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Dacryoendoscopy: Historical development, philosophical foundation, and clinical perspective

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Abstract:

Dacryoendoscopy is valuable for managing epiphora, enabling direct visualization of the lacrimal outflow system. Notably, dacryoendoscopy enhances diagnostic precision and facilitates minimally invasive treatment. Over the past three decades, its evolution has fostered a deeper understanding of endoluminal pathology, refined recanalization techniques, and expanded therapeutic indications across age groups. Importantly, dacryoendoscopy represents not only technical refinement but also a conceptual shift – from blind intervention to anatomy-based diagnosis and management. This shift reflects a deeper surgical philosophy, that visualization must precede intervention, and that humility toward unseen structures is crucial for true minimally invasive practice. This narrative review explores the device design philosophy, terminology, and clinical use of dacryoendoscopy, focusing on the Bent group's contributions and the emergence of conservative minimally invasive lacrimal surgery, which emphasizes mucosal preservation and is specifically suited for pediatric cases. The Bent probe endoscopes, originating in Japan, have become the most widely used devices in Asia. Moreover, false passage was illustrated in relation to the duct lumen remnant within fibrous blockage, and key techniques, including sheath-guided endoscopic probing and sheath-guided intubation, were reviewed. Regardless of these advances, challenges such as long-term deterioration of surgical outcomes and the distant goal of mucosal regeneration persist. Relevant literature was identified through a nonsystematic search of PubMed and Ichushi-Web, using the keywords "dacryoendoscopy," "nasolacrimal duct," and "false passage," covering publications from 1995 to 2025.

Keywords:

Bent probe dacryoendoscope, dacryoendoscopy, duct lumen remnant, false passage classification, minimally invasive lacrimal surgery

Introduction

Dacryoendoscopy is not merely a technical innovation; rather, it represents a conceptual shift in the diagnosis and management of lacrimal outflow disorders. By enabling direct visualization of the lacrimal outflow system (LOS), dacryoendoscopy has transformed diagnostic reasoning from assumption-based intervention to anatomy-driven decision-making. This shift reflects a deeper surgical philosophy: That visualization must precede intervention, and that humility toward unseen structures is crucial for true minimally invasive practice. Notably, recent reviews have advanced therapeutic strategies by focusing mainly on clinical outcomes and device evolution.[1-4] However, the historical lineage and philosophical underpinnings that shaped the development of dacryoendoscopic techniques are often overlooked. Thus, this narrative review revisits the conceptual foundations of dacryoendoscopy, tracing its evolution through key contributors and examining how probe morphology exhibits distinct

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surgical philosophies. Specifically, we explore how the Bent group's approach, which is centered on mucosal preservation, diagnostic clarity, and long-term anatomical insight, has given rise to a conservative form of minimally invasive lacrimal surgery (MILS). This stands in contrast to the radical MILS approach of the straight group, which prioritizes high success rates that reflect short-term outcomes. Although these figures may appear impressive, they often mask long-term deterioration and diagnostic oversights. Conversely, the Bent group looks beyond numbers – toward anatomical understanding that endures. Their philosophy does not chase momentary success, but rather seeks meaning that survives time. By organizing and clarifying various terminologies (e.g., "dacryoendoscope," "false passage," "duct lumen remnant [DLR]," and "MILS"), this review offers a deeper understanding of dacryoendoscopy not only as a technical field but also as a fusion of science, philosophy, and surgical thought.

Methods

This narrative review focuses on the historical background and conceptual foundations of dacryoendoscopy, complementing previous publications that analyze individual clinical outcomes or technical performance. Relevant literature was identified through a nonsystematic search of PubMed and Ichushi-Web (a Japanese medical literature database provided by the Japan Medical Abstracts Society), using the keywords "dacryoendoscopy," "nasolacrimal duct," and "false passage," covering publications from 1995 to 2025.

To provide a more comprehensive understanding of the development and philosophy of current dacryoendoscopic practices, this review also included articles that were not written in English. By including these studies, regional preferences and conceptual differences are captured, especially those in relation to endoscope probe design and usage.

Historical background of the lacrimal endoscope

The lacrimal endoscope is a microendoscope specifically designed for the examination and treatment of the LOS. The term "dacryoendoscope" is often used interchangeably, but this technically refers to a third-generation model with defined structural features. Other microendoscopes, such as sialoscopes or angioscopes, may be adapted to visualize the LOS, but these are not authorized for lacrimal use and should not be classified as lacrimal endoscopes.

In 1979, Cohen first reported direct LOS visualization using a straight rigid probe with a rod lens, termed the dacryoscope.[5] This early device lacked internal illumination, irrigation, and an external visualization system. In 1989, Asanagi introduced a fiber-optic rigid endoscope with an improved resolution of 4000 pixels and external monitoring,[6] marking the second generation of lacrimal endoscopy. Subsequently, Ashenhurst and Hurwitz, Fein *et al.*, and Müllner explored flexible fiber-optic probes ranging from 0.3 to 0.7 mm.[7-9] Although these models were not widely adopted clinically, they emphasized the need for both internal illumination and irrigation, which became standard features in later designs. The third-generation lacrimal endoscope was introduced by Emmerich *et al*. in 1997; this was equipped with a rigid probe containing a fiber-optic bundle, dedicated internal illumination fibers, and working channels for irrigation and instrumentation.[10] This model was the first to be formally termed a "dacryoendoscope," and its use was termed as "dacryoendoscopy." Earlier devices did not meet this definition. The evolution of the probe design of the dacryoendoscope represents not only technological advancement but also a shift in surgical philosophy toward MILS.

Dacryoendoscope probe design and lacrimal anatomy

Dacryoendoscope probes are broadly categorized into straight and bent types [Figure 1 and Table 1]. The straight probe, introduced in 1997, offers forward – only navigation and compatibility with a microdrill and a laser probe.[10] In 2003, the bent probe was introduced to overcome anatomical constraints which hinder probe insertion from the punctum,[11] such as the superomedial orbital ridge (SOR) and medial canthal

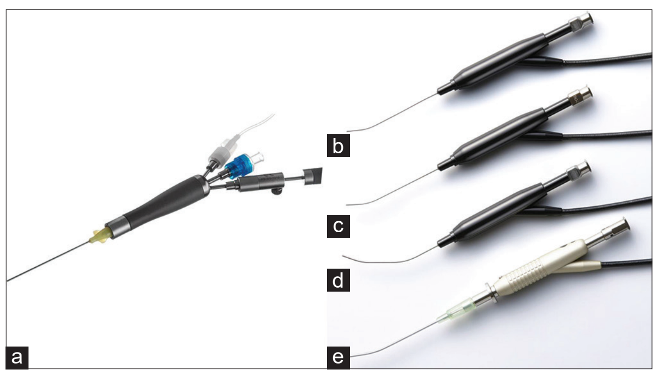

Figure 1: Dacryoendoscope models. Image of model (a) reproduced from the official website of Polydiagnost GmbH (Germany). Image of Karl Storz's model is not shown, as it is no longer commercially available after the COVID-19 pandemic. Model (a) shows the straight probe endoscope by Polydiagnost (Germany), comprised a fiberoptic bundle (3,000–10,000 pixels), shifter, handle, and shaft (0.75–1.1 mm). These components vary in specification, enabling multiple combinations. For dacryoendoscopy, polydiagnost offers three types of bundles and four types of shafts – all straight and single-use. The microdrill is also disposable. Visualization and drill systems are sold separately. Models (b-e) depict bent probe endoscopes by FiberTech (Japan), which available in four preset configurations: MT3 (b), CK10 (c), CK10TB (d), and EZ Tb (e). These reusable devices range from 3000 to 15,000 pixels and have a diameter of 0.7–0.9 mm. ZT Tb is plasma-sterilized; others use chemical sterilization. The system includes an integrated visualization unit

tendon (MCT) [Figure 2]. These anatomical constraints have posed a significant challenge in dacryoendoscopy. In 1999, Sasaki demonstrated that a straight milk duct microendoscope could not accurately visualize the nasolacrimal duct (NLD) lumen due to interference from the SOR and MCT, necessitating the use of a bent introducer for adequate visualization.[12] These findings marked a turning point in probe design.

Based on initial studies by the author, the optimal bending angle was determined to be 27°, enabling access to the NLD ostium in 77% of cases.[13] Meanwhile, angles below 25° were less effective, and those above 30° had diminished performance. Three angle variations have since emerged, refined by clinical experience.

A cadaveric study by Narioka *et al.*[14] and a computed tomography (CT) study by Nakamura *et al.*[15] confirmed that most Japanese adults and children exhibit anterior-type NLDs, wherein the probe has a steeper trajectory than the incline of the duct due to anatomical interference. In such cases, forward-bent probes offer better access [Figure 2]. Conversely, posterior-type NLDs, seen in 28% of cases, require upright handling and precise finger control [Figure 3a]. Finally, inward NLDs, which are sometimes visible on coronal CT images, likewise demand tortional finger control during recanalization [Figure 3b]. Despite various advancements, no single probe design can accommodate all anatomical variations. Nevertheless, the bent probe significantly expands procedural feasibility through dynamic control and tailored angulation, integrating anatomical insight with surgical adaptability.

Table 1: Comparison of the features of straight and bent probe endoscopes

	Straight probe	Bent probe
Introduction year	1997	2003
Microdevice compatibility		
Microdrill	○	×
Laser probe	○	×
Lacrima trephine (metal)	○	×
18 G intravenous catheter	Not needed	○
Accessibility to LOS		
Canalicular system	○	○
The duct	△	○
Controllability of direction		
Visualization	Only front view	Slightly adjustable by finger control
Navigation	Only forward	Slightly adjustable by finger control

The duct=Lacrimal sac and nasolacrimal duct. ○=good. □=fair. ×=poor, LOS=Lacrimal outflow system

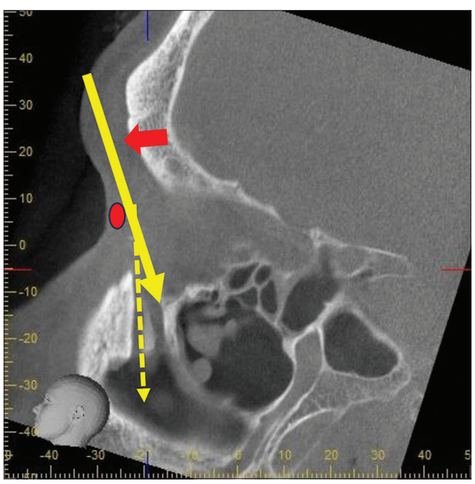

Figure 2: Sagittal computed tomography image. Probe trajectory (solid yellow arrow) is hindered by the superomedial orbital ridge (red arrow) and medial canthal tendon (red circle), causing misalignment between the probe and the duct inclination (dotted yellow line). Bending the probe is effective in overcoming this anatomical constraint

Dacryoendoscopic image and display perception

Recent advancements in fiber-optic technology have improved visualization within the LOS, with endoscopes routinely offering 10,000 pixels, even reaching up to 15,000 pixels in certain models. These higher pixel counts offer enhanced resolution of fine structures, improving diagnostic accuracy and navigation [Figure 4]. However, anatomical constraints limit further increases in probe pixel density. To address this, real-time digital

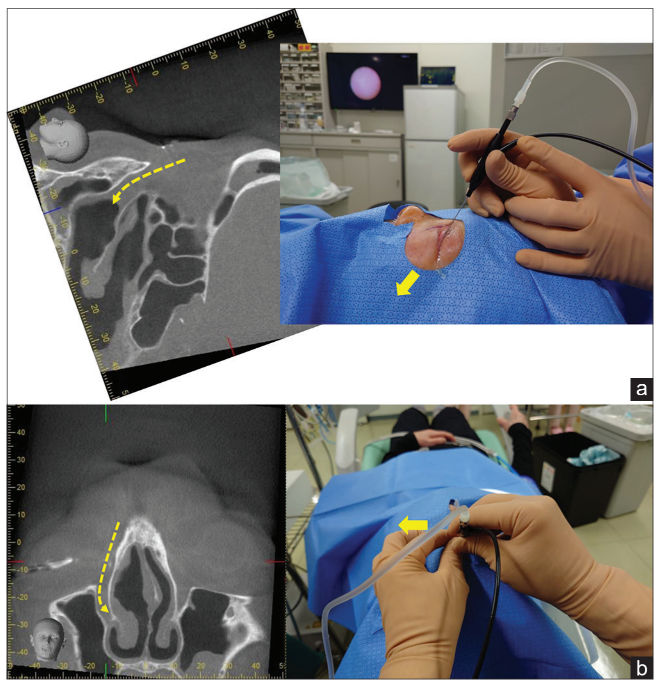

Figure 3: Finger control of the endoscope handpiece. The surgeon's finger control of the handpiece (e.g., angular modulation and rotation) enables precise adjustment of the endoscope probe trajectory in response to anatomical variations of the nasolacrimal duct (NLD). (a) Posterior-type NLD (dotted yellow arrow) on computed tomography (CT). The handpiece is held in an upright position to accommodate the posterior inclination of the NLD. The probe tip is directed posteriorly (solid yellow arrow). (b) Inward-type NLD (dotted yellow arrow) on CT. The handpiece is held in a counterclockwise position to accommodate the inward inclination of the NLD. The positioning of the image guide cable suggests an inward trajectory of the probe tip (solid yellow arrow)

enhancement tools have been developed, including a honeycomb artifact remover (WipeFiber®) and a contrast enhancer (Medical Imaging Enhancer: MIEr®), which algorithmically refine images [Figure 5]. As quantitatively demonstrated by Hoshi *et al*., this processing improves the visibility of mucosal surfaces and pathological features such as granulation tissue and fibrous blockage.[16]

Despite these innovations, dacryoendoscopy unfortunately remains among the lowest-resolution modalities in medical imaging.[17] Even at 15,000 pixels (i.e., 28.50 line pairs/mm), the effective display resolution is 150 × 100 pixels,[14] which is relatively low compared to cathode ray tube (CRT) monitors, which offer 720 × 480, high definition (HD) 1280 × 720, and full HD (FHD) up to 1920 × 1080. Thus, dacryoendoscopic images offer <1% of the standard modern video density, and the perceived visibility can even vary significantly with monitor performance.[18,19]

In older CRTs, coarse images were often softened to make them appear somewhat visible. Inexpensive lucid crystal displays, however, emphasize pixelation and jagged edges[20] at the cost of compromising subtle color gradients. Meanwhile, high-grade in-plane switching monitors enable smoother gradation and clearer anatomical detail with FHD resolution, 100% standard RGB (sRGB) gamut, and high contrast.[21]

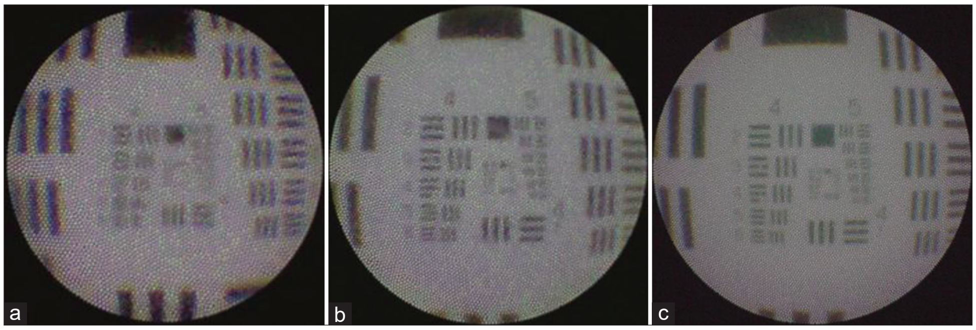

Figure 4: Improvement of image resolution of the dacryoendoscope. Images obtained using dacryoendoscopes with 6000, 10,000, and 15,000 pixels, observing a USAF 1951 resolution test chart at 1.5 mm from the probe tip. Higher pixel counts yield improved image resolution. (a) 6000 pixels, (b) 10,000 pixels, (c) 15,000 pixels

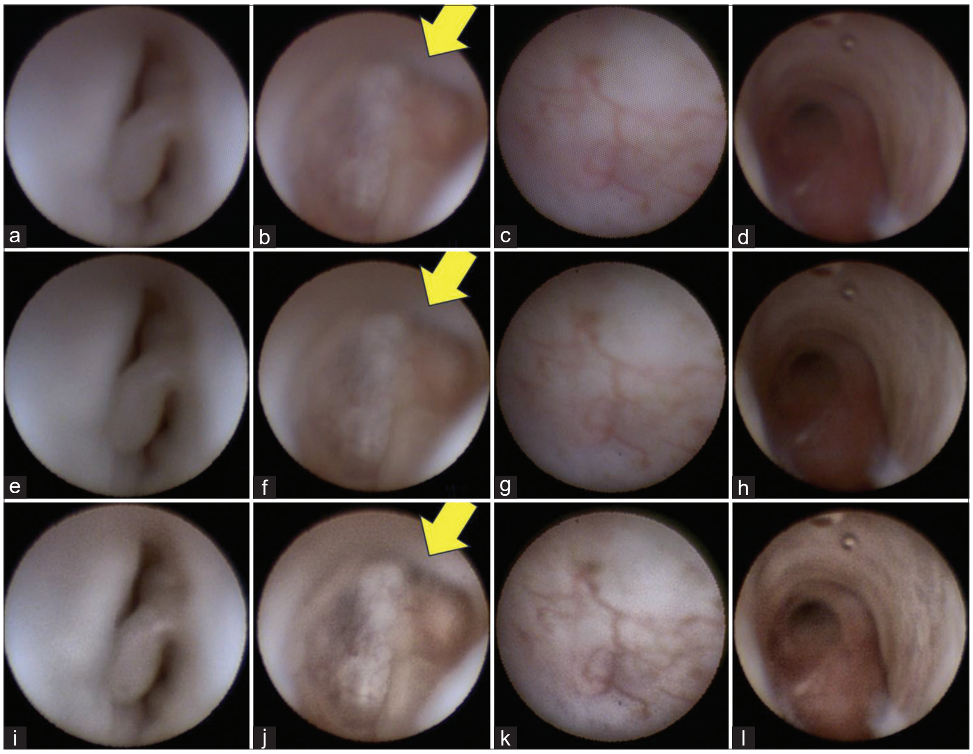

Figure 5: Enhancement of contrast and visibility in dacryoendoscopy via digital image processing. (a-d) Original images. (e-h) Images after honeycomb-removal processing. (i-l) Images after combined honeycomb-removal and image-sharpening procedures. (a, e, i) Distal portion of canaliculus. A physiological polypod structure can be seen. (b, f, j) Common canaliculus and a pinhole on the blockage membrane (yellow arrow). (c, g, k) Lacrimal sac wall. (d, h, l) Nasolacrimal duct. Digital image processing markedly improved visibility, enabling detailed observation of the obstruction site (j), blood vessels within the lacrimal sac mucosa (k), and luminal structures of the nasolacrimal duct (l)

Despite these limitations, experienced surgeons can accurately interpret low-resolution images due to perceptual learning, a form of neural plasticity.[22] Similar effects have been documented in the fields of radiology and pathology as well.[23,24] Thus, observation accuracy does not solely depend on technical specifications, but also on display quality and observer expertise.

Terminology in dacryoendoscopy

The terminology discussed in this review includes established technical terms, as well as conceptual groupings (i.e., Bent/Straight groups), which clarify philosophical distinctions in lacrimal surgery. Table 2 summarizes the key terms and their roles in device design, clinical application, and surgical philosophy. Some terms, such as the slit sign, DLR, and false passage, are further elaborated on due to their clinical significance.

Slit sign

The slit sign is a key dacryoendoscopic finding that indicates a fully patent NLD.[28] It is seen as a slit-like configuration of the lacrimal sac, also visible on horizontal CT [Figure 6]. Paulsen anatomically described this structure as well.[32]

Duct lumen remnant

The DLR is a residual anatomical trace of the original ductal lumen within fibrous tissue, often visible during recanalization [Figure 7a]. Endoscopically, this appears as a narrow space surrounded by soft, white, fibrous tissue [Figure 7b] that has a patent portion beyond the blockage. Histopathologically, this was described by Limberg as a markedly narrowed lumen encased by periductal fibrosis,[33] closely aligning with dacryoendoscopic observations.

For precise recanalization, careful finger control (e.g., tortional or back-and-forth movements) is essential when searching for the DLR. The DLR can serve as a reliable guide for navigating the dacryoendoscope [Figure 7c], enabling recanalization while avoiding the creation of a nonphysiological route (i.e., a false passage) [Figure 7d]. Even if not initially visible, the DLR may emerge during the procedure. Identifying the DLR followed by precise positioning of a lacrimal stent can improve surgical outcomes [Figure 7e]. Overlooking the DLR may lead to false passage formation, followed by false passage intubation that cannot maintain patency in long term.

Table 2: Key terminologies in dacryoendoscopy: technical and conceptual framework

Term	Full name/origin	Definition/conceptual role	Implication
LOS	Lacrimal outflow system	Canaliculi, lacrimal sac, and nasolacrimal duct	Anatomical foundation of visualization
Lacrimal endoscope	General term for endoscopes applicable to the LOS	Broad category including various constructions and imaging systems	Embodies historical development
Dacryoendo scope	Device defined by Emmerich, a subtype of lacrimal endoscope	Rigid probe containing fiberoptics, internal illumination, and working channels	Enables simultaneous diagnosis and treatment[10,25-27]
Slit sign	Endoscopic finding	Linear mucosal gap in lacrimal sac indicating a fully patent nasolacrimal duct	Confirms duct patency with minimal invasiveness[28]
The duct	Convenient term encompassing two portions within the LOS	Lacrimal sac + nasolacrimal duct	Reflects anatomical ambiguity in dacryoendoscopic visualization
DLR	Duct Lumen Remnant [omukaeno ana]	Residual luminal space within fibrous blockage, formerly functional	Evidence of preserved anatomy; guides conservative intervention[29]
False passage	Iatrogenic, non-physiological tract	Misguided channel outside the true lumen–identifiable simple type or unidentifiable complex-type nasal endoscopically	Requires recognition and redirection to preserve anatomical integrity
MILS	Minimally invasive lacrimal surgery	Philosophy prioritizing mucosal preservation and anatomical fidelity	Emmerich's core ethos[27]
Radical MILS	Subtype within MILS	Aggressive intervention aiming for full restoration within the duct	Pursues DCR-level success with minimal invasion
Conservative MILS	Subtype within MILS	Minimal intervention preserving mucosa and anatomy	Offers alternative treatment as DCR triage
Straight group	Conceptual group defined in this review	Dacryologists using straight probe endoscopes with specialized devices (e.g., laser, microdrill)	Surgical philosophy emphasizing postoperative duct patency
Bent group	Conceptual group defined in this review	Dacryologists using bent probe endoscopes with common devices (e.g., sheaths)	Surgical philosophy emphasizing visualization, mucosal preservation, and anatomical fidelity
DEP	Direct endoscopic probing	Primitive recanalization technique using endoscope probe without sheath	Basic therapeutic dacryoendoscopy; suited for membranous blockage[28]
SEP	Sheath-guided endoscopic probing	Improved recanalization technique integrating visualization and treatment using sheath	Standard therapeutic dacryoendoscopy; embodies visual precision[29]
SNEP	Sheath-guided non-endoscopic probing	Modified SEP using a Bowman's probe within sheath for dense blockage recanalization	Advanced therapeutic dacryoendoscopy[30]
SGI	Sheath-guided intubation	Technique drawing lacrimal stent from punctum via sheath guidance	Avoids complex false passage formation[31]

DCR=Dacryocystorhinostomy

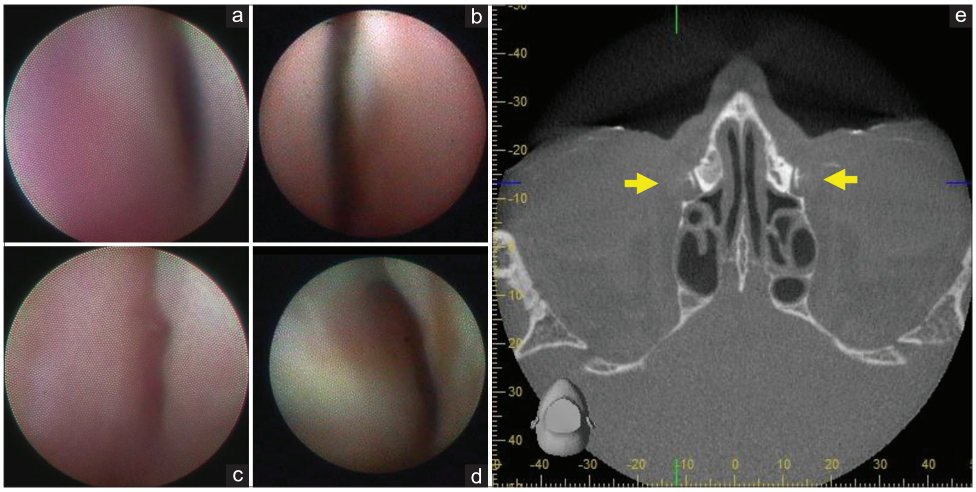

Figure 6: Slit sign in lacrimal sac. (a-d) Dacryoendoscopic images showing the slit sign, indicating a fully patent nasolacrimal duct (NLD). The slit sign has a sensitivity of 92% and specificity of 84% for determining NLD patency (Jpn J Ophthal Surg 2023;36 (2):271-75, [in Japanese]). (e) Horizontal computed tomography-dacryocystography image showing the slit sign (yellow arrow). Slit sign (a) observed in case (e), right-side lacrimal outflow system

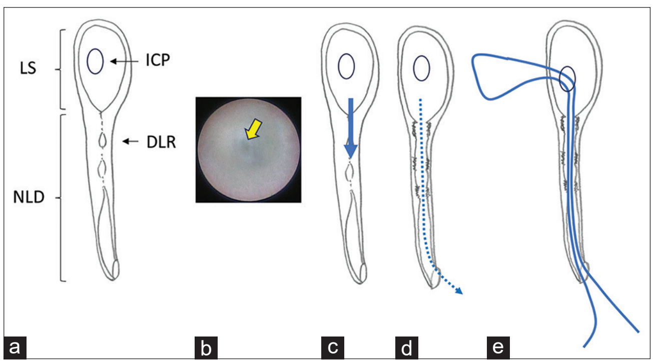

Figure 7: Duct lumen remnant (DLR). (a) DLR within the nasolacrimal duct (NLD) blockage. (b) Dacryoendoscopic image of the DLR (yellow arrow). (c) Recanalization was done along the physiological route by following the DLR (blue arrow). (d) Successful recanalization along the physiological route, with the endoscope trajectory shown by the dotted blue arrow. (e) Lacrimal stent (blue line) correctly placed within a single lumen of the physiological route. LS: Lacrimal sac, ICP: Internal common punctum

False passage

False passages may be created during either blind procedures or dacryoendoscopy, and their configurations vary considerably [Figures 8 and 9]. To clarify this divergence, the present review classifies false passages into two subtypes: Simple and complex.

Simple false passage

Traditionally, a false passage refers to stent malpositioning, which is typically diagnosed through nasal endoscopy. In a simple false passage, one end or both ends of the lacrimal stent protrude from distinct mucosal sites adjacent to the physiological ostium [Figure 8a]. This form is commonly associated with blind intubation, even when preceded by correct dacryoendoscopic recanalization.[34] Although theoretically preventable with nasal endoscopy, this may occur due to poor anatomical accessibility in the inferior meatus.

Complex false passage

With the advent of dacryoendoscopy, more intricate complex false passage configurations have been identified. For example, both ends of the stent may appear correctly positioned at the ostium, but one can traverse periductal tissue or orbit before re-entering the lumen [Figure 8b].[35] This configuration is undetectable through nasal endoscopy alone and was only previously observed intraoperatively during DCR.[36] Alternatively, the stent may deviate from the lumen and course through submucosal tissue [Figure 8c], typically due to poor visualization during dacryoendoscopic procedures. Such cases are identified mainly on postoperative diagnostic dacryoendoscopy.[37] Another complex configuration is when dacryoendoscopic recanalization fails to identify the DLR [Figure 9a], and both ends of the stent are guided within a single lumen of a nonphysiological route [Figure 9b]. This configuration is unique to dacryoendoscopic recanalization and intubation.

Results

Main advancements of dacryoendoscopy

Therapeutic dacryoendoscopy has evolved through both straight and bent probe applications, yielding notable diagnostic and surgical outcomes. The key studies are summarized in Tables 3 and 4, noting their areas of focus, techniques, findings, and success rates.[10,25-27,29-31,38-67]

Discussion

Probe morphology and surgical philosophy

As shown in Tables 3 and 4, the Straight and Bent groups differ fundamentally in their clinical philosophy. In adult dacryoendoscopy, the Straight group has several reports boasting high success rates over 90%.

Table 3: Achievements using straight probe endoscopes

Year	Author(s)	Focus	Technique	Cases/Findings	Success rates	Follow-up period	Reference
				Adult dacryoendoscopy			
1997–2000	Emmerich *et al.*	Diagnosis and success rate	SI versus LDP versus MDP versus Ex DCR	220 SI, 220 LDP, 75 MDP, 133 Ex DCR for LOO	77% (LDP), 82% (MDP)	3 months	[10,25-27]
2010	Javate *et al.*	Short term success rate	Javate's ELDR versus, Ex DCR	86 ELDR, 80 Ex DCR for PANDO	93% anatomical, 85% functional (ELDR); 94% anatomical, 90% functional (Ex DCR)	6 months	[38]
2013	Gao and Shan	Short term success rate	LDP	49 LDP for chronic dacryocystitis	84%	3–6 months	[39]
2013	Lü *et al.*	Short term success rate	Unspecified technique	64 procedures for chronic dacryocystitis	91%	3–6 months	[40]
2015	Zhang *et al.*	Short term success rate	LDP	24 procedures for CANO	75%	3 months	[41]
2015	Tang *et al.*	Short term success rate	MDP versus Ex DCR	62 MDP, 58 Ex DCR for chronic dacryocystitis	92% (MDP), 97% (Ex DCR)	1 year	[42]
2019	Stock *et al.*	Short-term success rate	LDP	40 CANS, 67 NLDO	71%	3 months	[43]
2023	Javate	Short-term success rate	Javate's ELDR w/ balloon procedure	35 ELDR for dense PANDO	96% anatomical=functional	61 weeks	[44]
2024	Li *et al.*	Long-term deterioration	LDP	170 prox NLDOs, 174 dist NLDO, 178 NLDS	85% overall; 91%–98% at 12 months, 65%–85% at 27 months, Kaplan–Meier	27 months	[45]
				Pediatric dacryoendoscopy			
2017	Heichel *et al.*	Short-term success rate	LDP	18 LDP for CNLDO with dacryocystitis	94%	3 months	[46]
2020	Gupta *et al.*	Long-term success rate	LDP	13 LDP for CNLDO	54%	3 years	[47]

SI=Silicone Intubation, LDP=Laser Dacryoplasty, MDP=Microdrill Dacryoplasty, Ex DCR=External Dacryocystorhinostomy, LOO=Lacrimal Outflow Obstruction, ELDR=Endoscopic Lacrimal Duct Recanalization, PANDO=Primary Acquired Nasolacrimal Duct Obstruction, CANO=Canalicular Obstruction, NLDO=Nasolacrimal Duct Obstruction, NLDS=Nasolacrimal Duct Stenosis, CANS=Canalicular Stenosis, CNLDO=Congenital Nasolacrimal Duct Obstruction

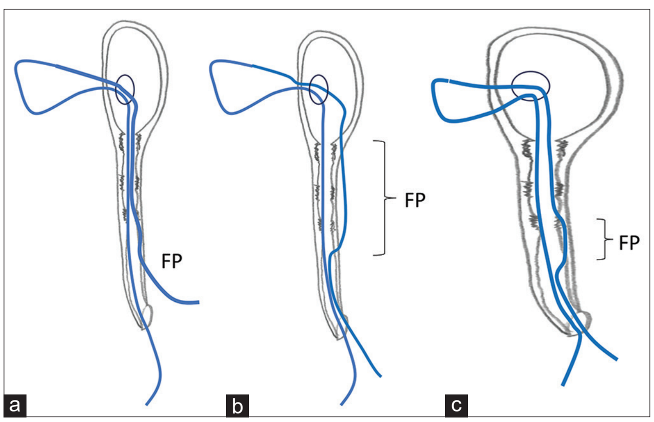

Figure 8: False passage (FP): Simple and complex types. Lacrimal stent (blue line). (a) Simple-type FP detectable through nasal endoscopy. (b) Complex-type FP seen on dacryoendoscopy. (c) Complex-type FP seen on postoperative diagnostic dacryoendoscopy

In contrast, Bent group reports lower success rates but places greater emphasis on diagnostic insight into the LOS and long-term deterioration. Some researchers may interpret the Bent group as a later-emerging anomaly, representing a divergent and less successful branch of dacryoendoscopy. However, we believe that the clinical philosophy of the Bent group originated not as a deviation, but rather from the very moment Emmerich

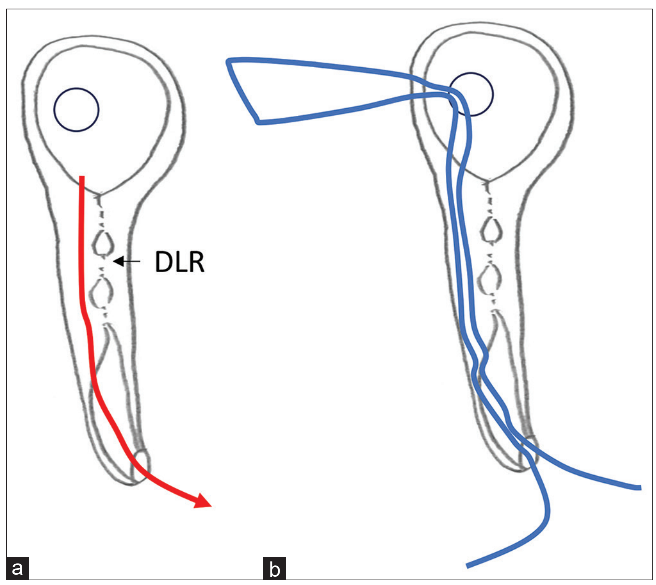

Figure 9: Complex-type false passage unique to dacryoendoscopy. (a) Dacryoendoscopic recanalization deviated from the duct lumen remnant (DLR), with the endoscopic image closely mimicking dense fibrous blockage. Even experienced surgeons may misinterpret this misdirection as blockage without the DLR (red line). (b) Lacrimal stent (blue line) precisely placed along the recanalized route, deviated from the original lumen

et al. introduced dacryoendoscopy into clinical practice in 1995.[10]

Table 4: Achievements using bent probe endoscopes

Year	Author(s)	Focus	Technique	Cases/findings	Success rates, conclusive metrics	Follow-up period	Reference
			Adult dacryoendoscopy				
2003	Suzuki	Diagnosis, Terminology	DEP	Slit sign, dimple	No description	N/A	[28]
2005	Suzuki	Diagnosis: epiphora causes	Diagnostic DE	5 retained lacrimal stents, false passages	N/A	N/A	[35]
2005	Fujii *et al.*	Diagnosis: False passage analysis	DEP/blind probing followed by DSI	65 NLDOs, 22% False passage	93.8% success rate after stent correction	6 months	[37]
2005	Sasaki *et al.*	Diagnosis: blockage localization	Diagnostic DE	149 NLDOs, 27% Low focal NLDO	N/A	N/A	[48]
2005	Sasaki *et al.*	Short term success rate	Inferior meatal dacryorhinotomy	40 Low focal NLDOs	87.50%	6 months–2 years	[49]
2007	Suzuki and Noda	Long-term deterioration (Kaplan–Meier)	DEP followed by DSI	137 NLDOs w/o canalicular blockage	Outcome: Shorter epiphora history ▯ longer patency	▯1200 days	[50]
2007	Sugimoto	New technical development	SEP	12 LOOs	No description	N/A	[29]
2008	Inoue	New technical development	SGI	89 LOOs, 2.2% False passage	No description	N/A	[31]
2010	Sugimoto and Inoue	Long-term deterioration (Kaplan–Meier)	DEP/SEP followed by DSI/SGI	639 NLDOs w/ wo canalicular blockage	Outcome: deterioration to 64% in long term	▯3000 days	[51]
2013	Sugimoto	New technical development	SNEP	N/A	N/A	N/A	[30]
2016	Mimura *et al.*	Diagnosis; post-STI granulation management	Steroid ointment injection guided by dacryoendoscope	9 granulations after STI	100% resolution without tube removal	12 months	[52]
2020	Bae *et al.*	Diagnosis: DCG versus DE	Evaluation of blockage localization	68 LOSs	κ=0.60	N/A	[53]
2021	Kamao *et al.*	Short term success rates	SEP followed by SGI (SEP and SGI)	128 LOOs	77.3%–100% according to blockage localization	6.5–72 months	[54]
2022	Nakamura *et al.*	Lacrimal stent size comparison (1.0 vs. 1.5 mm)	SEP followed by SGI (SEP and SGI)	130 NLDOs	1.0 mm versus 1.5 mm: 73.9% versus 85.7% (anatomical), 56.9% versus 84.7% (functional)	1 years	[55]
2022	Kim *et al.*	Long-term deterioration (Kaplan–Meier)	Diagnostic DE followed by therapeutic DE using sheath + STI	Structural versus inflamed, partial versus total type	Higher recurrence in the inflamed and total obstruction type	5 years	[56]
2022	Kim and Lew	Diagnosis: failure analysis after STI	Diagnostic DE followed by therapeutic DE	61 Recurrence after STI	62%–96% according to dacryoendoscopic findings	6 months	[57]
2022	Kim and Lew	Diagnosis: false passage management	Diagnostic DE followed by therapeutic DE using sheath + STI	19 False passages with a previous history of lacrimal procedures	73.7% in cases with false passages < normal case success rate	6 months	[58]
2023	Nakamura *et al.*	Diagnosis: Syringing test versus DE + CT-DCG	Evaluation of syringing accuracy	188 LOSs	κ=0.73	N/A	[59]
2023	Ueda *et al.*	Diagnosis: direct biopsy during dacryoendoscopy	Sheath-guided biopsy and drug delivery	Enhanced patency with steroid or rebamipide	N/A	N/A	[60]
2024	Kim and Lew	Diagnoses: indirect biopsy during dacryoendoscopy	Modified liquid-based thin prep method	Mucin plugs	N/A	N/A	[61]
			Pediatric dacryoendoscopy				
2013	Sasaki *et al.*	Short term success rates	DEP	13CNLDOs	92.30%	6 months	[62]

Contd...

Table 4: Contd...

Year	Author(s)	Focus	Technique	Cases/findings	Success rates, conclusive metrics	Follow-up period	Reference
			Pediatric dacryoendoscopy				
2016	Matsumura *et al.*	Diagnosis	Diagnostic DE using a high-resolution endoscope	59 CNLDOs + SANDO	N/A	N/A	[63]
2019	Matsumura *et al.*	Short term success rates	SEP + DSI/G-SGI	56 CNLDOs	100%	6 months	[64]
2020	Nakayama *et al.*	Short term success rates	DEP + DSI	85 CNLDOs	97.60%	3 months	[65]
2023	Ueta *et al.*	Short term success rates	DEP	72CNLDOs	97.20%	2 weeks	[66]
2024	Nakamura *et al.*	Diagnosis: LOS morphology in CNLDO using DCG	Evaluation of probe trajectory within the duct	64 NLDOs	27% cases of steeper trajectory due to SOR interference	N/A	[67]

DEP=Direct Endoscopic Probing, DSI=Direct Silicone Intubation, NLDO=Nasolacrimal Duct Obstruction, DE=Dacryoendoscopy, SEP=Sheath-guided Endoscopic Probing, SGI=Sheath-guided Intubation, LOO=Lacrimal Outflow Obstruction, SNEP=Sheath-guided Non-Endoscopic Probing, STI=Silicone Tube Intubation, DCG=Dacryocystography, LOS=Lacrimal Outflow System, CT-DCG=Computed Tomography-Dacryocystography, G-SGI=Goto's Sheath-guided Intubation,[68] CNLDO=Congenital Nasolacrimal Duct Obstruction, SANDO=Secondary Acquired Nasolacrimal Duct Obstruction, SOR=Superomedial Orbital Ridge, NA: Not available

Through a series of four foundational reports,[10,25-27] Emmerich first demonstrated that dacryoendoscopy was clinically feasible as a novel visualization tool for diagnosing lacrimal disorders. This direct visualization of mucosal pathology enabled the precise classification of blockage localization and guiding tailored interventions. In addition, techniques such as laser dacryoplasty (LDP) and microdrill dacryoplasty (MDP) were introduced with silicone intubation to maintain patency. Patient selection was central to this process, reflecting a philosophy that prioritized diagnostic clarity and mucosal preservation over procedural aggressiveness. This early framework reveals the conceptual origin of the Bent group, whose clinical philosophy was influenced by the minimally invasive ethos of Emmerich.

Dacryologists in China subsequently adopted and developed the dacryoendoscope of Emmerich, alongside the techniques of LDP and MDP.[39-42] They reported short-term (<1 year) success rates ranging from 84% to 92%, although their studies rarely addressed mucosal pathology or the rationale for surgical selection based on endoscopic findings. Similarly, Javate also reported high success rates exceeding 93%.[38,44] To complete dacryoendoscopy using his own lacrimal trephine, he commissioned a separate company to develop a straight probe endoscope, distinct from Emmerich's original provider. This gave rise to a novel technique for endoscopic lacrimal duct recanalization, termed Javate's ELDR. His work similarly highlighted dacryoendoscopy as a minimally invasive and efficient alternative to external dacryocystorhinostomy (Ex DCR), with less emphasis on diagnostic evaluation. This perspective implies the narrowing role of Ex DCR.

These contributions are undeniably impressive and deserve recognition for demonstrating the full potential of dacryoendoscopy as a replacement for Ex DCR. Unfortunately, their outcomes are distilled into a single percentage derived from simple arithmetic. These studies fail to address the inherent challenge of long-term deterioration, a fate that dacryoendoscopic surgery cannot escape, nor do they discuss the critical diagnostic concern of false passage formation. There appears to be an aggressive pursuit of high success rates. In addition, the use of laser, microdrill, and metal trephine raises further questions about whether mucosal preservation in the LOS is truly being considered. These techniques may create artificial routes with high short-term success but are devoid of healthy mucosa.

Such approaches may extend beyond the scope of Emmerich's original philosophy of mucosal preservation and MILS. Thus, the surgical form adopted by the Straight group might be better described as radical MILS. For many years, we hoped that this respected radical MILS approach could be validated through Kaplan–Meier analysis. While this has been sporadically used in Bent group studies since its inception,[50] it has been notably absent from the Straight group until recently, showing an absence of deterioration over time.

In 2024, a long-awaited study from the Straight group was finally published.[45] Li *et al*. conducted a Kaplan–Meier analysis of successful cases over a follow-up of up to 27 months. Although not strictly long term, their findings revealed that even very high short-term success rates were ultimately subject to rapid deterioration. Some outcome differences were also examined based on the dacryoendoscopic diagnostic classification, echoing Emmerich's original emphasis on diagnostic value. Therefore, even radical MILS cannot escape the fate of deterioration. Some dacryologists may challenge this view, although such rebuttals must be supported by equally rigorous study designs demonstrating sustained success beyond at least 3 years. Despite the difficulty of long-term follow-up, both Javate and Li *et al.* demonstrated that anatomical and functional success rates are closely aligned,[44,45] suggesting that even telephone surveys assessing epiphora symptoms can suffice as meaningful long-term evaluation.

The limitations of short-term metrics and the absence of diagnostic emphasis in many Straight group studies underscore the need to reexamine what dacryoendoscopy was originally designed to achieve. In contrast to the procedural assertiveness seen in radical MILS, the Bent group has consistently prioritized diagnostic clarity, mucosal preservation, and long-term anatomical understanding. This ethos is not merely a reaction to surgical outcomes but rather a deliberate, philosophical stance rooted in the belief that visualization precedes intervention. They believe that the LOS must be first understood before it is altered. This approach may be described as "conservative MILS" since it values restraint, anatomical insight, and diagnostic precision over procedural dominance. Importantly, this philosophy does not oppose Emmerich's original vision but rather builds upon it. The early reports of Emmerich emphasized direct visualization, selective intervention, and mucosal integrity, laying the conceptual foundation for a diagnostic-first ethos. Thus, the conservative MILS practiced by the Bent group would be best described as a faithful evolution, rather than a deviation, of Emmerich's minimally invasive ideal.

Despite their lower success rates in adult dacryoendoscopy, the Bent group studies compensate with richer anatomical insight and a willingness to accept complexity. For example, early Bent group reports such as that by Fujii *et al*. documented anatomical success rates exceeding 90%,[37] demonstrating that diagnostic emphasis does not preclude favorable short-term outcomes. Rather than simplifying pathology into binary outcomes, these reports explore the nuances of mucosal texture, false passage formation, and blockage morphology. Therefore, success in dacryoendoscopy cannot be defined merely by a single number, but rather it is a sustained dialogue between diagnosis, intervention, and time.

Historical background of the bent probe endoscope and false passage

We offer a personal interpretation regarding the diagnostic emphasis frequently seen in Bent group studies. Aside from being the most prominent feature of Emmerich's original concept of dacryoendoscopy, this focus on diagnosis is also deeply rooted in the historical background of the Bent probe itself.

Initially, the Bent group used dacryoendoscopy to identify problematic conditions encountered during blind intubation for the treatment of epiphora. Their original focus was never on establishing a new surgical technique to replace Ex DCR, but rather on diagnosing the underlying causes of complications that were prevalent in lacrimal surgery at the time. Before 2000, NLD intubation in Japan shifted from the Crawford technique to a more convenient method known as direct silicone intubation (DSI), which employed the Nunchaku-style silicone tube (N-ST) developed by Kurihashi in 1993.[69] Although DSI reportedly achieved high success rates similar to the Straight group, intraoperative technical difficulties were often observed during stent insertion. Thus, lacrimal surgeons sought visualization inside the LOS not only preoperatively but also intraoperatively and postoperatively.

To achieve this, an endoscope capable of exploring the full extent of the LOS, especially the distal NLD, was required. A bent probe endoscope was more suitable than straight probes for this purpose, offering superior accessibility and controllability when investigating stent insertion difficulties. Using this instrument, the Bent group reported false passage formation during DSI in up to 22% of cases.[37] Simultaneously, false passages in silicone intubation were generally considered to be of the simple type and to be preventable through the use of a nasal endoscope during DSI. However, the findings reveal another reality, i.e., false passages still occurred in 22% of cases despite nasal endoscopic guidance, suggesting that the mucosal condition within the LOS was far more complex than previously anticipated. Consequently, a new category, the complex type of false passage, was identified as the predominant form associated with DSI.

In practice, complex false passages were more frequently discovered not during the initial procedure, but in subsequent diagnostic dacryoendoscopy performed after days or weeks.[37] These false passages were newly formed during the intubation process itself, even after dacryoendoscopic recanalization. Thus, despite using dacryoendoscopy to visualize and guide recanalization, the act of intubation itself could still create a false passage. These complex false passages were difficult to detect despite the superior accessibility and controllability of the bent probe endoscope. These cases challenge the assumption that visualization alone could prevent false passage formation during the recanalization process, highlighting the need for a new intubation technique that could be continuously guided and monitored by a dacryoendoscope itself.

New method of dacryoendoscopic intubation using Teflon sheath

In 2008, Inoue developed a new technique to prevent false passage intubation, sheath-guided intubation (SGI).[31] Prior to this, Sugimoto introduced a recanalization technique that improves visibility within fibrous blockage tissue, termed sheath-guided endoscopic probing (SEP).[29] In both techniques, an elastic 18 G intravenous catheter is placed over the dacryoendoscope probe as a sheath and used as a guide for recanalization and intubation.

When SGI is combined with SEP, lacrimal stents connected to the sheath are precisely drawn into the recanalized route during sheath retrieval from the inferior meatus.[54] The use of a single sheath enables the entire process, from recanalization to intubation, to be performed under continuous dacryoendoscopic visualization. This combined technique, known as SEP and SGI, has now become the standard method for dacryoendoscopic intubation in Japan, and has reduced the false passage formation rate to 2%,[31] originally from 22% in DSI.[37]

However, this innovation does not eliminate all cases of complex false passage intubation. If the DLR cannot be identified during SEP, resulting in the creation of a false passage, then the lacrimal stent may still be accurately drawn into that route by SGI [Figure 9]. In other words, overlooking the DLR increases the risk of false passage formation. The endoscope may be guided by the bony nasolacrimal canal to the inferior meatus, bypassing the DLR entirely, even when the DLR is present but not visualized. The resulting lumen is a nonphysiological route that is artificially created by misdirected probing. Furthermore, dacryoendoscopic images within fibrous tissue surrounding the DLR are indistinguishable from dense blockages without the DLR, which can be misinterpreted even by experienced surgeons who are unaware that the true DLR was overlooked. Nevertheless, this innovation marks a turning point that expanded the diagnosis-centered philosophy of the Bent group into a broader framework that encompasses a fully visualized therapeutic approach.

Therapeutic dacryoendoscopy in the Bent group

The approach of the Bent group to therapeutic dacryoendoscopy embodies the philosophy of conservative MILS, emphasizing mucosal preservation and the regeneration of healthy tissue. Their strategy in adult NLDO avoids excessive invasion and prioritizes the elimination of false passages. In contrast, removing fibrous tissue in the Straight group can risk damaging residual or adjacent healthy mucosa, potentially compromising physiological drainage restoration. Moreover, unrecognized migration of the dacryoendoscope into the submucosal tissue (i.e., false passage formation) followed by tissue removal may cause unintended injury.

Due to the structural limitations of the bent probe endoscope, aggressive instruments (e.g., lasers, microdrills, and metal trephines) are not applicable and are fundamentally incompatible with the Bent group's philosophy. Instead, the Bent group relies on a simple elastic sheath, an accessible, gentle tool found in any hospital, to carefully open the DLR, although some may consider this sheath invasive due to its 1.1-mm thickness. Nevertheless, Sugimoto demonstrated its utility in locating and recanalizing the DLR, as first documented in the development of SEP in 2007,[29] a task previously difficult with direct endoscopic probing.[28]

The Straight group believes that conservative MILS cannot address dense blockage tissue, which may require radical MILS. Nevertheless, such dense blockages are often associated with canalicular damage following oral administration of TS-1 (tegafur/gimeracil/oteracil) or viral infection, which conditions not fundamentally suited for dacryoendoscopy. Within the duct, dense tissue is typically confined to the surface of the obstructive membrane, where sheath-guided nonendoscopic probing (SNEP), a combined sheath technique with Bowman's probe, can be effective.[30] Furthermore, the presence of dense resistance during recanalization often suggests false passage formation, and such cases should be converted to DCR.

Skepticism regarding the accessibility of straight probe endoscopes within the duct initially led to the promotion of the bent probe endoscope, which has long supported conservative MILS. This technique involves careful and delicate recanalization while avoiding aggressive removal of the blockage tissue. The elastic sheath is used to gently follow and widen the DLR, ideally until the slit sign is restored. Preoperative CT can help determine the inclination of the nasolacrimal canal. Inward types are navigated with meticulous finger control, while posterior types can be managed with modified SNEP, partially with blind probing under nasal endoscopic guidance. Even if the bent probes are optimally angled, the duct opening is reached in only 77% of normal cases,[13] suggesting that the probe may exit through a false passage in 23% of recanalization cases. Thus, while the bent probe reduces false passages, its aggressive use (even with the intent of full visualization) can create false passages.

The Bent group's contributions are especially evident in pediatric cases. Conversely, reports from the Straight group in this area remain limited and had less effective outcomes.[47] The primary concern is infantile epiphora, which is primarily due to congenital NLD obstruction (CNLDO), though occasionally involving acquired forms. Matsumura's work clearly distinguished these conditions.[63] In an analysis of lateral dacryocystography (DCG) images in CNLDO, Nakamura *et al*. reported that SOR interference hinders straight probe trajectory in 27% of cases, underscoring the potential importance of bent probes.[67] Considering the generally favorable prognosis of CNLDO, radical MILS is fundamentally unsuitable. Conservative MILS is far more appropriate for pediatric cases, especially since it integrates diagnosis and treatment while minimizing invasiveness.

Advanced dacryoendoscopy as a diagnostic application in the Bent group

Bae examined the consistency between dacryoendoscopic findings and DCG.[53] Nakamura proposed that combining dacryoendoscopy with CT-DCG offers the most accurate assessment of lacrimal patency; this approach was used to evaluate the reliability of the traditional syringing test.[59] Meanwhile, Ueda opened a new avenue by introducing dacryoendoscopic biopsy within the LOS.[60] Lastly, Ishikawa developed a novel corneal disease category, lacrimal drainage pathway disease-associated keratopathy, based on dacryoendoscopic findings.[70,71]

The contributions of dacryoendoscopy to ophthalmology extend beyond lacrimal surgery, influencing the categorization of ocular surface disease. To support its broader clinical use, the Japanese Society of Lacrimal Passage and Tear Dynamics established formal protocols for endoscope hygiene and management.[72]

Dacryoendoscopy is now being increasingly recognized as a standard ophthalmic instrument in Japan. An introductory textbook, supplemented with lots of technical video links, was published in 2013.[73] Beyond Japan, across Asia, the bent probe endoscope has become the most widely used dacryoendoscopic device.[3]

Comparative perspectives on diagnostic and therapeutic dacryoendoscopy

Diagnostic dacryoendoscopy specializes in real-time, direct visualization of the LOS, enabling precise localization and assessment of stenosis severity without radiological exposure. This offers a comparative advantage over DCG and CT-DCG, which provide structural outlines but lack dynamic mucosal feedback. However, CT-DCG remains useful for functional evaluation via passive contrast instillation, allowing visualization without active injection.[74] Furthermore, therapeutic dacryoendoscopy enables targeted recanalization under local anesthesia without any incision, reconstructing the physiological route of the LOS. This contrasts with DCR, which requires osteotomy but achieves high long-term success. Owing to its patient-friendly approach, dacryoendoscopy is repeatable and allows for deferred DCR until patients are ready to accept surgical invasiveness.

Conclusion

Although dacryoendoscopy has demonstrated diagnostic and therapeutic value across all age groups,[1-4] it cannot reveal everything. Notably, pathology outside the duct, such as tumors or inflammatory sinus disease, remains beyond its field of view. Moreover, inadvertent false passages are indistinguishable from fibrous blockage without the DLR. Most importantly, anatomical truth may lie beyond the illuminated lumen. Thus, this awareness of what remains unseen should be central when performing dacryoendoscopy, allowing for true MILS. Practicing dacryoendoscopy with humility – not merely prioritizing visual access or surgical outcomes – may facilitate its true advantage and guide its responsible evolution. Furthermore, future perspectives include the integration of digital imaging, AI-assisted interpretation, and microendoscopic refinement. These advances may enhance diagnostic precision, automate pattern recognition, and reduce procedural variability. However, the philosophical core of dacryoendoscopy – direct visualization and anatomical respect – must remain central. As technology evolves, preserving this ethos will be essential to ensure that innovation serves insight, not merely efficiency.

Declaration of generative AI use

The authors used Microsoft Copilot for editorial support, including language refinement and structural suggestions. All revisions were made by the authors, who take full responsibility for the final content.

Data availability statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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