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Preoperative probing and dilation in nasolacrimal silicone intubation for incomplete primary acquired nasolacrimal duct obstruction

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鼻泪道硅胶插管术前泪道探通扩张治疗原发性获得性不完全鼻泪道梗阻

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摘要

目的:评估术前泪道探通扩张对原发性获得性不完全鼻泪管阻塞患者行鼻泪管硅胶导管置入术治疗效果的影响。

方法:本研究是一项回顾性病例对照临床试验。研究纳入了 2022 年 10 月至 2024 年 10 月期间在本院接受鼻泪管硅胶导管置入术的原发性获得性不完全鼻泪管阻塞患者。根据术前是否接受鼻泪管探通扩张治疗,将参与者分为两组:A 组为术前已接受一次或多次鼻泪管探通扩张治疗的患者,B 组为术前未接受鼻泪管探通扩张治疗的患者。所有患者在鼻泪管硅胶导管置入术后 3 mo 取出鼻泪管硅胶导管,并在导管取出后继续观察 6 mo,以评估手术成功率。

结果:共 136 例患者(152 眼)完成了拔管后 6 mo 的随访。两组手术总体成功率均为 72.4%(110/152 眼)。A 组纳入男 22 例,女 36 例,平均年龄 58.09±11.07 岁,其手术成功率为 82.8%(53/64 眼),B 组纳入男 27 例,女 51 例,平均年龄 59.35±8.84 岁,其手术成功率为 64.8%(57/88 眼)。两组之间的手术成功率差异具有统计学意义($P=0.014$)。此外,A 组的完全成功率达到 67.2%(43/64 眼),而 B 组为 47.7%(42/88 眼),该差异同样具有统计学意义($P=0.017$)。两组均未出现严重的术后并发症。

结论:鼻泪管硅胶插管术是一种安全有效的治疗原发性获得性不完全鼻泪管阻塞的方法,术前进行鼻泪管探通扩张可能有助于改善治疗效果。

关键词:原发性获得性不完全鼻泪管阻塞;鼻泪管硅胶导管置入术;鼻泪管探通扩张;成功率

Abstract

• AIM: To assess the influence of preoperative lacrimal passage probing and dilation on the therapeutic effectiveness of nasolacrimal silicone intubation in cases of incomplete primary acquired nasolacrimal duct obstruction (PANDO).

• METHODS: A retrospective case-control clinical study was conducted. The study included patients with incomplete PANDO who underwent nasolacrimal silicone intubation at the hospital between October 2022 and October 2024. Participants were categorized into two groups based on their receipt of nasolacrimal duct probing and dilation prior to intubation. Group A consisted of patients who had undergone one or more sessions of nasolacrimal duct probing and dilation before nasolacrimal silicone intubation, while Group B included patients who did not receive nasolacrimal duct probing and dilation before intubation. All patients had their nasolacrimal silicone tubes removed 3 mo postoperatively and were monitored for 6 mo following tube removal to evaluate surgical success rates.

• RESULTS: A total of 136 patients (152 eyes) completed the six-month follow-up period. The overall surgical success rate for both groups was 72.4% (110/152 eyes). Group A included 22 males and 36 females, mean age 58.09±11.07 y, and achieved a success rate of 82.8% (53/64

eyes), while Group B included 27 males and 51 females, mean age 59.35±8.84 y and attained a success rate of 64.8% (57/88 eyes). The difference in surgical success rates between the two groups was statistically significant (P=0.014). Furthermore, Group A achieved a complete success rate of 67.2% (43/64 eyes), compared to 47.7% (42/88 eyes) in Group B, with this difference also reaching statistical significance (P=0.017). No serious postoperative complications were observed in either group.

• CONCLUSION: Nasolacrimal silicone intubation is a safe and effective intervention for incomplete PANDO, with preoperative nasolacrimal duct probing and dilation potentially enhancing therapeutic outcomes.

• KEYWORDS: incomplete primary acquired nasolacrimal duct obstruction; nasolacrimal silicone intubation; nasolacrimal duct probing and dilation; success rate
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INTRODUCTION

Primary acquired nasolacrimal duct obstruction (PANDO) is a prevalent lacrimal drainage disorder in adults, characterized as an idiopathic inflammatory condition of the nasolacrimal duct, resulting in fibrosis of the ductal wall and subsequent partial stenosis or complete obstruction[1]. The incidence of PANDO ranges from 3% to 6.6%[2-4]. The etiology of PANDO is multifactorial, with contributing factors including exposure to topical antiglaucoma medications, hormonal fluctuations, the chemical composition of tears, sinusitis, and the morphology of the bony nasolacrimal duct morphology have been proposed as etiologic factors for the development of PANDO[2,5-8]. The conventional treatment for complete PANDO is dacryocystorhinostomy, which has been reported to have a success rate of approximately 90%[9]. For cases of incomplete PANDO, surgical interventions such as balloon dacryoplasty and nasolacrimal silicone intubation are employed, with the latter demonstrating success rates ranging from 64.7% to 87.6%[10-11]. Nasolacrimal silicone intubation preserves the nasolacrimal duct structure and facilitates natural lacrimal drainage[12]. Some studies have investigated the factors associated with the failure of nasolacrimal silicone intubation in incomplete PANDO[7,13-14]. Despite the limited research on the influence of preoperative probing on the effectiveness of nasolacrimal silicone intubation, this study seeks to assess the correlation between preoperative lacrimal duct dilation and the surgical outcomes of nasolacrimal silicone intubation in cases of incomplete PANDO.

PARTICIPANTS AND METHODS

Ethical Approval The study was conducted according to the tenets of the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee of our hospital. Informed consent was waived because of the retrospective and anonymous nature of this study.

Participants This was a retrospective, nonrandomized, comparative study. The study included patients with incomplete PANDO who underwent nasolacrimal silicone intubation in the Ophthalmology Department of our hospital between October 2022 and October 2024. Participants were divided into two groups based on their prior treatment history: Group A consisted of patients who had undergone one or more sessions of nasolacrimal duct probing and dilation before nasolacrimal silicone intubation. In contrast, Group B included patients who had not received nasolacrimal duct probing and dilation before intubation. The diagnosis of PANDO was based on a history of acquired epiphora an increased tear meniscus height (TMH) ($\geqslant$300 μm) and positive irrigation with reflux on syringing[7]. Diagnostic probing was performed from the lower lacrimal punctum. After a feeling of "hard stop", irrigation of the nasolacrimal duct with isotonic sodium chloride solution was performed. Patients with some amount of reflux through the upper lacrimal punctum (resistance to positive-pressure irrigation) and simultaneous passage of fluid in the throat were included.

Inclusion and Exclusion Criteria The inclusion criteria were as follows: 1) age$\geqslant$18 y; 2) a diagnosis of PANDO; 3) patients must have completed a six-month follow-up after the removal of the lacrimal duct drainage tube. Patients who had no flow of fluid into the nose were diagnosed with complete nasolacrimal duct obstruction and were not considered candidates for nasolacrimal silicone intubation. Participants were excluded from analyses for the following reasons: complete nasolacrimal duct obstruction, patients with ocular surface diseases, abnormal lid position at rest or in blinking, punctal or canalicular abnormality, prior trauma or surgery of the lacrimal system, history of nasal diseases, history of ipsilateral facial palsies, prior treatment with chemotherapeutic agents (*e.g.*, docetaxel, 5-fluorouracil, methotrexate), early tube removal or early tube loss, and less than 6 mo of follow-up after the tube removal.

Methods The height of the central, lower tear meniscus of the participants was measured using optical coherence tomography (OCT, Topcon, Japan). TMH on the OCT images were measured using the inbuilt calipers of the manufacturer provided software. The mean of three consecutivemeasurements was noted. All measurements were measured by the same observer. All tests were performed in a dim lit room to avoid reflex tearing. All patients were instructed not to use any topical eye drops at least 2 h before testing tonegate the effect of medication on tear film. Patients were asked to look straight ahead at the fixating target within the OCT system. Subjects were instructed to blink and OCT measurements were taken immediately after blinking to avoid the effects of delayed blinking.

For patients with incomplete PANDO who met the inclusion criteria, it was routinely recommended in the outpatient setting to perform nasolacrimal duct probing and dilation prior to nasolacrimal silicone intubation. Some patients adhered to

this recommendation and underwent one or multiple sessions of nasolacrimal duct probing and dilation treatment in the outpatient department, with a one-week interval between treatments. Subsequently, these patients proceeded with nasolacrimal silicone intubation surgery in the outpatient department (Group A). Conversely, another subset ofpatients underwent outpatient nasolacrimal silicone intubation without prior probing and dilation of the nasolacrimal duct (Group B). All nasolacrimal duct probing and dilation treatments were conducted by the same experienced outpatient physician. The specific steps involved administering topical anesthesia using 2-3 drops of alcaine eye drops (Alcon, Rijksweg) prior to probing. Both the upper and lower puncta of the affected eyewere widened intraoperatively using a punctum dilator. Then, the lacrimal passagewere probed and the lacrimal system was irrigated with 0.9% sodium chloride solution. Finally, a 9-gauge lacrimal duct cannula probe (Suzhou Mingren, China) was systematically inserted through the lower and upper lacrimal puncta. The procedure commenced at the inner aspect of the lacrimal sac fossa bone wall and proceeded downward until resistance was encountered. Upon determining the approximate location of the nasolacrimal duct obstruction, mechanical force was applied to clear the obstruction towards the inferior nasal passage. Subsequently, the lacrimal duct probe was withdrawn, and the duct was flushed. The sensation of water in the patient's throat served as an indication of successful clearance of the lacrimal duct. Patients whose nasolacrimal ducts could not be successfully probed were excluded from the study and were advised to undergo dacryocystorhinostomy procedure.

Surgery and Postoperative Management Different surgical options were explained to the patients, and informed consent was obtained. All nasolacrimal intubation were performed under local nerve block anesthesia by a single experienced ophthalmologist. For nasolacrimal duct intubation, a commercially available bicanalicular silicone self-pushed tube was used (RS-2, Jinan Runshi, China) (Figure 1). Specifically, 1 mL of 0.5% lidocaine was mixed with 1 mL of 0.5% ropivacaine to perform the anterior ethmoid nerve block and infraorbital nerve block anesthesia, respectively. Both puncta were widened intraoperatively using a punctum dilator. Then, the canaliculi were probed and the lacrimal system was irrigated with 0.9% sodium chloride solution. Finally, the ends of the nasolacrimal silicone tube were inserted *via* the lower and the upper punctum, and the nasolacrimal duct was intubated in its entire length. After the surgery, antibiotic (gatifloxacin eye drops) and corticosteroid drops (tobramycin and dexamethasone eye drops) were prescribed 4 times a day for 1 wk in all patients. All patients were examined within 1 wk postoperative, 1 mo postoperative, 3 mo postoperative to ensure the correct tube positioning. Silicone lacrimal tubes were removed 3 mo postoperatively, and patients received an additional 2 wk of antibiotic-steroid drops. The final follow-up examination was conducted approximately 6 mo after silicone lacrimal tubes were removed, at which point clinical outcomes were recorded.

Definition of Success Two measures were used to grade the success of the procedure. Patients were asked to quantitate any epiphora they had after the procedure. Clinical assessment of lacrimal patency was assessed by irrigation of the lacrimal system. TMH was used as an objective measure of functional lacrimal drainage. The results were categorized as follows: 1) Complete success. Patients did not experience any epiphora, exhibited a normal TMH and had little or no reflux after irrigation of the lacrimal system. 2) Partial success. Patients experienced occasional epiphora with some reflux on lacrimal irrigation. Both these outcomes were considered a "successful outcome". 3) No improvement. Patients did not have any significant improvement in epiphora postoperatively with a high TMH, and had significant reflux during irrigation of the lacrimal system.

Statistical Analysis Results are presented as mean ± standard deviation for continuous variables and as percentage for categorical variables. Differences in continuous variables were tested for statistical significance using Student's t-test. Differences in categorical variables were tested for statistical significance using Chi-square or Fisher's exact test. All tests were two-sided, and statistical significance was defined as $P<0.05$. Data were analyzed using IBM SPSS ver. 22.0 (IBM Co., Armonk, NY, USA).

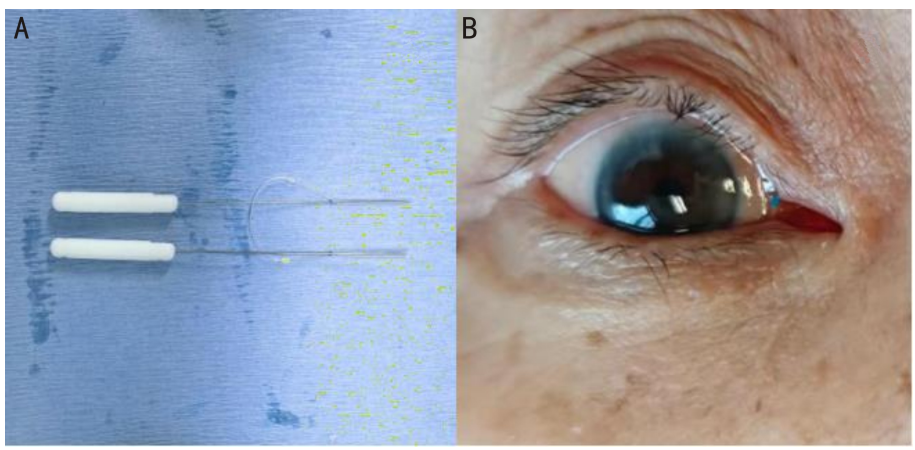

Figure 1 Nasolacrimal silicone before implantation (A) and when implanted (B).

RESULTS

Comparison of General Information A total of 152 eyes (136 patients) underwent nasolacrimal silicone intubation operations performed at the ophthalmology department of our hospital between October 2022 and October 2024. Among these patients, there were 49 males and 87 females, involving 77 right eyes and 75 left eyes. The mean age was 58.82±9.83 y (range from 30 to 84 y), the period of preoperative obstruction was 23.34±18.06 mo (range from 3 to 120 mo). Three months postoperative, the nasolacrimal silicone tubes were removed, and all patients underwent a six-month follow-up period after tube removal (Table 1). The overall success rate was 72.4%, while the failure rate was 27.6%. Specifically, Group A (64 eyes of 58 patients) underwent additional preoperative lacrimal duct probing. This group included 22 males and 36 females, with 30 right eyes and 34 left eyes. Their mean age was 58.09±11.07 y, and the average period of preoperative obstruction was 25.69±22.15 mo. In contrast, Group B (88 eyes of 78 patients) had not received additional preoperative lacrimal duct probing. This group consisted of 27 males and 51 females, with 47 right eyes and 41 left eyes. Their mean age was 59.35±8.84 y, and the average period of preoperative obstruction was 21.63±14.27 mo. The TMH of the patients in Groups A and B were 565±321 and 547±342 μm respectively. No statistically significant differences were observed between Groups A and B in terms of age, period of preoperative obstruction and TMH.

Surgical Success Rate A total of 152 eyes (136 patients) were included in a 6-month follow-up study after the removal of nasolacrimal silicone tubes. Of these, 85 eyes (55.9%) demonstrated complete success, while 25 eyes (16.5%) showed partial success. The overall success rate was 72.4%, with 42 eyes (27.6%) exhibiting no improvement and thus considered as failures. In Group A, 53 eyes (82.8%) achieved either complete or partial success, including 43 eyes (67.2%) with complete success and 10 eyes (15.6%) with partial success. In Group B, 57 eyes (64.8%) achieved success, comprising 42 eyes (47.7%) with complete success and 15 eyes (17.1%) with partial success. The success rate and complete success rate in Group A were significantly higher than those in Group B, with statistically significant differences observed between the two groups (Table 2).

Postoperative Complications No severe postoperative complications were observed in either group during the tube placement period. Three cases of dacryocystitis or canaliculitis were reported (1 in Group A and 2 in Group B), all of which resolved following antibiotic therapy. Two cases of granulation tissue hyperplasia at the lacrimal punctum were noted (1 in each group), and these had spontaneously atrophied by the 6-month follow-up after nasolacrimal silicone tube removal. Neither Group A nor Group B experienced tube dislocation or keratitis during the study period.

DISCUSSION

The causes of adult PANDO include age-related stenosis and low-level infection[6]. The stenosis contributesto increased stasis and infection within the lacrimal sac and canal, further exacerbating the existing stenosis through mucosal wall thickening. Early implementation of mechanical intervention can disrupt this cycle. Patient acceptance of dacryoplasty is generally high, as this procedure preserves the natural tear drainage pathway and avoids visible scarring or incisions. Silicone intubation may also be considered in patients with incomplete PANDO in adulthood. A key advantage of this approach is that it does not preclude the subsequent performance of dacryocystorhinostomy surgery in the event of treatment failure. The primary surgical principle underlying this method is to achieve optimal outcomes while minimizing trauma. Regarding the surgical success rate of nasolacrimal silicone intubation in treating incomplete PANDO in adults, the reports from various studies vary, ranging from 52% to 82%[7,9,15]. A recent Meta-analysis indicates that the silicone intubation success rate ranges from 52.6% to 84.6%, with a mean success rate of 75.65%[9]. In this study, the overall surgical success rate of silicone tube intubation for treating

Table 1 Comparison of the general data of the two groups of patients

Parameters	Group A	Group B	*P*
Eyes (*n*)	64	88	-
Male/female (*n*)	22/36	27/51	-
Age ($\bar{x}\pm s$, y)	58.09±11.07	59.35±8.84	0.917
Period of preoperative obstruction ($\bar{x}\pm s$, mo)	25.69±22.15	21.63±14.27	0.503
Tear meniscus height ($\bar{x}\pm s$, μm)	565±321	547±342	0.471
Duration of tube intubation (mo)	3	3	
Observation period aftertube removal (mo)	6	6	

Table 2 Comparison of therapeutic effects between the two groups of patients 6 mo after tube removal

Parameters	Complete success (eyes, *n*)	Partial success (eyes, *n*)	No improvement (eyes, *n*)	Complete success rate (%)	Success rate (%)
Group A	43	10	11	67.2	82.8
Group B	42	15	31	47.7	64.8
P				0.017	0.014

incomplete acquired nasolacrimal duct obstruction in adults was 72.4%, which is comparable to the average success rate reported in prior studies. Previous studies have revealed that the surgical success of nasolacrimal silicone intubation is associated with a larger smallest minor axis diameter of the bony nasolacrimal duct sections in incomplete PANDO[7,16-17]. The diameters of different silicone tubes for the lacrimal duct insertion procedure vary, which consequently affects the success rate of the surgery[18]. Baek *et al*[13] found that patient age influences surgical outcome of silicone tube intubation and found that success rate was negatively correlated with patient age. The size of the lacrimal sac and the location and severity of the obstruction in the lacrimal duct all have an impact on the success rate of nasolacrimal silicone intubation[14]. Due to the differences in patients' age, the location and severity of the nasolacrimal duct obstruction, as well as the follow-up time, the success rates reported in previous studies also vary. A total of 136 participants (involving 152 eyes) underwent nasolacrimal silicone intubation surgeryin this study. Among these participants, 49 were male and 87 were female. Notably, the proportion of female participants reached 64.0%, which was significantly higher than that of male participants. The anatomical basis for the development of PANDO was fueled by the female preponderance and supported by a mount of epidemiologic studies indicating that 68%-73% of the patients are female[15,19]. The underlying reasons for this gender disparity remain unclear; however, several hypotheses have been proposed. First, females tend to have smallerbony nasolacrimal duct diameters and cross-sectional areas[20-23]. Additionally, the observed female predominance in PANDO, particularly within the postmenopausal age group, prompted researchers to hypothesize that hormonal influences may serve as a potential etiopathogenicfactor[2,6,24-26]. Estrogen has been reported to induce mucosal distension, resulting in stenosis of the nasolacrimal duct, with its effects being most pronounced during the premenstrual period. Consequently, hormonal fluctuations during the premenopausal period may contribute to permanent obstruction of the nasolacrimal passage. Some scholars hypothesize that the use of cosmetics among women may potentially contribute to the higher prevalence of PANDO in this population[24].

The findings of this study indicate that the success rate of the cohort undergoing one or more nasolacrimal duct probings prior to lacrimal duct catheterization was higher compared to the cohort receiving direct lacrimal duct catheterization. This provides a valuable strategy for improving the success rate of lacrimal duct catheterization in clinical practice. We propose that the influence of preoperative exploration on the therapeutic efficacy of nasolacrimal silicone tube insertion may be attributed to the following potential factors. Firstly, lacrimal duct probing and dilation can optimize patient selection and enhancing treatment specificity. Preoperative probing serves as an accurate method to ascertain the nature and location of obstructions. In our study, patients who exhibited successful probing, indicated by soft and elastic resistance, predominantly presented with simple membranous obstruction or stenosis of the nasolacrimal duct. These conditions are amenable to the supportive and dilatory effects of silicone intubation. By identifying suitable candidates through preoperative probing, we effectively avoided performing intubation in complex cases, such as those involving extensive fibrosis, bony obstruction, or lacrimal sac masses, thereby significantly enhancing the overall success rate of the treatment. Additionally, lacrimal duct probing and dilation can reduce intraoperative complications and preserving the anatomical pathway. Preoperative probing serves to pre-dilate the stenotic lacrimal pathway and elucidate its natural course. This procedure facilitates the smoother insertion of the silicone tube guidance system during surgery and significantly reduces the incidence of complications such as false passage formation, mucosal tearing, and bleeding. Maintaining an intact and atraumatic lacrimal mucosa is crucial for postoperative epithelial regeneration and ensuring long-term patency. Moreover, the enhancement of the local microenvironment and the suppression of inflammation and fibrosis are achieved through the combination of preoperative probing and irrigation, which effectively eliminates persistent inflammatory secretions and pathogens from the lacrimal system. This process alleviates pre-existing mucosal edema and chronic inflammation. We propose that this "debulking" effect mitigates the risk of excessive local inflammatory responses and the formation of granulation tissue following intubation, consequently reducing the likelihood of re-obstruction after the removal of the silicone tube.

While preoperative probing has been shown to confer protective benefits in terms of intraoperative guidance and patient selection, it is important to acknowledge that probing itself carries the potential for mucosal injury, which could theoretically predispose to granulation tissue formation and long-term re-obstruction. In the present study, we employed a standardized protocol of gentle probing performed by experienced surgeons. Under these conditions, we observed that the benefits of probing—namely, evacuation of inflammatory debris, decompression of mucosal edema, and provision of a clear pathway for atraumatic intubation—outweighed the risks. In our study, at the six-month follow-up following lacrimal duct stent removal, the success rate was higher in Group A (lacrimal probing and dilation combined with silicone intubation) than in group B (silicone intubation alone). This indicates that preoperative lacrimal duct probing serves as a protective factor associated with improved success rates of silicone intubation. We hypothesize that the mechanical support provided by the indwelling silicone tube likely mitigates the consequences of probing-induced mucosal microtrauma—specifically by preventing epithelial apposition and subsequent fibrotic adhesion formation. However, this hypothesis requires validation through prospective studies with

extended follow-up duration and adequate statistical power.

Currently, there is no universally accepted standard for the timing of tube removal following anterograde lacrimal duct stenting. International studies have reported that the duration of tube placement varies from 6 wk to 1 y depending on the specific condition being treated[27]. In cases of nasolacrimal duct obstruction, the drainage tube inserted *via* anterograde lacrimal duct stenting fails to adequately expand the duct wall due to the nasolacrimal duct lumen typically exceeding 3 mm in diameter, whereas the maximum diameter achieved by the double-strand silicone tube does not exceed 2 mm[7,18]. Consequently, the supportive function diminishes over time, leading to no significant therapeutic advantage between 1-month and 3-month tube retention. Although, a standardized protocol for the optimal timing has yet to be established. In clinical practice in China, the majority of physicians choose to remove the tube between 3 and 6 mo post-stenting. Research indicates that the surgical outcomes are comparable whether the nasolacrimal duct support tube is removed at 3 or 6 mo[9,28]. Nevertheless, complications such as granulation tissue formation, localized pain in the lacrimal region, and difficulty during tube removal occur more frequently when the tube is retained for 6 mo. Based on these findings, this study implements a protocol for tube removal at 3 mo.

Our study has several limitations that warrant consideration. First, the retrospective nature and lack of randomization may introduce selection bias, raised the potential for selection bias in the choice of procedure, and that unmeasured confounders might have influenced the results. Despite being a retrospective interventional case series, we assert that our findings are significant as they offer valuable insights for clinicians and may serve as preliminary data for larger studies with extended follow-up periods. Second, the patients included in this study underwent a varying number of nasolacrimal duct probing procedures prior to silicone intubation in Group A, with a range of 1 to 3 procedures. However, no classification-based analysis was performed regarding the impact of the number of prior nasolacrimal duct probing procedures on outcomes. Future studies should address this gap by performing a detailed analysis to elucidate the precise role of preoperative nasolacrimal duct probing in nasolacrimal silicone intubation and determine the optimal number of nasolacrimal duct probing procedures required. This would provide valuable insights and actionable guidance for clinical practice. Moreover, the current analysis did not stratified outcomes by anatomical site (*e.g.*, canalicular versus nasolacrimal duct obstruction) or by obstruction severity, factors known to influence procedural success and long-term patency. Subgroup analyses incorporating these clinically relevant variables would enhance the precision and applicability of our findings for individualized surgical decision-making.

In summary, our study demonstrates that nasolacrimal silicone intubation is a safe and efficacious surgical intervention for addressing incomplete PANDO in adults. Furthermore, the integration of one or more nasolacrimal duct probing procedures prior to surgery can substantially enhance the success rate of lacrimal duct stenting.

Conflicts of Interest: Hu C, None; Liu Y, None; Chen J, None; Fang JR, None; Xiang N, None; Du F, None; Zeng B, None.

Authors' Contributions: Hu C and Liu Y conceptualized the manuscript; Chen J, Fang JR, and Xiang N collected the clinical data; Du F and Zeng B helped in drafting the manuscript. All authors have read and agreed to the published version of the manuscript.

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