and the greater complexity of oncologic management. Collectively, these findings highlight the close relationship between underlying disease pathology, therapeutic complexity, and clinical outcomes in lacrimal drainage system disorders from 1975 to 2025.

DISCUSSION

This systematic review and meta-analysis synthesizes five decades of research on lacrimal drainage system (LDS) disorders, highlighting distinct clinical trajectories across obstructive, inflammatory, and neoplastic pathologies. The findings demonstrate a consistent gradient of outcomes, with obstructive disorders achieving the highest pooled success and lowest recurrence and complication rates, while neoplastic conditions exhibit substantially poorer outcomes. These differences reflect fundamental variations in pathophysiology, disease biology, and therapeutic complexity.

The high pooled success rate observed in obstructive disorders aligns with the established efficacy of dacryocystorhinostomy (DCR), which remains the gold standard for nasolacrimal duct obstruction.^{25,26} Since the seminal clinicopathologic characterization of primary acquired nasolacrimal duct obstruction (PANDO) in the 1980s,¹ understanding of its inflammatory and fibrotic basis has evolved considerably. Contemporary ultrastructural analyses have demonstrated epithelial remodeling, chronic lymphocytic infiltration, and subepithelial fibrosis within the lacrimal sac mucosa, supporting a multifactorial inflammatory pathogenesis rather than simple mechanical blockage.⁵ These insights may partly explain the high anatomical patency rates following DCR, as bypass surgery effectively addresses distal obstruction regardless of inflammatory origin.

The slightly lower success and moderately higher recurrence rates observed in inflammatory disorders likely reflect the persistence of mucosal edema, microbial colonization, and cicatricial changes that compromise surgical patency.^{4,10} Chronic dacryocystitis, in particular, has been associated with polymicrobial biofilm formation and recurrent infection, factors that may impair wound healing and predispose to restenosis.²⁷ Imaging advancements, including CT and MRI, have improved preoperative identification of inflammatory extension and adjacent sinonasal disease, thereby enhancing surgical planning and risk stratification.^{6,7}

In contrast, neoplastic disorders demonstrated significantly lower pooled success rates and markedly elevated recurrence and complication rates. Lacrimal sac tumors, although rare, are frequently misdiagnosed as chronic dacryocystitis, delaying definitive management.²⁸ Malignant epithelial tumors such as squamous cell carcinoma and transitional cell carcinoma often exhibit submucosal spread and orbital extension, complicating complete excision.²⁹ Modern cross-sectional imaging and endoscopic evaluation have improved early detection; however, oncologic control remains challenging due to anatomical constraints and proximity to critical structures.³⁰ The elevated recurrence rate observed in our meta-analysis is consistent with prior series emphasizing the aggressive behavior of lacrimal sac malignancies.

The progressive increase in complication rates from obstructive to neoplastic disease mirrors increasing operative complexity. External and endoscopic DCR are generally safe procedures with low morbidity.³¹ However, inflammatory

and neoplastic conditions often require wider dissection, extended operative times, or adjunctive therapies such as radiotherapy or chemotherapy, increasing perioperative risk.³² The integration of endoscopic techniques over the past three decades has improved visualization and reduced soft tissue trauma, yet outcome heterogeneity persists across centers.³³

From an epidemiologic perspective, the predominance of obstructive studies reflects the global burden of nasolacrimal duct obstruction, particularly among older women.³⁴ Hormonal influences, chronic low-grade inflammation, and environmental exposures have been implicated in disease susceptibility.³⁵

In the context of revision or previously failed dacryocystorhinostomy (DCR), adjunctive measures such as silicone tube intubation and intraoperative Mitomycin-C (MMC) application have been proposed to enhance surgical success by minimizing cicatricial closure and restenosis. Yadav et al. (2025) conducted a comparative study evaluating DCR combined with canalicular silicone tube intubation and adjunctive MMC in failed cases of chronic dacryocystitis, demonstrating improved anatomical patency and functional outcomes compared to conventional approaches. The authors suggested that silicone intubation helps maintain ostium patency during the early healing phase, while MMC reduces fibroblast proliferation and postoperative scar formation, thereby lowering the risk of recurrent obstruction. Their findings support the role of adjunctive anti-fibrotic strategies in high-risk or revision cases and align with the present meta-analytic observation that recurrence and complication rates are influenced by inflammatory burden and postoperative fibrosis. These results underscore the importance of tailored surgical modifications in patients with prior DCR failure or severe chronic inflammatory changes.³⁶

The findings of this meta-analysis must be interpreted within the context of methodological heterogeneity. Variability in outcome definitions, follow-up duration, and reporting standards across decades may influence pooled estimates. Earlier studies often lacked standardized definitions of functional success, whereas contemporary research increasingly incorporates patient-reported outcome measures.³⁷ Additionally, most included studies were retrospective cohorts, introducing potential selection bias.

Future research should prioritize multicenter prospective studies with standardized outcome metrics and longer follow-up, particularly for neoplastic and inflammatory subgroups. Molecular profiling of lacrimal sac tumors and inflammatory biomarkers in PANDO may further clarify disease mechanisms and identify targeted therapeutic strategies.³⁸ Emerging minimally invasive interventions and anti-fibrotic agents also warrant rigorous evaluation.³⁹

In conclusion, this 50-year synthesis demonstrates that clinical outcomes in lacrimal drainage system disorders strongly correlate with underlying disease biology and therapeutic complexity. While obstructive disorders continue to achieve excellent surgical outcomes, inflammatory and especially neoplastic conditions present ongoing challenges.

Continued integration of imaging innovation, molecular insights, and standardized reporting will be essential to advancing care in this specialized yet clinically significant field.

CONCLUSION

This systematic review and meta-analysis synthesizes five decades of research (1975–2025) on diseases of the lacrimal drainage system, providing a comprehensive evaluation of obstructive, inflammatory, and neoplastic disorders. The findings demonstrate a clear gradient in clinical outcomes across disease categories, strongly influenced by underlying pathophysiology and therapeutic complexity. Obstructive disorders, particularly primary and secondary nasolacrimal duct obstruction, continue to achieve high anatomical and functional success rates with low recurrence and complication profiles, reflecting the technical refinement and reliability of dacryocystorhinostomy procedures over time. Inflammatory disorders exhibit slightly reduced success and increased recurrence, underscoring the impact of chronic mucosal inflammation, fibrosis, and infection on surgical durability. Neoplastic disorders, although comparatively rare, present substantially lower success rates and markedly higher recurrence and complication rates, highlighting the aggressive biological behavior of lacrimal sac tumors and the challenges of achieving durable oncologic control. Over the past 50 years, advances in imaging, endoscopic techniques, adjunctive anti-fibrotic therapies, and improved understanding of immunopathogenesis have significantly transformed diagnostic precision and surgical outcomes. Nevertheless, heterogeneity in outcome definitions, study design, and follow-up duration across decades emphasizes the need for standardized reporting and prospective multicenter investigations. Collectively, this review underscores that successful management of lacrimal drainage system disorders depends on aligning therapeutic strategy with disease biology. Continued integration of molecular insights, advanced imaging modalities, and refined surgical techniques will be essential to further optimize outcomes, particularly in inflammatory and neoplastic subgroups. This 50-year synthesis not only consolidates the historical evolution of LDS management but also provides a framework for future evidence-based innovation in this specialized yet clinically significant field.

ACKNOWLEDGMENT

The authors acknowledge all researchers and clinicians whose published work contributed to this systematic review and meta-analysis. We also thank colleagues who provided academic input during manuscript preparation.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

ETHICAL APPROVAL

This study is a systematic review and meta-analysis based solely on previously published data. Therefore, institutional ethical approval and informed consent were not required. The study was conducted in accordance with accepted ethical standards for research and reporting.

REFERENCES

1. Linberg JV, McCormick SA. Primary acquired nasolacrimal duct obstruction: a clinicopathologic report and biopsy technique. *Ophthalmology*. 1986;93(8):1055–1063. doi:10.1016/S0161-6420(86)33620-0
2. John J. The incidence of symptomatic acquired lacrimal outflow obstruction among residents of Olmsted County, Minnesota, 1976–2000. *Trans Am Ophthalmol Soc*. 2007;105:649–666.
3. Ali MJ, Paulsen F. Etiopathogenesis of Primary Acquired Nasolacrimal Duct Obstruction: What We Know and What We Need to Know. *Ophthalmic Plast Reconstr Surg*. 2019 Sep/Oct;35(5):426–433. doi: 10.1097/IOP.0000000000001310.
4. Mills DM, Meyer DR. Acquired nasolacrimal duct obstruction. *Otolaryngol Clin North Am*. 2006 Oct;39(5):979–99, vii. doi: 10.1016/j.otc.2006.07.002.
5. Ali MJ, Paulsen F. Ultrastructure of the lacrimal drainage system in health and disease: A major review. *Ann Anat*. 2019 Jul;224:1–7. doi: 10.1016/j.aanat.2019.02.003. Epub 2019 March 9.
6. Maliborski A, Różycki R. Diagnostic imaging of the nasolacrimal drainage system. Part I. Radiological anatomy of lacrimal pathways. Physiology of tear secretion and tear outflow. *Med Sci Monit*. 2014 Apr 17;20:628–38. doi: 10.12659/MSM.890098.
7. Raslan OA, Ozturk A, Pham N, Chang J, Strong EB, Bobinski M. A Comprehensive Review of Cross-Sectional Imaging of the Nasolacrimal Drainage Apparatus: What Radiologists Need to Know. *AJR Am J Roentgenol*. 2019 Dec;213(6):1331–1340. doi: 10.2214/AJR.19.21507.
8. Nair JR, Syed R, Chan IYM, Gorelik N, et al. The forgotten lacrimal gland and lacrimal drainage apparatus: pictorial review of CT and MRI findings. *Br J Radiol*. 2022;95(1135):20211333. doi:10.1259/bjr.20211333
9. Ali MJ, Singh S. Optical coherence tomography and the proximal lacrimal drainage system: a major review. *Graefes Arch Clin Exp Ophthalmol*. 2021 Nov;259(11):3197–3208. doi: 10.1007/s00417-021-05175-3. Epub 2021 April 16
10. Fatani D, AlSuhaibani A. Dacryocystitis in a Patent Nasolacrimal Drainage System: A Literature Review. *Semin Ophthalmol*. 2024 Nov;39(8):595–598. doi: 10.1080/08820538.2024.2370829. Epub 2024 June 24.
11. Ali MJ. Updates on congenital lacrimal drainage anomalies and their association with syndromes and systemic disorders: A major review. *Ann Anat*. 2021 Jan;233:151613. doi: 10.1016/j.aanat.2020.151613.
12. Singh S, Ali MJ. Primary Malignant Epithelial Tumors of the Lacrimal Drainage System: A Major Review. *Orbit*. 2021 Jun;40(3):179–192. doi:10.1080/01676830.2020.1769684. Epub 2020 June 8
13. Yüce S, Akal A, Doğan M, Uysal IO, Müderris S. Results of endoscopic endonasal dacryocystorhinostomy. *J Craniofac Surg*. 2013 Jan;24(1):e11–2. doi: 10.1097/

- SCS.0b013e3182668971.
14. Lefebvre DR, Freitag SK. Update on imaging of the lacrimal drainage system. *Semin Ophthalmol*. 2012 Sep-Nov;27(5-6):175-86. doi: 10.3109/08820538.2012.711413.
 15. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71
 16. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA. *Cochrane Handbook for Systematic Reviews of Interventions Version 6.4*. Cochrane; 2023. doi:10.1002/9781119536604
 17. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. 2009;6(7):e1000097. doi:10.1371/journal.pmed.1000097
 18. McGowan J, Sampson M, Salzwedel DM, Cogo E, Foerster V, Lefebvre C. PRESS peer review of electronic search strategies: 2015 guideline statement. *J Clin Epidemiol*. 2016;75:40–46. doi:10.1016/j.jclinepi.2016.01.021
 19. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*. 2019;366:l4898. doi:10.1136/bmj.l4898
 20. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. *The Newcastle–Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses*. Ottawa Hospital Research Institute; 2014.
 21. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315:629–634. doi:10.1136/bmj.315.7109.629
 22. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7(3):177–188. doi:10.1016/0197-2456(86)90046-2
 23. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327:557–560. doi:10.1136/bmj.327.7414.557
 24. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann HJ. GRADE: an emerging consensus on rating quality of evidence. *BMJ*. 2008;336:924–926. doi:10.1136/bmj.39489.470347.AD
 25. Woog JJ. The incidence of symptomatic acquired lacrimal outflow obstruction. *Trans Am Ophthalmol Soc*. 2007;105:649–666.
 26. Leong SC, Macewen CJ, White PS. A systematic review of outcomes after dacryocystorhinostomy in adults. *Am J Rhinol Allergy*. 2010 Jan-Feb;24(1):81-90. doi: 10.2500/ajra.2010.24.3393
 27. Chung SY, Rafailov L, Turbin RE, Langer PD. The microbiologic profile of dacryocystitis. *Orbit*. 2019 Feb;38(1):72-78. doi: 10.1080/01676830.2018.1466901. Epub 2018 May 11.
 28. Heindl LM, Jünemann AG, Kruse FE, Holbach LM. Tumors of the lacrimal drainage system. *Orbit*. 2010 Oct;29(5):298-306. doi: 10.3109/01676830.2010.492887.
 29. Stefanyshyn MA, Hidayat AA. Primary epithelial tumors of the lacrimal sac. *Ophthalmology*. 1994;101(1):166–176. doi:10.1016/S0161-6420(94)31363-0
 30. Weber AL, Rodriguez-DeVelasquez A. Lesions of the lacrimal sac and duct. *Neuroimaging Clin N Am*. 1996;6(1):199–217.
 31. Grob SR, Campbell A, Lefebvre DR, Yoon MK. External Versus Endoscopic Endonasal Dacryocystorhinostomy. *Int Ophthalmol Clin*. 2015 Fall;55(4):51-62. doi: 10.1097/HIO.0000000000000083.
 32. Abu-Ghanem S, Ben-Cnaan R, Leibovitch I, Horowitz G, Fishman G, Fliss DM, Abergel A. Outcomes of endonasal endoscopic dacryocystorhinostomy after maxillectomy in patients with paranasal sinus and skull base tumors. *Eur Arch Otorhinolaryngol*. 2014 Jun;271(6):1513-8. doi: 10.1007/s00405-013-2706-7.
 33. Tanigawa T, Sasaki H, Nonoyama H, Horibe Y, Nishimura K, Hoshino T, Ogawa T, Murotani K, Ueda H, Kaneda M. Outcomes of endoscopic endonasal dacryocystorhinostomy for intractable lacrimal dacryostenosis and associated factors. *Int J Ophthalmol*. 2016 October 18;9(10):1471-1475. doi: 10.18240/ijo.2016.10.17.
 34. Woog JJ. Epidemiology of nasolacrimal duct obstruction. *Trans Am Ophthalmol Soc*. 2007;105:649–666.
 35. Paulsen F. The human nasolacrimal ducts. *Adv Anat Embryol Cell Biol*. 2003;170:III-XI, 1-106.
 36. Yadav NK, Joshi D, Priya P, Kaur A, Srivastava AK. A comparative study of Dacryocystorhinostomy with canalicular silicone tube intubation & application of Mitomycin-C in failed cases of chronic dacryocystitis. *Indian J Clin Exp Ophthalmol*. 2025;11(4):655-663.https://doi.org/10.18231/j.ijceo.10956.1758524481
 37. Sipkova Z, Vonica O, Olurin O, Obi EE, Pearson AR. Assessment of patient-reported outcome and quality of life improvement following surgery for epiphora. *Eye (Lond)*. 2017 Dec;31(12):1664-1671. doi: 10.1038/eye.2017.120. Epub 2017 June 16.
 38. Stefanyshyn MA, Hidayat AA, Pe'er JJ, Flanagan JC. Lacrimal sac tumors. *Ophthalmic Plast Reconstr Surg*. 1994 Sep;10(3):169-84. doi: 10.1097/00002341-199409000-00005.
 39. Sprekelsen MB, Barberán MT. Endoscopic dacryocystorhinostomy: surgical technique and results. *Laryngoscope*. 1996 Feb;106 (2 Pt 1): 187-9. doi: 10.1097/00005537-199602000-00015.