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ORIGINAL RESEARCH

Optimizing Endo-DCR Outcomes in Traumatic Nasolacrimal Duct Obstruction

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Purpose: We evaluated the clinical value of computed tomography dacryocystography with multiplanar reconstruction (CT-DCG-MPR) in assisting endoscopic dacryocystorhinostomy (Endo-DCR) for traumatic nasolacrimal duct obstruction (NLDO).

Patients and Methods: We retrospectively analyzed 16 patients (18 eyes) with traumatic NLDO who were treated between April 2019 and November 2021. All patients underwent CT-DCG-MPR and Endo-DCR. Patient demographics, fracture patterns, and surgical outcomes were analyzed.

Results: The cohort had a mean age of 41.2 ± 12.3 years, and 62.5% were male. Traffic accidents were the predominant injury mechanism (81.3%). Naso-orbito-ethmoidal (NOE) fractures were the most common type. CT-DCG-MPR showed a 94.7% correlation with intraoperative findings. Endo-DCR achieved 94.4% anatomical success and 88.9% functional success, with significant symptom improvement ($p < 0.001$).

Conclusion: The lacrimal sac–nasolacrimal duct junction was the most frequent site of obstruction or fracture in traumatic NLDO. CT-DCG-MPR-guided Endo-DCR is highly effective for traumatic NLDO, providing precise preoperative planning and excellent long-term outcomes.

Keywords: computerized tomography dacryocystography, endoscopic dacryocystorhinostomy, multiplanar reconstruction, traumatic nasolacrimal duct obstruction

Introduction

Nasolacrimal duct obstruction (NLDO) following maxillofacial trauma presents complex diagnostic and therapeutic challenges. The naso-orbito-ethmoidal (NOE) complex, with its intricate anatomy, is particularly vulnerable to injury, with reported incidence rates of 20–30% in midface trauma cases.[1] Traditional management approaches, while effective, often fail to address the three-dimensional complexity of post-traumatic anatomical distortions.

Recent advancements in imaging technology and endoscopic techniques have revolutionized the management paradigm. Multiplanar CT reconstruction combined with dacryocystography (CT-DCG-MPR) now enables millimeter-level visualization of the lacrimal drainage pathway,[2] while endoscopic approaches offer minimally invasive solutions with superior cosmetic outcomes.[3] However, the integration of these technologies into a standardized treatment protocol remains inadequately explored, particularly for traumatic etiologies in which anatomical landmarks are often disrupted.

This study presents our institutional experience with 16 consecutive cases, demonstrating how the synergistic application of advanced imaging and endoscopic techniques can overcome traditional limitations. We focus specifically on: (1) the diagnostic accuracy of CT-DCG-MPR in fracture characterization, (2) the surgical outcomes of image-guided endoscopic dacryocystorhinostomy (Endo-DCR), and (3) the long-term patency rates in this challenging patient population.Conventional approaches, such as external dacryocystorhinostomy(Ex-DCR), are frequently limited by postoperative scarring and disruption of medial canthal anatomy—issues that may be mitigated through image-guided endoscopic techniques.

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Material and Methods

Study Design and Participants

We conducted a retrospective analysis of patients treated at the Department of Ophthalmology, Ningbo University-affiliated Li Huili Hospital between April 2019 and November 2021. The inclusion criteria were: (1) documented history of facial trauma, (2) clinical evidence of NLDO (epiphora or dacryocystitis), and (3) radiographic confirmation of nasolacrimal system injury. Patients with non-traumatic NLDO etiologies (congenital, inflammatory, or neoplastic) were excluded.

The final cohort included 16 patients (18 eyes), with demographic and clinical characteristics summarized in Table 1. The study protocol adhered to the principles of the Declaration of Helsinki (World Medical Association, 2013) and received ethical approval from the Institutional Review Board (Ethics No. KY2022PJ038). Written informed consent was obtained from all participants prior to enrollment.

Imaging Protocol

All patients underwent CT-DCG-MPR according to a standardized protocol. After administration of topical anesthesia, 2 mL of non-ionic iodinated contrast medium (iopromide, Ultravist-370, 370 mg iodine/mL; Bayer Pharma AG, Berlin, Germany) was injected through the inferior lacrimal punctum with gentle sac compression to ensure uniform contrast distribution (performed only after confirming absence of iodine allergy history). Axial scans were acquired using a 64-detector row CT scanner (Philips Brilliance 64; Philips Healthcare, the Netherlands) from the supraorbital margin to the hard palate, parallel to the infraorbital line.[4] Scan parameters were as follows: Voltage: 120 kV; Current: 225 mA; Detector configuration: 16×0.75 mm; Pitch: 0.563; Reconstruction matrix: 512×512; Field of view: 15 cm; Collimation: 0.75 mm; Slice thickness: 1 mm (0.5 mm intervals).

Multiplanar reconstructions (2 mm thickness, 0 mm spacing) were generated using the Philips EBW workstation and analyzed in both bone (window width [WW]: 2000–3000 hounsfield units [HU]; window level [WL]: 400–600 hU) and soft tissue (WW: 350–400 hU; WL: 40–60 hU) settings. The most diagnostically significant images were selected based on evaluation in three orthogonal planes (axial, coronal, sagittal) according to the following criteria: (1) maximal lacrimal sac cross-sectional area, (2) optimal fracture line visualization, and (3) longest continuous nasolacrimal duct segment.

Surgical Technique

All Endo-DCR procedures were performed under general endotracheal anesthesia by a standardized surgical team. The nasal cavity was initially prepared with 1:1000 (w/v) epinephrine-soaked cotton pledgets for 10 minutes to achieve decongestion, followed by identification of anatomical landmarks using 0° and 30° rigid endoscopes (Karl Storz GmbH & Co. KG, Germany) and submucosal injection of 2% lidocaine with 1:100,000 epinephrine at the lateral nasal wall. A 10-mm mucosal incision was made 1 cm anterior to the middle turbinate insertion, through which osteotomy was performed using 2–3 mm Kerrison rongeurs (B. Braun Aesculap, Germany) and a high-speed drill (15,000 rpm, 1-mm diamond burr) under CT-DCG-MPR guidance, creating a 15×10 mm bone window extending to the medial canthal

Table 1 Patient Characteristics and Fracture Patterns

Variable	Value (n=16)
Age (years)	41.2 ± 12.3 (18–63)
Sex (Male:Female)	10:6 (62.5%:37.5%)
Trauma Mechanism	
- Road traffic accidents	13 (81.3%)
- Blunt-force impact	2 (12.5%)
- Falls	1 (6.2%)
Fracture Type	
- Isolated NOE	8 (50.0%)
- NOE + zygomatic	3 (18.8%)
- NOE + skull base	1 (6.2%)
- Isolated NLD fracture	4 (25.0%)

tendon level. The displaced lacrimal sac was endoscopically identified, vertically incised (5–7 mm), and marsupialized without suturing. In cases with canalicular stenosis (n=2/16, 12.5%), silicone intubation (Crawford tubes) was performed. Intraoperative CT-DCG-MPR correlation was utilized for anatomical confirmation in complex cases (n=3/16, 18.8%), with hemostasis achieved through bipolar cautery and absorbable nasal packing (Surgicel®).

Postoperative Evaluation and Follow-up

All patients received standardized postoperative management consisting of topical tobramycin-dexamethasone (Tobradex® 0.1% ophthalmic suspension, Alcon) administered four times daily for 4 weeks combined with twice-daily nasal saline irrigation for 8 weeks. The first endoscopic debridement was performed at 2 postoperative weeks to assess ostium healing, with silicone stents (when present) removed under direct endoscopic visualization at 3 months. Patients underwent systematic follow-up evaluations at 1 week, 1 month, 3 months, and 6 months postoperatively followed by annual assessments, with each examination including: (1) standardized Munk epiphora grading (Table 2), (2) endoscopic verification of ostium patency (>3 mm diameter) and mucosal re-epithelialization, (3) fluorescein dye disappearance test (FDDT; ≤3 minutes considered normal), and (4) lacrimal irrigation when indicated. Treatment outcomes were stratified into three categories: success (asymptomatic with patent irrigation and stable ostium >3 mm), improved (≥50% symptom reduction but residual epiphora), or failure (persistent symptoms requiring surgical revision), with all assessments conducted by the same surgical team to ensure consistency.

Statistical Analysis

Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were expressed as numbers and percentages [n (%)]. Survival analysis was performed using the Kaplan-Meier method to evaluate long-term ostium patency rates. The threshold for statistical significance was established a priori at $p < 0.05$ (two-tailed). All analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA), with detailed methodological considerations provided in the Results section.

Results

This retrospective study analyzed 16 consecutive patients (18 eyes) with traumatic NLDO treated at Ningbo University Affiliated Li Huili Hospital between April 2019 and November 2021. The cohort demonstrated male predominance (10 males, 62.5%) with a mean age of 41.2±12.3 years and a mean follow-up duration of 55.4±10.9 months (up to January 2025). Road traffic accidents accounted for the majority of injuries (13 cases, 81.3%), with NOE fractures being the most common fracture pattern (12 cases, 75.0%), including 8 isolated NOE fractures, 3 NOE-zygomatic complex fractures, and 1 NOE-skull base fracture. Four patients (25.0%) presented with isolated nasolacrimal duct fractures (Table 1).

Intraoperative findings confirmed CT-DCG-MPR's diagnostic accuracy, revealing lacrimal sac displacement (12 eyes, 66.7%), sac rupture (4 eyes, 22.2%), medial canthal tendon disruption (3 patients, 18.8%), and nasal septal deviation (9 eyes, 50.0%). CT-DCG-MPR demonstrated significantly superior performance compared to conventional CT in obstruction level specificity (92.3% vs 69.2%, p=0.032), sac displacement sensitivity (100% vs 58.3%, p=0.002), and positive predictive value (94.7% vs 63.2%, p=0.002). Two eyes (11.1%) with canalicular stenosis required silicone intubation (Table 3).

The postoperative results demonstrated significant clinical improvement, with epiphora severity decreasing from 66.7% preoperatively to 5.6% at the 6-month follow-up (p<0.001). Transient complications included adhesions (3 eyes, 16.7%) and granulation tissue (2 eyes, 11.1%), all of which resolved completely with appropriate management. Notably,

Table 2 Standardized Epiphora Grading Scale

Grade	Clinical Characteristics
0	No epiphora
1	Mild (occasional moisture requiring dabbing <2×/day)
2	Moderate (persistent moisture requiring dabbing 3–5×/day)
3	Severe (constant tearing requiring dabbing >5×/day or functional impairment)

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Table 3 Diagnostic Performance: CT-DCG-MPR Vs Conventional CT

Parameter	CT-DCG-MPR	Conventional CT	p-Value
Obstruction specificity	92.3%	69.2%	0.032
Sac displacement	100%	58.3%	0.002
Fracture extension	94.1%	82.4%	0.125
PPV	94.7%	63.2%	0.002

Table 4 Postoperative Outcomes and Complications

Parameter	Preoperative (n=18 eyes)	6-Month Postoperative (n=18 eyes)	Final Follow-Up	p-Value
Epiphora Grading				<0.001
- Grade 0 (None)	0 (0%)	14 (77.8%)	16 (88.9%)	
- Grade 1 (Mild)	0 (0%)	2 (11.1%)	1 (5.6%)	
- Grade 2 (Moderate)	6 (33.3%)	1 (5.6%)	1 (5.6%)	
- Grade 3 (Severe)	12 (66.7%)	1 (5.6%)	0 (0%)	
Complications	–	5 (27.8%)	0 (0%)	–
- Synechiae	–	3 (16.7%)	Resolved	
- Granulation tissue	–	2 (11.1%)	Resolved	
Success Rates	–	–	–	
- Anatomical success	–	–	17 (94.4%)	
- Functional success	–	–	16 (88.9%)	

Abbreviations: CT-DCG, computerized tomography dacryocystography; Endo-DCR, endoscopic dacryocystorhinostomy; NLDO, nasolacrimal duct obstruction; MPR,multiplanar reconstruction; NOE, nasoorbitoethmoidal; Ex-DCR, external dacryocystorhinostomy.

one patient developed severe nasal septal deviation requiring revision surgery for correction, while two others presented with minor nasal synechiae affecting functional recovery. Final evaluation revealed 94.4% anatomical success (17/18 eyes) and 88.9% functional success (16/18 eyes) (Table 4).

Representative Case Report

A 33-year-old male with a history of blunt-force trauma to the right orbit, resulting in fractures of the lateral orbital wall, anterolateral maxilla, and nasal septal deviation, developed progressive chronic dacryocystitis over one year. CT-DCG-MPR imaging revealed:(1) lateral displacement of the contrast-filled lacrimal sac (Figure 1A, red arrow), and (2) a clearly identifiable

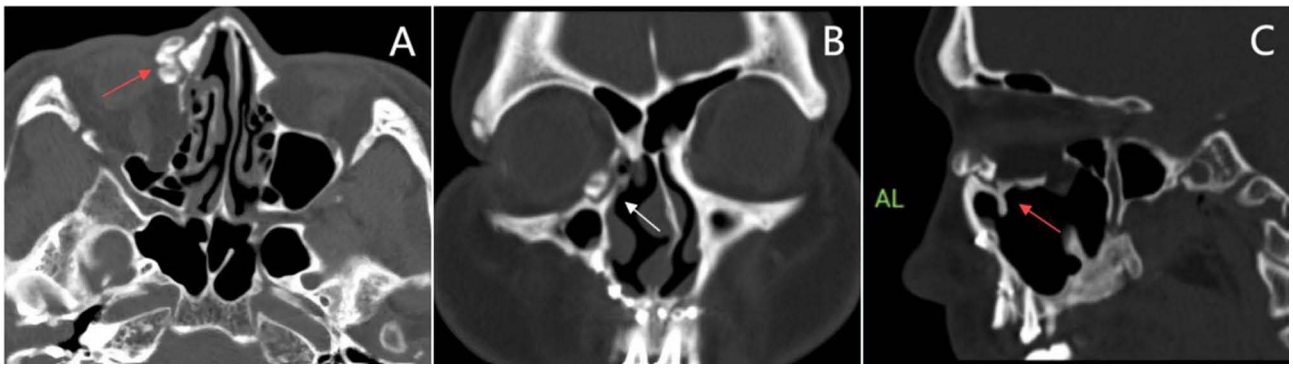

Figure 1 CT-DCG-MPR findings in a patient with epiphora and purulent discharge following blunt trauma. (**A**) Axial view showing lateral displacement of the lacrimal sac (red arrow). (**B**) Coronal view illustrating a maxillary frontal process fracture (white arrow, 8-mm displacement) and 15° nasal septal deviation. (**C**) Sagittal view demonstrating a nasolacrimal duct fracture (red arrow).(All images acquired with iopromide enhancement, 1-mm slice thickness.).

nasolacrimal duct fracture across all reconstructed planes (Figure 1A–C). Endo-DCR confirmed an 8-mm displaced fracture of the maxillary frontal process and abnormal lacrimal sac positioning, with intraoperative findings fully consistent with preoperative imaging. Postoperatively, the patient exhibited patent lacrimal irrigation and complete resolution of epiphora (VAS score improved from 9 to 1). At 12-month follow-up, postoperative endoscopic evidence demonstrated complete mucosal epithelialization of a 3.5-mm diameter ostium.

Discussion

Our comprehensive analysis of traumatic NLDO management yields clinically significant findings that warrant detailed discussion. The injury etiology and fracture patterns observed in our cohort provide critical insights into the biomechanical vulnerability of the nasolacrimal system. Bipasha Mukherjee's retrospective analysis of 28 traumatic dacryocystitis cases demonstrated that 70% resulted from high-velocity blunt trauma due to road traffic accidents, with NOE fractures representing 64% of injuries.[5] Our study corroborates these findings, showing road traffic accidents as the predominant etiology (81.3%) and NOE complex involvement in 75.0% of cases. The fracture patterns ranged from isolated NOE fractures (50.0%) to complex NOE-zygomatic (18.8%) and NOE-skull base (6.2%) combinations. Uraloglu et al reported a 68.4% incidence of NLDO following NOE fractures, manifesting as permanent epiphora or chronic dacryocystitis,[6] highlighting the critical relationship between fracture patterns and subsequent lacrimal dysfunction. This vulnerability stems from three anatomical factors: (1) inherent structural weakness at the frontal process-maxilla articulation, (2) concentration of shear forces during impact, and (3) natural narrowing at the lacrimal sac-duct transition zone.

The diagnostic performance of CT-DCG-MPR in our series represents a significant advancement in traumatic NLDO evaluation. Conventional CT's well-documented limitations in NOE fracture assessment - with only 5% concordance with surgical findings[7] - stem from its inability to adequately visualize the complex 20–25° angulation between the lacrimal sac and bony duct axes.[8] Our CT-DCG-MPR protocol achieved 94.7% positive predictive value for surgical findings and 92.3% specificity for obstruction level localization (vs 69.2% for conventional CT, p=0.032). These results are consistent with Wushuang Wang's analysis of 114 lacrimal trauma cases, which emphasized the importance of multiplanar CT reconstruction for preoperative assessment of lacrimal sac dimensions and obstruction levels.[9]

For surgical management, while external dacryocystorhinostomy(EX-DCR) was historically preferred for its wide surgical field,[10] it carries inherent risks of iatrogenic mucosal injury and scar formation.[11] In contrast, Endo-DCR offers distinct advantages:[12] (1) unobstructed visualization of the entire lacrimal drainage system, (2) precise mucosal flap creation under direct vision, and (3) preservation of the medial canthal tendon and lacrimal pump mechanism. Although Rajabi's comparison of 803 cases showed comparable patient satisfaction between Endo-DCR (73%) and EX-DCR (82%),[3] our data suggest CT-DCG-MPR guidance enhances endoscopic outcomes through more accurate osteotomy placement in post-traumatic anatomy. Welham and Wulc's analysis of 208 unsuccessful DCR cases demonstrated the superiority of Endo-DCR over EX-DCR, as endoscopy provides better identification of ethmoid sinus structures and related mucosa.[13] Li's evaluation of clinical characteristics, surgical treatment, and outcomes in 80 pediatric cases with post-traumatic nasolacrimal duct obstruction revealed that while both approaches achieved comparable anatomical and functional success rates, Endo-DCR offered the distinct advantage of reduced facial scarring.[14]

The surgical approach for traumatic NLDO differs from that for primary acquired dacryocystitis in terms of osteotomy window size and location. Based on our experience, traumatic cases typically require wider osteotomy windows and larger ostium diameters. In Endo-DCR technique, complete exposure of the sac fundus is crucial, with optimal positioning achieved when the osteotomy window covers more than half of the lacrimal sac. For trauma patients, several factors significantly impact surgical outcomes: disruption of orbital rim structures severely compromises surgical landmarks and osteotomy placement accuracy; facial scar tissue (particularly from previous trauma or surgery) impairs lacrimal pump function; persistent fracture fragments observed at the sac-duct junction; and severe lacrimal sac displacement - all of which may directly contribute to surgical failure. Therefore, CT-DCG-MPR imaging assistance proves invaluable in these cases.

Study limitations include the single-center retrospective design, though our injury demographics match epidemiological benchmarks.[15] Long-term (>5 year) patency data remains essential, particularly for complex fractures prone to delayed scarring. While CT-DCG-MPR excels in anatomical assessment, complementary functional evaluations like dynamic CT-DCG are needed for comprehensive tear drainage analysis.[16] Future research should explore AI-assisted automated fracture segmentation for surgical planning and biomaterial-enhanced stents to prevent granuloma formation in high-risk cases.

Conclusion

This study establishes a new standard for traumatic NLDO management through the integration of advanced imaging and refined surgical technique. CT-DCG-MPR guided Endo-DCR achieves excellent outcomes (94.4% success) while preserving normal anatomy - a critical advantage for trauma patients often requiring multiple reconstructive procedures. These advances, combined with emerging technologies like intraoperative navigation and dynamic imaging, promise to further improve outcomes for this challenging patient population.

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Disclosure

The authors report no conflicts of interest in this work.

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