Original Article

Predictors of nasolacrimal duct intubation failure for primary acquired nasolacrimal duct obstruction: a computed tomography-dacryocystography (CT-DCG) study

Wushuang Wang[#], Tong Lin[#], Lan Gong, Yan Wang

Department of Ophthalmology, Eye & ENT Hospital of Fudan University, Shanghai, China

Contributions: (I) Conception and design: Y Wang, L Gong; (II) Administrative support: T Lin, L Gong; (III) Provision of study materials or patients: W Wang, Y Wang; (IV) Collection and assembly of data: W Wang; (V) Data analysis and interpretation: T Lin, W Wang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Yan Wang, PhD; Lan Gong, PhD. Department of Ophthalmology, Eye & ENT Hospital of Fudan University, 83 Fenyang Rd., Xuhui District, Shanghai 200031, China. Email: wangyandoc@163.com; 13501798683@139.com.

Background: Making a choice between nasolacrimal duct intubation and dacryocystorhinostomy (DCR) for primary acquired nasolacrimal duct obstruction (PANDO) is an important issue in clinical practice. This study aimed to determine the potential lacrimal sac characteristics that could be used as predictors of unsuccessful intubation for PANDO based on computed tomography-dacryocystography (CT-DCG).

Methods: In this retrospective comparative observational study, we included PANDO patients with a history of failed intubation for nasolacrimal duct obstruction as the intubation failure group and PANDO patients without a history of intubation as the control group. We analyzed the lacrimal sac height, lacrimal sac width, and obstruction site based on CT-DCG, all measured based on several reference levels on axial sections (upper, intermediate, lower level, common canaliculus level, and lowermost contrast level), which were defined according to the contrast and the bony structure.

Results: A total of 114 sides of the PANDO were studied, including 36 in the intubation failure group and 78 in the control group. The intubation failure group showed a smaller lacrimal sac height (11.69±4.59 mm) and width (2.28±1.97 mm, intermediate level) than the control group (14.13±2.92, 3.32±2.02 mm, P=0.005 and 0.012, respectively). The intubation failure group had a higher obstruction site than the control group (P=0.009).

Conclusions: A small lacrimal sac and high obstruction site are predictors of nasolacrimal duct intubation failure in PANDO. For PANDO patients with a small lacrimal sac or a high obstruction position, DCR is recommended as opposed to intubation.

Keywords: Lacrimal drainage; imaging; nasolacrimal duct obstruction; dacryocystorhinostomy (DCR); intubation

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Introduction

Obstruction of the nasolacrimal duct can lead to epiphora, which is a common symptom in the clinical setting (1). Nasolacrimal duct intubation, also known as stent implantation, is widely used in various obstruction conditions, including canalicular stenosis, congenital nasolacrimal

duct obstruction, and primary acquired nasolacrimal duct obstruction (PANDO) (2-4). When treating PANDO, intubation can be regarded as an alternative to dacryocystorhinostomy (DCR), which remains the standard procedure of PANDO and has a success rate of over 80% (5). Compared to DCR, intubation has the advantage of being quick, low-cost, and less traumatic. However, the success rate of intubation is not as high as that of DCR, ranging from about 52% to 75% according to previous studies (6-8). If the intubation fails to relieve the epiphora, DCR is still needed.

Ideally, "mild" PANDO patients can undergo intubation instead of the traumatic DCR, whereas "refractory" PANDO patients can choose DCR as the first choice to avoid repeated surgeries. Thus, it is important to predict the types of patients with PANDO who are likely to experience failed nasolacrimal duct intubation. Previous studies have found that the success rate of intubation might be higher in patients with a milder degree of nasolacrimal duct stenosis, an easy passage of fluid in the preoperative syringing test, or a larger smallest minor axis diameter of the bony nasolacrimal duct (9,10). However, no study has ever focused on intubation outcomes from the perspective of lacrimal sac size and obstruction site.

In this study, we investigated the predictors of unsuccessful nasolacrimal duct intubation for PANDO using computed tomography-dacryocystography (CT-DCG). CT-DCG involves the application of contrast agent, which is injected into the nasolacrimal duct before the examination. It can directly display the lacrimal sac and the location of obstruction compared to the normal computed tomography (CT) exam (11). The prognostic value of CT-DCG in patients treated with endoscopic DCR has been previously documented, and here we applied its prognostic value to the intubation surgeries (11,12). We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-519/rc).

Methods

Design and patients

In this comparative observational study, we retrospectively reviewed the medical records of patients with PANDO who underwent CT-DCG examinations at the Eye & ENT Hospital of Fudan University from February 2021 to August 2022. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Eye & ENT Hospital of Fudan University (No. 2023164) and individual consent for this retrospective analysis was waived.

We included patients with PANDO over 18 years of age with a diagnosis based on epiphora symptoms, irrigation tests, and CT-DCG. Only the obstructed sides were included in the analysis, which were defined as complete nasolacrimal duct obstructions confirmed by irrigation tests and CT-DCG. Patients were excluded if they had canalicular obstruction, a history of DCR, a history of repeated intubation surgeries (≥2 times), a retained nasolacrimal duct tube, facial fracture, significant trauma, or tumor. We divided all the patients who meet the criteria into two groups: an intubation failure group (PANDO patients with histories of failed nasolacrimal duct intubation about 1–3 months before enrollment) and a control group (PANDO patients with no history of intubation). The failure of nasolacrimal duct intubation surgery was diagnosed by the irrigation test and symptom of epiphora at the post-operative clinical interview.

Demographic data including age, sex, symptom duration, and medical history were collected. Chronic dacryocystitis was diagnosed when mucoid or mucopurulent material was found during irrigation. The CT measurements were performed as follows.

CT acquisition

All CT images were obtained using a multidetector-row scanner (Siemens Medical Systems, Erlangen, Germany); 0.75-mm-thick axial scans throughout the orbits and nasal structures were acquired in the helical mode with a tube voltage of 120 kV and a current of 230 mA. We performed lacrimal irrigation and injected the contrast agent ioversol into the nasolacrimal duct to obtain the CT-DCG. Images were analyzed using a digital image workstation (Carestream CGRIS; Carestream Health, Rochester, NY, USA). All CT measurements were performed by one of the authors (W.W.) who was blinded to all demographic and clinical information during the analysis.

Image analysis

The main parameters included lacrimal sac height, lacrimal sac width, and obstruction sites, measured based on the contrast imaging and reference levels. As in previous studies (13,14), we defined several reference

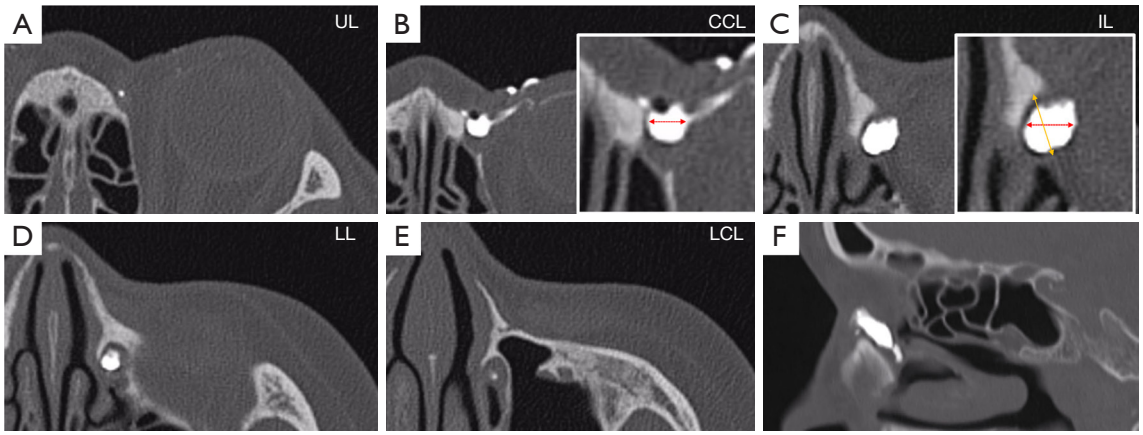

Figure 1 Methods of lacrimal sac width measurements, taking the example of CT-DCG images of a nasolacrimal duct obstruction type PANDO patient, in which the LCL is below LL. (A-E) The axial sections of the obstruction side. (F) The sagittal section of the obstruction side. Red dotted arrow in (B) and (C): lacrimal sac width, the largest transverse width of agent in the lacrimal sac. Yellow arrow in (C): bony lacrimal sac fossa width, the distance from the anterior extent of the lacrimal sac fossa to the posterior lacrimal crest. UL, upper level; CCL, common canaliculus level; IL, intermediate level; LL, lower level; LCL, lowermost contrast level; CT-DCG, computed tomography-dacryocystography; PANDO, primary acquired nasolacrimal duct obstruction.

levels in the axial sections: the upper level (UL) shows the highest section in which contrast in the lacrimal sac is observed, which refers to the top part of the lacrimal sac (*Figure 1A*). The common canaliculus level (CCL) is the section where common canaliculus opens to the lacrimal sac (*Figure 1B*). The intermediate level (IL) refers to the lowest section in which the middle turbinate inserts into the lateral nasal wall (*Figure 1C*). The lower level (LL) is defined as the lowest section before the bony lacrimal sac fossa becomes nasolacrimal duct (*Figure 1D*). The lowermost contrast level (LCL) is defined as the lowest section where the contrast agent is observed, which refers to the obstruction site (*Figure 1E*).

Based on these reference levels, we defined the obstruction sites into 3 types:

(I) Nasolacrimal duct obstruction type (*Figure 1*): the LCL is below the LL, which means that the obstruction site is in the nasolacrimal duct.

(II) Low sac obstruction type (*Figure 2*): the LCL is between the IL and LL, which means that the obstruction site is in the low part of lacrimal sac.

(III) High sac obstruction type (*Figure 3*): the LCL is between the CCL and IL, which means that the obstruction site is in the high part of lacrimal sac.

We defined the lacrimal sac height as the distance (numbers of the section × 0.75 mm) from the UL to LL in the nasolacrimal duct obstruction type, and from the UL to the LCL in the low and high sac obstruction type. The lacrimal sac width was defined as the largest transverse width of the agent in the lacrimal sac, which was measured at the CCL and in IL (red dotted arrows in *Figure 1B*, *Figure 1C*, respectively). Specifically, in the high sac obstruction type, there is no contrast agent in IL, so the width is 0 mm (*Figure 3D*). The bony lacrimal sac fossa width was the distance from the anterior extent of the lacrimal sac fossa to the posterior lacrimal crest (yellow arrow in *Figure 1C*).

Statistical analysis

Statistical data were analyzed using SPSS 19.0 (IBM Corp., Chicago, IL, USA). The results are expressed as mean ± standard deviation (SD) or percentage. For demographic and lacrimal sac size parameters, *t*-tests and Chi-squared tests were used to compare continuous and categorical variables, respectively. Multiple regression models were used to identify the factors affecting lacrimal sac size. The frequency distribution of obstruction site types in the two groups was also measured using the chi-squared test. Differences were considered statistically significant at $P<0.05$.

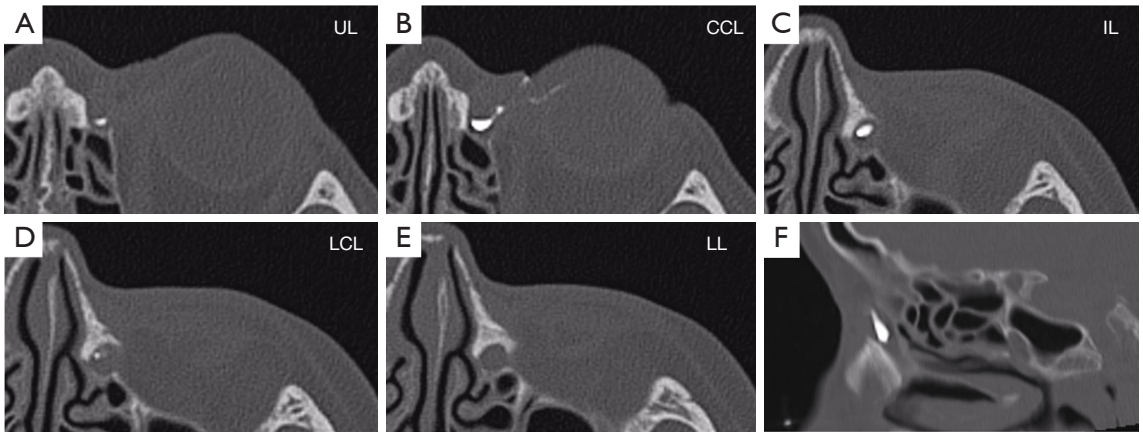

Figure 2 CT-DCG images of a low sac obstruction type PANDO patient, in which the LCL is between IL and LL. (A-E) The axial sections of the obstruction side. (F) The sagittal section of the obstruction side. UL, upper level; CCL, common canaliculus level; IL, intermediate level; LCL, lowermost contrast level; LL, lower level; CT-DCG, computed tomography-dacryocystography; PANDO, primary acquired nasolacrimal duct obstruction.

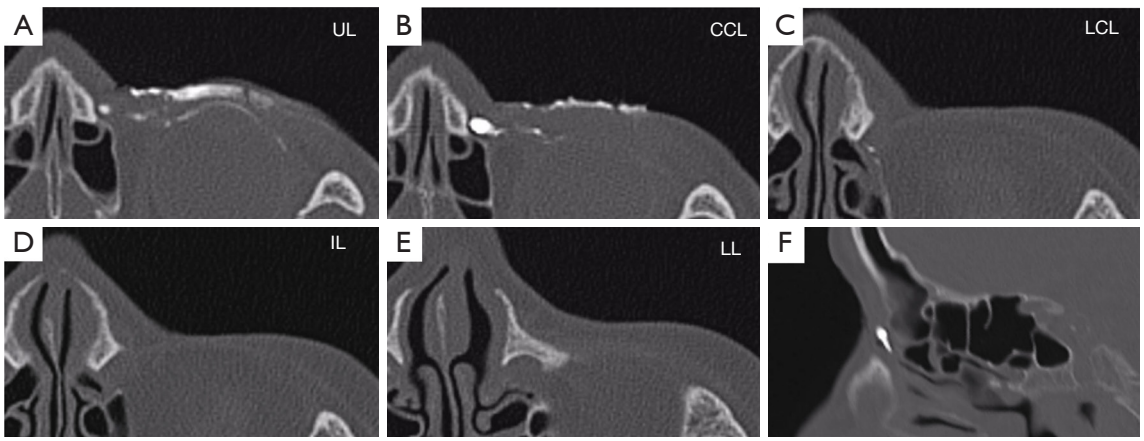

Figure 3 CT-DCG images of a high sac obstruction type PANDO patient, in which the LCL is between CCL and IL. (A-E) The axial sections of the obstruction side. (F) The sagittal section of the obstruction side. UL, upper level; CCL, common canaliculus level; LCL, lowermost contrast level; IL, intermediate level; LL, lower level; CT-DCG, computed tomography-dacryocystography; PANDO, primary acquired nasolacrimal duct obstruction.

Results

A total of 114 sides of PANDO were studied after excluding patients with a history of DCR (n=13), nasolacrimal duct tube retained (n=1), and lacrimal sac fossa fracture (n=1) from the 129 available cases. Among them, 36 sides of PANDO had a history of nasolacrimal duct intubation failure; the other 78 sides did not have a history of intubation (*Table 1*). The distribution of age, sex, composition, and symptom duration was balanced between the failure history group and the control group (P=0.141, 0.202, 0.267, and 0.085, respectively). The complication of chronic dacryocystitis was observed in 77.78% of patients in the intubation failure group, and in 88.46% of patients in the control group (P=0.137). The two groups also showed no difference in the bony lacrimal sac fossa width (6.45±1.19 mm in intubation failure group, 6.50±1.18 mm in the control group, P=0.839). All data about the height and length of the lacrimal sac was normally distributed.

Both lacrimal sac height and width were significantly smaller in the intubation failure group (*Table 2*). The mean

Table 1 Demographics and clinical characteristics of intubation failure group and control group

Variables	Intubation failure group (n=36 sides)	Control group (n=78 sides)	P†
Age (years)	53.50±12.20	57.17±12.29	0.141
Sex			0.202
Male	7 (19.44)	7 (8.97)	
Female	29 (80.56)	71 (91.03)	
Composition			0.267
Bilateral	4 (12.50)	14 (21.88)	
Unilateral	28 (87.50)	50 (78.12)	
Symptom duration (years)	6.68±6.11	9.33±9.94	0.085
Chronic dacryocystitis	28 (77.78)	69 (88.46)	0.137
Anatomic structures of bony lacrimal sac fossa			
Width (mm)	6.45±1.19	6.50±1.18	0.839

Data are represented as mean ± SD or number (%). †, *t*-test and Chi-squared test. SD, standard deviation.

Table 2 Comparison of lacrimal sac height and width between intubation failure group and control group

Variables	Intubation failure group (n=36 sides)	Control group (n=78 sides)	P†
Lacrimal sac height (mm)	11.69±4.59	14.13±2.92	0.005*
Lacrimal sac width (mm) (IL level)	2.28±1.97	3.32±2.02	0.012*
Lacrimal sac width (mm) (CCL)	3.28±2.01	3.72±2.28	0.324

Data are represented as mean ± SD. †, *t*-test; *, P<0.05. IL, intermediate level, refers to the lowest section in which the middle turbinate inserts into the lateral nasal wall; CCL, common canaliculus level; SD, standard deviation.

lacrimal sac height was 14.13±2.92 mm in the control group, whereas it was only 11.69±4.59 mm in the intubation failure group (P=0.005). Similarly, the intubation failure group also showed a narrower lacrimal sac width (2.28±1.97 mm) compared to the control group (3.32±2.02 mm) in the IL level (P=0.012), but not in the CCL (intubation failure group: 3.28±2.01 mm, control group: 3.72±2.28 mm, P=0.324). To further confirm the difference and find other factors related to the lacrimal sac size, a multiple regression model was implemented, which showed that a history of intubation failure (standardized β=−0.304, P=0.001) was significantly associated with lacrimal sac height, and a history of intubation failure (standardized β=−0.260, P=0.003), symptom duration (standardized β=−0.180, P=0.036), and bony lacrimal sac fossa width significantly (standardized β=0.384, P<0.001) were related to lacrimal sac width at the IL level (*Table 3*).

Differences were found in the composition of obstruction types between the two groups (P=0.009, *Table 4*). PANDO with a history of intubation failure had more high sac obstruction type (10 of 36 cases, 27.8%) and low sac obstruction type (16 of 36 cases, 44.4%) compared to PANDO without a history of intubation (9.0% and 38.5%, respectively). Also, PANDO with a history of intubation failure had less nasolacrimal duct obstruction type (10 of 36 cases, 27.8%) compared to PANDO without a history of intubation (41 of 78 cases, 52.6%).

Discussion

Whether to choose DCR or intubation as an initial treatment for PANDO still lacks a consensus. The ability to identify the risk factors related to intubation failure as the predictors of the failure is of great significance to surgical method decision-making. In this study, we found that a small lacrimal sac width, height, and a high obstruction site determined on CT-DCG can be such predictors.

Several previous studies have focused on the nasolacrimal

Table 3 Multiple regression analysis of factors affecting lacrimal sac size

Variables	Lacrimal sac height		Lacrimal sac width (IL level)	
	β	P†	β	P†
History of intubation failure	−0.304	0.001*	−0.260	0.003*
Age	−0.058	0.529	−0.030	0.754
Sex	0.104	0.259	0.030	0.728
Symptom duration	−0.083	0.368	−0.180	0.036*
Bony lacrimal sac fossa width	N/A	N/A	0.384	<0.001*

†, multiple regression models with standardized β; *, P<0.05. IL, intermediate level; N/A, not applicable.

Table 4 Comparison of obstruction sites between intubation failure group and control group

Variables	High sac obstruction type	Low sac obstruction type	Nasolacrimal duct obstruction type	P†
Intubation failure group	10 (27.8)	16 (44.4)	10 (27.8)	0.009*
Control group	7 (9.0)	30 (38.5)	41 (52.6)	

Data are represented as number (%). †, Chi-squared test; *, P<0.05.

duct structure, the syringe test result, and other demographic data as the predictors of intubation failure (8,9). However, some of these features are not directly related to the obstruction, for example, whether a small bony nasolacrimal duct size is a risk factor of PANDO is still controversial (15). No study has ever focused on characteristics of the lacrimal sac as predictors. Here, we found that both the height and the width of the lacrimal sac were smaller in PANDO patients with a history of intubation failure. This was not caused by the difference of bony structure, since there was also no difference in the bony lacrimal sac fossa width between the two groups. The regression model showed that symptom duration and bony lacrimal sac fossa width were also associated with lacrimal sac width: long symptom duration may contribute to inflammation and fibrosis of the lacrimal sac, causing lacrimal sac narrowing, whereas bony lacrimal sac fossa size was reasonably correlated with the lacrimal sac size. Moreover, PANDO with a history of intubation failure also had a higher obstruction site, with nearly three-fourths of the patients' obstruction site at the lacrimal sac, compared to only about half of the cases in the control group. The obstruction site also reflects lacrimal sac size, and is more valuable and important in clinical practice.

The characteristics of small sac and high obstruction in the intubation failure group indicated a severe fibrosis of the lacrimal sac and nasolacrimal duct. Researchers have reported a large proportion of lacrimal sac pathologic changes in patients with chronic dacryocystitis (16), including thickened epithelial changes, stromal fibrosis with an increase in collagen fiber, and proliferating blood vessels. A long duration of nasolacrimal duct obstruction can spread upward and lead to secondary changes of lacrimal sac, causing narrow or occlusive lumina (17). Possible explanations how they can decrease the success rate of intubation are as follows. A small sac lumen will increase the tear drainage flow resistance because of the obstructive effect of sac fibrosis and granulation, making it harder to be relieved by simple intubation. Additionally, a small sac can increase the risk of a probe entering the sac wall, causing false passage.

Our study provides a new potential method to predict the outcome of intubation based on the lacrimal sac structure, and further helps determination of appropriate surgical methods. CT-DCG is widely applied in the diagnosis of PANDO (18), and making a prediction using its image is both feasible and reliable in clinical applications, as PANDO patients with a small lacrimal sac or high obstruction site may have a relatively higher intubation failure rate. In such cases, DCR is recommended instead of intubation to avoid repeated surgery. In contrast, those with a large lacrimal sac or low obstruction site are suitable for intubation.

This study had some limitations because of its retrospective design. First, the CT-DCG results used in the intubation failure group were not acquired before the nasolacrimal duct intubation surgeries, but were acquired

in the clinic visits after the surgeries. Although there was no evidence that a silicone tube can lead to lacrimal sac fibrosis and narrowing, a previous report suggested that a nasolacrimal duct mucosal inflammatory reaction resulted from the retained silicone tube (19). In this study, all the patients in the failure group had undergone intubation surgery only once about 1–3 months before the enrollment. Since we excluded patients with a history of repeated intubation surgery and limited the interval between intubation and enrollment, we thought it appropriate to ignore the influence of tube on the lacrimal sac size and obstruction site. Second, the control group were newly diagnosed PANDO patients representing a general PANDO population, instead of patients with a successful intubation history, which would have been better in this study design. Third, the sample size was still relatively small, especially for the intubation failure group. A further cohort study involving the performance of CT-DCG for PANDO patients before nasolacrimal duct intubation with post-surgery outcome visits would be more convincing.

Conclusions

We found that PANDO patients with a history of nasolacrimal duct intubation failure had a smaller lacrimal sac and higher obstruction site than those with no intubation history. In other words, a small lacrimal sac and a high obstruction site are predictors of nasolacrimal duct intubation failure. This indicates that if CT-DCG shows a small lacrimal sac or a high obstruction position in a PANDO patient, it is advisable to perform a DCR instead of nasolacrimal duct intubation.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-24-519/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-24-519/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Eye & ENT Hospital of Fudan University (No. 2023164) and the requirement for individual consent for this retrospective analysis was waived.

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