Surgical outcomes of external dacryocystorhinostomy and risk factors for functional failure: a 10-year experience

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Abstract

Purpose: To analyze the surgical outcomes of external dacryocystorhinostomy (DCR) and the risk factors associated with functional failure.

Methods: We reviewed the medical records of 769 patients who underwent external DCR for primary lacrimal drainage obstruction between 2005 and 2014. Recorded data included intraoperative anatomical findings, postoperative diagnosis, and surgical outcomes. We performed univariate and multivariate analyses to identify risk factors for functional failure.

Results: Of the 769 cases, primary nasolacrimal duct obstruction (NLDO) was diagnosed in 457 cases; common canaliculal obstruction in 228 cases; and canaliculal obstruction in 84 cases. Anatomical success was achieved in 98.8% (760/769) and functional success in 81.9% (630/769) of the cases. An analysis of 760 anatomically successful DCRs showed that common canaliculal obstruction (OR = 1.752, $P = 0.014$) and canaliculal obstruction (OR = 2.058, $P = 0.015$) were independent risk factors for functional failure. In a subgroup analysis of patients with primary NLDO, patients with a small lacrimal sac had a significantly higher risk of functional failure (OR = 2.500, $P = 0.018$).

Conclusions: The overall surgical outcomes of external DCR were favorable in this case series. Site of obstruction was an important risk factor for functional failure in cases with primary lacrimal drainage obstruction. A small lacrimal sac was also found to be a risk factor for functional failure in cases with primary NLDO.

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Introduction

External dacryocystorhinostomy (DCR) is the treatment option for most cases of lacrimal drainage obstruction, including distal canaliculal obstruction, common canaliculal obstruction, and nasolacrimal duct obstruction (NLDO). Although endonasal DCR has increasingly become more popular over the last decade, many oculoplastic surgeons still prefer external over endonasal DCR, reporting a higher success rate in the former.¹ Another advantage of external DCR is that it provides a wide and clear surgical field, allowing the lacrimal drainage system and surrounding structures including nasal cavity, ethmoid sinus, and lacrimal sac fossa, to be directly and clearly visualized. Furthermore, the features of lacrimal drainage obstruction can be assessed more precisely intraoperatively during external DCR.

Most studies have reported an excellent success rate of >90%, when anatomical patency was examined by a lacrimal irrigation test.² Symptomatic success rate is usually reported to be lower than anatomical success rate, lying within the range of 74–83%.^{3–5} Some patients complain of persistent tearing after DCR even though a lacrimal drainage system is patent and there are no attributable problems in the eyelid or the ocular surface. This discrepancy between anatomical and symptomatic success after DCR is referred to as 'functional failure'.^{6,7} The ultimate purpose of DCR is the resolution of tearing symptom; therefore, the functional aspect must be emphasized when analyzing surgical outcomes. However, the causes or risk factors for functional failure remain largely undetermined, and an adequate management strategy has yet to be established.

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The aim of this study was to report the surgical outcomes of external DCR in a large case series. A number of clinical and anatomical variables were assessed as potential risk factors for functional failure after external DCR in patients with primary lacrimal drainage obstruction.

Materials and methods

We reviewed the medical records of all patients who had undergone external DCR performed by one surgeon (SIK) at Seoul National University Hospital over a period of 10 years between 2005 and 2014. Preoperatively, all patients underwent a comprehensive ophthalmologic examination and an assessment of the lacrimal drainage system including the lacrimal syringing test and probing. Dacryocystography or lacrimal scintigraphy was not routinely performed. External DCR operations were recommended for patients who were diagnosed to have NLDO or common canaliculus obstruction. This was determined by the presence of a bothersome epiphora symptom and a strong opposite punctal reflux without nasal passage on the lacrimal irrigation test. External DCR operations were also indicated in distal canaliculus obstruction. Patients with facial nerve palsy, significant eyelid abnormalities including ectropion and entropion, secondary lacrimal drainage obstruction, or on a follow-up period of <4 months, were excluded from this study. The protocol for this study was approved by the institutional review board of Seoul National University Hospital.

Surgical techniques

The external DCRs were performed using a standardized procedure described in our previous reports.^{8–10} Bone was removed from beneath the medial canthal tendon superiorly, superomedial part of the nasolacrimal duct inferiorly, posterior lacrimal crest posteriorly, and frontal process of the maxilla anteriorly. All ethmoidal air cells between the lacrimal sac and the nasal mucosa were carefully removed. The vertical size of osteotomy was measured intraoperatively. Nasal mucosal and lacrimal mucosal flaps were made, and both the posterior and anterior flaps were sutured. In most instances, a silicone bicanaliculus tube (solid tube, 0.064 cm diameter, C-Line canaliculus intubation set 8590450; Medtronic Ophthalmics, Jacksonville, FL, USA) was inserted. When stenosis or obstruction was present at the common canaliculus or distal canaliculus, double silicone intubation was performed after internal excision of the obstructed portion of the canaliculus.¹⁰

After surgery, the intraoperative anatomical findings were recorded in a prescribed form.⁸ These findings

included the width of the nasal cavity; thickness of the lacrimal bone (thin, moderate, and thick); thickness of the maxilla (thin, moderate, thick); severity of the ethmoid sinus intervention between the lacrimal sac fossa and nasal cavity (mild, moderate, severe); vertical size of the lacrimal sac (small, moderate, and large); and the presence of mucous dacryocystitis. The width of the nasal cavity was evaluated by measuring the distance from the nasal septum to the lateral nasal wall after nasal mucosal shrinkage using variably sized Frazier suction tips. A narrow cavity was defined as one through which a 3-mm diameter suction tip could not pass or could barely pass, a moderate cavity as one through which a 5-mm-diameter suction tip could easily pass, and a wide cavity as one through which a 7-mm diameter suction tip could pass. The severity of the ethmoid sinus intervention was determined by evaluating the ethmoid sinus space after removal of the anterior lacrimal crest, bony lacrimal sac fossa, and ethmoidal air cells. We defined mild ethmoid sinus intervention as air cells occupying the superior half between the lacrimal sac and nasal mucosa, and moderate as air cells occupying the superior two thirds of the medial space of the lacrimal sac fossa. Severe ethmoid sinus intervention was defined as air cells completely occupying the lacrimal sac fossa. The size of the lacrimal sac was evaluated on the vertical height of the cavity created by making a vertical incision on the medial wall of the lacrimal sac as follows: small (<5 mm), moderate (5–10 mm), and large (>10 mm). The postoperative diagnosis was determined based on the intraoperatively confirmed site of obstruction (NLD, common canaliculus, and distal canaliculus).

Postoperatively, all patients received antibiotic steroid eyedrops (Forus, neomycin sulfate 3.5 mg/ml; dexamethasone 1 mg/ml, polymyxin B sulfate 6000 IU/ml, Sam Il Pharm, Seoul, Korea) four times per day for 4 weeks, and 2–3 times per day thereafter.

Outcome assessment

All patients were followed-up after 1 week, 1 month, and between 4 and 6 months postoperatively, and then variably thereafter. The silicone tube was removed 4–6 months after surgery. At each visit, tearing was checked and a lacrimal syringing test was performed. The surgical outcome was assessed anatomically and functionally based on records from the last visit. Anatomical success was defined as patent irrigation without significant reflux on a syringing test. Functional success was defined as absence of tearing assessed using Munk's score.¹¹ Epiphora of grade 0 or 1 (no epiphora or occasional epiphora requiring dabbing less than twice a day) was considered as success, whereas epiphora from

grade two or more (epiphora requiring dabbing twice and over) was defined as failure.

Statistical analysis

The χ^2 -test or Student's *t*-test was used to determine whether there were significant differences between surgical success and failure groups by demographic and anatomical factors. Logistical regression was used to estimate the associations between variables and the surgical outcomes. The univariate analysis included all factors that could have potentially affected the outcomes. Factors found to be associated with the outcome at a significance level of $P < 0.1$ using univariate analysis were included in the multivariate analysis. Data were entered in a Microsoft Excel spread sheet (Microsoft, Redmond, WA, US) and exported to the IBM SPSS Statistics program version 21.0 (IBM, Armonk, NY, USA).

Results

Patient characteristics

A total of 872 external DCRs were performed during the study period. Of these, 52 cases had a short postoperative follow-up period, 39 cases had lacrimal drainage obstruction from secondary causes, 4 cases had facial nerve palsy, and 8 cases had significant lid abnormalities. These cases were excluded from the analysis. As a result, 769 cases from 603 patients were included in this study. The mean age was 57.7 ± 12.2 years (range 3–84), and most patients (77.6%, 468 of 603) were women. The mean duration of tearing was 62.8 ± 92.3 months (range 1–720). Of the 769 DCRs, postoperative diagnoses included 457 cases of primary NLDO with patent canaliculi; 228 cases of common canalicular obstruction; and 84 cases of canalicular obstruction. The mean postoperative follow-up period was 11.0 ± 16.3 months (range 4–108). Anatomical success was achieved in 760 (98.8%) cases, and functional success in 630 (81.9%) cases.

Risk factors for functional failure after external DCR in primary lacrimal drainage obstruction

We sought to analyze factors associated with surgical outcomes for external DCR in patients with primary lacrimal drainage obstruction. However, this was difficult to ascertain as the anatomical success rate was 98.8% (760/769) with only 9 patients who showed anatomical failure. Therefore, we compared the demographic factors and intraoperative anatomical findings between the functional success group ($n = 630$) and the functional failure group ($n = 130$) in anatomically successful DCRs (Table 1). Functionally failed DCR cases showed a shorter

tearing duration than functionally successful DCR cases ($P = 0.045$, *t*-test). Among intraoperative anatomical findings, site of obstruction, size of lacrimal sac, and the presence of mucous dacryocystitis were statistically different between two groups ($P = 0.000$, $P = 0.023$ and $P = 0.001$ respectively, χ^2 -test, Table 1). Table 2 shows the results of the univariate and multivariate logistic regression analysis. Univariate analysis identified common canalicular or canalicular obstruction, presence of a small lacrimal sac, and absence of mucous dacryocystitis as possible risk factors for functional failure after external DCR. In multivariate logistic analysis, the site of obstruction and absence of mucous dacryocystitis were identified as independent risk factors for functional failure after external DCR. Common canalicular obstruction increased the risk of functional failure by 1.75 ($P = 0.014$), while canalicular obstruction doubled the risk ($P = 0.015$). Absence of mucous dacryocystitis was also associated with functional failure based on multivariate analysis, but this only achieved borderline significance ($P = 0.047$).

Risk factors for functional failure after external DCR in primary NLD

We performed subgroup analysis that focused on the primary NLDO ($n = 453$) group, excluding patients with common canalicular obstruction and canalicular obstruction. We compared demographic factors and intraoperative anatomical findings between the functional success group ($n = 396$) and the functional failure group ($n = 57$). The distribution of lacrimal sac size was significantly different between the two groups ($P = 0.040$, Table 3). Univariate logistic regression analysis, and subsequent multivariate logistic regression analysis revealed that the presence of a small lacrimal sac was the only independent risk factor for functional failure in primary NLDO (Table 4).

Discussion

In this study, the anatomical success rate of external DCR was 98.8% (760/769) in patients with primary lacrimal outflow obstruction, higher than that reported in previous studies (~90%).^{12,13} However, direct comparison between studies is limited because of the differences in techniques, follow-up period, and definition of success in these studies. In most studies, however, functional success was assessed based on improvement in tearing symptom or patient's satisfaction. In this study, the functional success rate was 81.9% (630/769), which is comparable with that in previous studies which have reported success rate ranging from 71 to 92%.^{3–5,14}

Table 1 Demographic and intraoperative anatomical findings of 760 anatomically successful DCRs for primary lacrimal drainage obstruction; comparison between functional success and failure groups

	Functional success (n = 630)	Functional failure (n = 130)	P-value ^a
<i>Demographic factors</i>			
Age (mean ± SD; years)	57.5 ± 12.7	58.3 ± 10.1	0.469
Gender (F:M)	492:138	101:29	0.908
Laterality (Rt:Lt)	292:338	71:59	0.101
Duration of symptom (mean ± SD; months)	65.32 ± 97.42	51.86 ± 62.13	0.045
<i>Intraoperative findings</i>			
Width of the nasal cavity, no (%)	Open 191 (30.3) Moderate 238 (37.8) Narrow 201 (31.9)	Open 38 (29.2) Moderate 50 (38.5) Narrow 42 (32.3)	0.970
Lacrimal bone thickness, no (%)	Thin 438 (69.5) Moderate 108 (17.1) Thick 84 (13.3)	Thin 100 (76.9) Moderate 20 (15.4) Thick 10 (7.7)	0.149
Maxilla bone thickness, no (%)	Thin 57 (9.0) Moderate 310 (49.2) Thick 263 (41.7)	Thin 11 (8.5) Moderate 61 (46.9) Thick 58 (44.6)	0.873
Ethmoid sinus anteriorization, no (%)	Absent 58 (9.2) Mild 149 (23.7) Moderate 182 (28.9) Severe 241 (38.3)	Absent 8 (6.2) Mild 31 (23.8) Moderate 35 (26.9) Severe 56 (43.1)	0.584
Site of obstruction, no (%)	NLDO 396 (62.9) CCO 173 (27.5) CO 61 (9.7)	NLDO 57 (43.8) CCO 52 (40.0) CO 21 (16.2)	0.000
Size of the lacrimal sac, no (%)	Small 106 (16.8) Moderate 207 (32.9) Large 317 (50.3)	Small 31 (23.8) Moderate 50 (38.5) Large 49 (37.7)	0.023
Presence of mucous dacryocystitis, no (%)	207 (32.9)	24 (18.5)	0.001

Abbreviations: CCO, common canalicular obstruction; CO, canalicular obstruction; F, female; Lt, left; M, male; NLDO, nasolacrimal duct obstruction; Rt, right. ^aStudent *t*-test or χ^2 -test.

Table 2 Univariate and multivariate analyses for risk factors associated with functional failure of anatomically successful external DCR in patients with primary lacrimal drainage obstruction

	Odds ratio (95% CI)	P-value
<i>Univariate</i>		
Duration of symptom	0.998 (0.995–1.001)	0.135
Site of obstruction (reference, nasolacrimal duct)		0.000
Common canaliculus	2.088 (1.377–3.166)	0.001
Canaliculus	2.392 (1.355–4.222)	0.003
Size of the lacrimal sac (reference, large lacrimal sac)		0.025
Small lacrimal sac	1.892 (1.147–3.121)	0.013
Moderate lacrimal sac	1.563 (1.015–2.405)	0.042
Absence of mucous dacryocystitis	2.161 (1.347–3.469)	0.001
<i>Multivariate</i>		
Duration of symptom	NA	0.128
Site of obstruction (reference, nasolacrimal duct)		0.013
Common canaliculus	1.752 (1.123–2.733)	0.014
Canaliculus	2.058 (1.152–3.706)	0.015
Size of the lacrimal sac (reference large lacrimal sac)		0.320
Small lacrimal sac	NA	0.389
Moderate lacrimal sac	NA	0.439
Absence of mucous dacryocystitis	1.674 (1.006–2.786)	0.047

Abbreviations: CI, confidence interval; NA, not available because criteria of inclusion in multivariate model not met.

Few studies have investigated the factors associated with DCR outcomes. Most studies analyzed basic clinical parameters, unintentionally collected anatomical parameters, or postoperative endoscopic findings.^{15,16} However, several anatomical structures constituting DCR fields could theoretically affect surgical outcomes.

We postulated that a narrow nasal cavity, a thick maxilla, severe anteriorization of the ethmoid sinus, canalicular stenosis or obstruction, a small lacrimal sac, and absence of mucous dacryocystitis could be possible risk factors for surgical failure of external DCR. These factors were systematically recorded and analyzed along with other

Table 3 Demographic and intraoperative anatomical findings of 453 anatomically successful DCRs for primary nasolacrimal duct obstruction excluding canalicular or common canalicular obstruction; comparison between functional success and failure groups

	Functional success (n = 396)	Functional failure (n = 57)	P-value ^a
<i>Demographic factors</i>			
Age (mean ± SD; years)	56.4 ± 13.3	56.5 ± 9.6	0.960
Gender (F:M)	310:86	50:7	0.066
Laterality (Rt:Lt)	171:225	32:25	0.087
Duration of symptom (mean ± SD; months)	66.3 ± 109.3	46.2 ± 48.7	0.172
<i>Intraoperative findings</i>			
Membrane at the internal punctum, no (%)	18 (4.5)	6 (10.5)	0.059
Width of the nasal cavity, no (%)	Open 121 (30.6)	Open 20 (35.1)	0.786
	Moderate 147 (37.1)	Moderate 20 (35.1)	
	Narrow 128 (32.3)	Narrow 17 (29.8)	
Lacrimal bone thickness, no (%)	Thin 273 (68.9)	Thin 44 (77.2)	0.208
	Moderate 70 (17.7)	Moderate 10 (17.5)	
	Thick 53 (13.4)	Thick 3 (5.3)	
Maxilla bone thickness, no (%)	Thin 43 (10.9)	Thin 3 (5.3)	0.274
	Moderate 179 (45.2)	Moderate 31 (54.4)	
	Thick 174 (43.9)	Thick 23 (40.4)	
Ethmoid sinus anteriorization, no (%)	Absent 38 (9.6)	Absent 6 (10.5)	0.637
	Mild 98 (24.7)	Mild 10 (17.5)	
	Moderate 106 (26.8)	Moderate 15 (26.3)	
	Severe 154 (38.9)	Severe 26 (45.6)	
Size of the lacrimal sac, no (%)	Small 46 (11.6)	Small 12 (21.1)	0.040
	Moderate 120 (30.3)	Moderate 21 (36.8)	
	Large 230(58.1)	Large 24 (42.1)	
Presence of mucous dacryocystitis, no (%)	183 (46.2)	21 (36.8)	0.184

Abbreviations: F, female; Lt, left; M, male; Rt, right. ^a Student *t*-test or χ^2 -test.

Table 4 Univariate and multivariate analyses for risk factors associated with functional failure of anatomically successful external DCR in patients with primary nasolacrimal duct obstruction

	Odds ratio (95% CI)	P-value
<i>Univariate</i>		
Female	1.982 (0.867–4.527)	0.105
Right side	1.684 (0.962–2.948)	0.068
Membrane at the internal punctum	2.471 (0.937–6.511)	0.067
Size of the lacrimal sac (reference, large lacrimal sac)		0.045
Small lacrimal sac	2.500 (1.167–5.356)	0.018
Moderate lacrimal sac	1.677 (0.897–3.136)	0.105
<i>Multivariate</i>		
Female	NA	0.187
Right side	NA	0.084
Membrane at the internal punctum	NA	0.089
Size of the lacrimal sac (reference, large lacrimal sac)		0.045
Small lacrimal sac	2.500 (1.167–5.356)	0.018
Moderate lacrimal sac	1.677 (0.897–3.136)	0.105

Abbreviations: CI, confidence interval; NA, not available because criteria of inclusion in multivariate model not met.

clinical factors. Among these factors, the site of the obstruction was the most significant risk factor for functional failure after external DCR. In this study, common canalicular obstruction or canalicular obstruction were independently associated with functional failure with a large number of patients. These results are in agreement with data from earlier, smaller studies.^{17,18} Choi *et al*¹⁸ evaluated the outcome of endoscopic DCR based on the obstruction level using dacryocystography and reported that obstruction at the lacrimal sac showed the most unsuccessful results, followed by common canalicular obstruction. In our opinion, the common canaliculus or distal canaliculus area is the narrowest portion through the lacrimal drainage system when the lacrimal sac is anastomosed with the nasal space bypassing the NLD that might act as a bottleneck in the tear drainage pathway even when it is anatomically patent. Rose has also previously described the lacrimal canaliculus as a conduit with a relatively high hydraulic resistance and has suggested that persistent flow symptoms can be caused by inadequate canalicular conductance after anatomically successful DCRs.¹⁹

In this study, we also analyzed risk factors for functional failure in the primary NLDO subgroup and found that a small lacrimal sac was the only independent risk factor. There have been a few reports showing that lacrimal sac size could be a predicting factor for the anatomical success of endonasal DCR.^{20,21} Mannor and Milliman²⁰ estimated the lacrimal sac size preoperatively using dacryocystography and reported that patients with a large sac showed a significantly higher success rate than those with a small lacrimal sac (82 *vs* 29%). This is in agreement with the results of another study, which showed that an intraoperatively observed small lacrimal sac was associated with failure of endonasal DCR.²¹ The causal relationship between lacrimal sac size and the functional failure of DCR has been unclear up until now. We speculate that the cicatrized and contracted lacrimal sac impinges upon the transmission of hydrostatic pressure resulting in a decrease in lacrimal pump activity. In this regard, silicone tube insertion might be helpful in facilitating the tear flow through capillary action. However, further studies will be needed to prove this theory.

We observed thin membranous structures at the internal punctum of the lacrimal sac in 5.5% of patients with primary NLDO. There has been a debate about the anatomical existence of a valve structure around the internal punctum even in recent cadaveric studies. Zoumalan *et al*²² demonstrated that there were variable valve-like structures at the canalicular/lacrimal sac junction in 59.7% (74 of 124 lacrimal systems) of cadavers. Whereas, Orhan *et al*²³ dissected 20 specimens

and reported that they had not observed the valve structure macroscopically. However, they noted that swelling was present around the opening hole of the common canaliculus in some cases. These anatomical studies were conducted on subjects with normal lacrimal systems, while we examined the internal punctal area in patients with nasolacrimal duct obstruction. Therefore, the results may not be directly comparable. In our opinion, the thin membranous structure may be either a prominent normal mucosal fold at the internal punctum or fibrinous condensation due to chronic inflammation. One previous study emphasized the need for a careful inspection of the internal canalicular aperture and proper membranectomy to enhance surgical outcomes for external DCR.²⁴ As such, we carefully remove the membrane and inserted double silicone tubes. Our success rate appeared to be unaffected by the presence of the membrane (Tables 3 and 4).

The strengths of this study are the uniformity in the surgical procedures as it was performed by a single surgeon, the standardized description of intraoperative findings, and the large number of cases that enabled the use of multivariate analysis. However, there are some limitations to this study. First, we only included patients who were followed up for more than 4 months, and some were included even though they were not followed up after tube removal. Olver²⁵ suggested that the outcome of DCR should be assessed over a minimum of 6 months after surgery and for at least 3 months after tube removal. Second, we did not use the fluorescein dye disappearance test, only the lacrimal syringing test to evaluate anatomical success rate, which might explain the high anatomical success rate reported in this study. Finally, the assessment of intraoperative findings are subjective; however, we tried to ensure standardization by having the same surgeon perform all the assessment.

In conclusion, the success rate of external DCR was 98.8% anatomically and 81.9% functionally in a large case series with primary lacrimal drainage obstruction. The strongest risk factor for functional failure was the site of obstruction; common canalicular obstruction and canalicular obstruction significantly increased the risk. In cases with primary NLDO, a small lacrimal sac was associated with functional failure. The lacrimal sac is a key structure influencing the surgical outcome. Therefore, careful inspection of the lacrimal sac during the DCR procedure should be emphasized to lacrimal surgeons. Descriptions of the vertical size, mucosal swelling and fibrosis, and the appearance of the internal punctal area are helpful in predicting functional success following external DCR.

Summary

What was known before

- Numerous studies have shown that the outcomes of external dacryocystorhinostomy were excellent anatomically and functionally. However, functional success rate is known to be somewhat lower than anatomical success rate, and the risk factors for functional failure were still ambiguous.

What this study adds

- This study reported the success rate of external DCR was 98.8% anatomically and 81.9% functionally in a large case series with primary lacrimal drainage obstruction. Multivariate analyses revealed that common canalicular obstruction and canalicular obstruction significantly increased the risk for functional failure after external dacryocystorhinostomy for primary lacrimal drainage obstruction. In subgroup analysis targeting nasolacrimal duct obstruction, small size lacrimal sac was the significant risk factor for functional failure.

Conflict of interest

The authors declare no conflict of interest.

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