

Long-term outcomes of laser dacryoplasty combined with intubation using a new silicon tube in patients with lacrimal duct obstruction

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Abstract

• **AIM:** To determine the 15-year outcomes of laser dacryoplasty (LDP) in patients with lacrimal duct obstruction; and to evaluate LDP combined with intubation using a new silicone tube to treat complicated cases.

• **METHODS:** Patients with lacrimal duct obstruction and treated with LDP between April 2000 and April 2005 were investigated retrospectively. Totally 116 eyes with completed 15-year follow-up records were included in this study. For complicated cases (52 eyes of 52 patients), both LDP and intubation using a self-made silicon tube were performed. For patients with uncomplicated obstruction (64 eyes of 61 patients), only LDP was performed. Outcomes were assessed based on results of lacrimal irrigation and degree of symptoms during follow-up.

• **RESULTS:** At the follow-up time of 15y, 81 eyes achieved full success (69.8%); 21 eyes got improved (18.1%); and 14 eyes were considered failure (12.1%). The success rate was 71.2% (37/52 eyes) for complicated cases; and 68.8% (44/64 eyes) for uncomplicated cases. No statistically significant difference between two groups was observed ($P=0.961$). No postoperative complication was observed.

• **CONCLUSION:** LDP is a well-tolerated, simple, and effective procedure with satisfactory long-term outcomes in selected patients, which make it a good alternative to conventional dacryocystorhinostomy. In addition, intubation

with the self-made mono-canalicular silicone tube facilitates the management of complicated cases with few complications.

• **KEYWORDS:** laser dacryoplasty; chronic dacryocystitis; lacrimal duct obstruction

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INTRODUCTION

Lacrimal duct obstruction is a common disorder in ophthalmology outpatient^[1]. Based on the obstruction site, it can be classified into two general types—obstruction of the upper lacrimal system (lacrimal punctum, canaliculi and common canaliculus) and obstruction of nasolacrimal duct. No matter which type is, the stasis of tears and secretions within the sac can lead to buildup of bacterial load and likely cause chronic dacryocystitis. The clinical picture of chronic dacryocystitis consists of constant epiphora, dilation of the sac, discharge and formation of pyocele^[2].

External dacryocystorhinostomy (DCR) has for a long time been recognized as the gold standard for surgical treatment of lacrimal duct obstruction^[2-4]. Its success rates in literature vary between 85% and 99%^[5-6]. Although the routine use of stenting for lacrimal duct obstruction is still controversial, the success rate may be further improved by intubating the lacrimal system in certain conditions, especially in complicated cases who tend to relapse^[7-10].

As enthusiasm for more minimally invasive procedure has increased in recent decades, lacrimal surgery using different lasers has progressively evolved. Laser dacryoplasty (LDP) is such a procedure to rechannel the closed lacrimal system. In LDP, focal stenoses within the lacrimal passage are detected and lasered using an erbium Yttrium-Aluminum-Garnet (Er-YAG), neodymium-doped Yttrium-Aluminum-Garnet (YAG), potassium titanyl phosphate YAG or diode laser^[11-12]. The

symptomatic success rate of LDP was about 80% at follow-up period of 20.4mo^[11]. For presaccal canalicular obstruction, the rate was as high as 93.3% at 3-6mo of follow-up and 89.66% at 9-12mo of follow-up, which is higher than that of all other surgical procedures described to date^[13-14]. Previous studies report outcomes of LDP up to less than 5y with limited cases^[15]. We believed longer term outcomes are needed to assess the overall benefits and complications of the LDP in a disease easy to relapse.

Therefore, the aims of this retrospective observational study were: 1) to determine the 15-year outcomes in a cohort of 113 patients with chronic dacryocystitis undergoing LDP; 2) to determine the clinical effectiveness of a self-made mono-canalicular silicone tube for the treatment of complicated lacrimal duct obstruction.

SUBJECTS AND METHODS

Ethical Approval The study was conducted in accordance with the Declaration of Helsinki and was approved by the Medical Ethics Committee of Xi'an People's Hospital (Xi'an Fourth Hospital; Approval number: 2020-127). All patients had been fully informed of the purpose and methods of the present study and provided written informed consent from themselves. For patients under the age of 18, written informed consent was obtained from their parents or legal guardians.

Study Design This was a retrospective observational study. The medical records of consecutive patients who underwent LDP in Xi'an People's Hospital (Xi'an Fourth Hospital) between April 2000 and April 2005 were reviewed. The inclusion criteria were 1) confirmed diagnosis of chronic dacryocystitis due to obstruction of the lacrimal system, based on lacrimal irrigation; 2) follow-up of longer than 15y after LDP. For complicated cases, additional inclusion criterium was previous history of lacrimal surgery, including lacrimal dilation, probing, threading, intubation, LDP or external DCR. Patients with incomplete medical records were excluded.

One hundred sixteen eyes of 113 patients with were included in this study. The demographic data was reviewed. For uncomplicated lacrimal obstruction (64 eyes of 61 patients), only LDP was performed. For complicated lacrimal obstruction (52 eyes of 52 patients), LDP and subsequent intubation using a self-made silicone tube were performed. The treatment algorithm is shown in Figure 1.

Equipment The Nd:YAG laser (LEK-0800SK; Laicon Co. Ltd., China) generates a 1064-nm wavelength laser beam and works in pulse mode with a pulse length of 100-150ms, allowing a variable energy of 3-6 W at the tip of fiber. The laser beam generated is invisible while diode laser serves as aiming beam. Further equipment used included a laser cannula (Size 9) with needle, routine irrigation packages and punctum dilators.

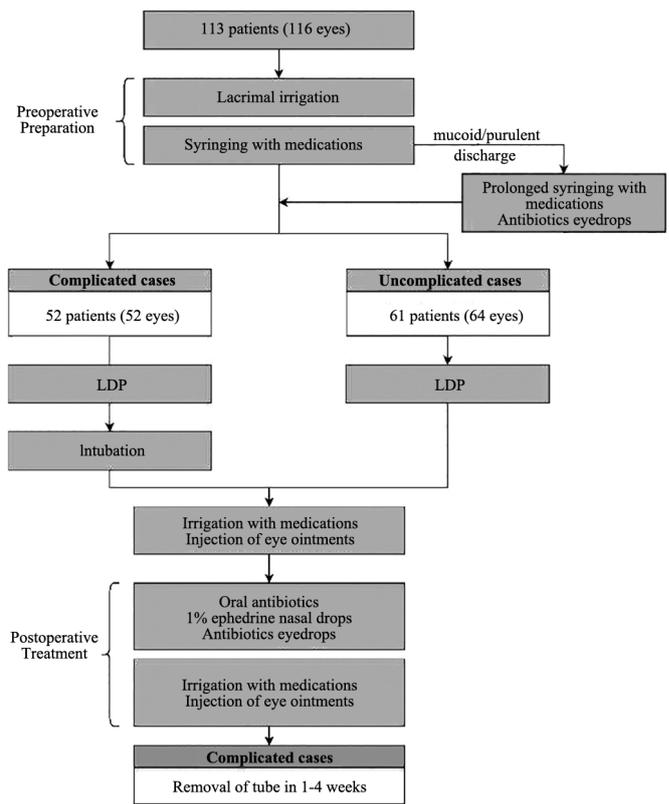


Figure 1 Treatment algorithm For complicated lacrimal obstruction, LDP with intubation using the self-made silicon tube was performed. For other patients with uncomplicated lacrimal obstruction, only LDP was performed. Complicated case was defined as patients who had received lacrimal surgery, including lacrimal dilation, probing, threading, intubation, LDP or external dacryocystorhinostomy. LDP: Laser dacryoplasty.

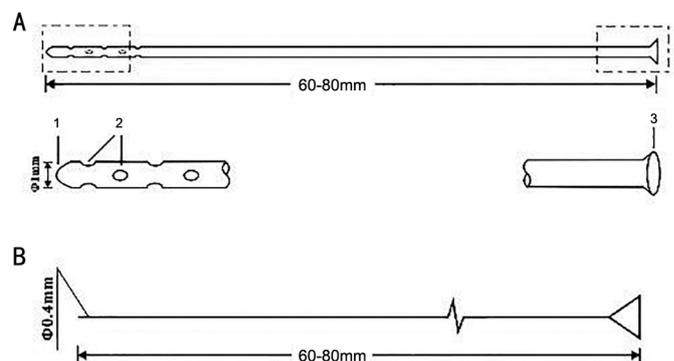


Figure 2 The schematic diagram of the self-made mono-canalicular silicone tube A: The outer hollow silicone tube and zoom-in images of its two ends (1, medial blind end; 2, side holes; 3, distal trumpet-shaped opening); B: The inner stainless-steel probe with a needle-hand-shaped end.

A self-made mono-canalicular silicone tube (Figure 2) was used in complicated cases. This device consists of two components: 1) a hollow silicone tube 0.9-1 mm in diameter and 60-80 mm long. The silicone tube has two ends: the medial one is a blind blunt end while the distal one is a trumpet-shaped opening. Two millimeters from the medial blind end

lie two coaxial side holes, allowing traction string to pass through. Further side holes distribute in a spiral line fashion along the tube with an angle of 90- or 60-degree between two neighboring holes. The distal trumpet-shaped opening of the tube is wider than the lacrimal meatus to prevent the migration of the tube and lower the possibility of infection. A bonding tape sits near the distal opening, which allows for a secure fixation and tight sealing of the trumpet-shaped opening. 2) an inner stainless-steel probe to facilitate the insertion, which is 0.4 mm in diameter and 60-80 mm long with a needle-hand-shaped end.

Preoperative Preparation Suffered eyes all underwent lacrimal irrigation and probing examination to locate the obstruction and to clean the mucoid or purulent secretions. Then, syringing with a mixture of 20 000 U gentamicin and 2.5 mg dexamethasone was performed daily for consecutive 3d. Such syringing was extended to 5-7d if mucoid or purulent discharge can still be observed at the third day. Besides, antibiotics eyedrops 3-5 times daily were prescribed for these patients with mucoid or purulent discharge. Irrigation was performed from the upper punctum for those with lower canalicular obstruction.

Laser Dacryoplasty Technique For both groups, topical anesthesia was performed. Infratrochlear and infraorbital nerve block was performed with 2% lidocaine when necessary (for patients sensitive to pain). Lower lacrimal punctum was dilated and a laser cannula was inserted into the lower punctum and marched along the lacrimal duct to the site of obstruction. With needle removed, the laser probe was introduced into the lacrimal duct through the cannula. After reaching the obstruction site, laser was applied. After several laser impulses, free irrigation was noted, suggesting the successful opening of the obstruction and the integrity of the lacrimal duct. Then, the cannula was pulled out 20-30min after LDP.

Intubation For complicated cases, intubation using our self-made silicon tube was performed after LDP as follows: After pulling out the laser cannula, anterior chamber viscoelastic was introduced into the canaliculi. The self-made tube coated with antibiotic eye ointment was inserted into the site needed (lacrimal sac, nasolacrimal duct or inferior nasal concha). Then, the inner probe was removed. Saline solution was injected to confirm a right intubation position.

All the procedures were done by the same surgeon (Yin XX).

Instant Postoperative Treatment Irrigation was performed with a mixture containing 20 000 U gentamicin and 2.5 mg dexamethasone, followed by injection of tetracycline-cortisone or tobramycin-dexamethasone eye ointment. For uncomplicated cases, irrigation and drug delivery mentioned above was done directly into the lacrimal tract. For complicated cases, it was done through the silicon tube.

Table 1 Patient demographics and characteristics

Information	All (n=113)	Complicated cases (n=52)	Uncomplicated cases (n=61)
Age (y), mean (range)	42 (15-80)	46.2 (18-65)	39 (15-80)
Gender, n (%)			
Male	25 (22.1)	20 (38.5)	5 (8.2)
Female	88 (77.9)	32 (61.5)	56 (91.8)
Side affected			
Right eye	55	24	31
Left eye	55	28	27
Both eyes	3	0	3
Duration of symptoms (y)	0.25-33	1.5-33	0.25-28

Postoperative Treatment Oral antibiotics were prescribed for 3-7d. Topical medications including 1% ephedrine nasal drops to the nostril three times per day and antibiotic eye drops used for 5-6 times a day in the ipsilateral conjunctival sac were routinely prescribed. The medications were tapered gradually until a positive irrigation showed the patency without epiphora or pyorrhea. Irrigation with a mixture containing 20 000 U gentamicin and 2.5 mg dexamethasone followed by injection of tetracycline-cortisone or tobramycin-dexamethasone eye ointment into the lacrimal duct was performed every second day for three times and then once a week for 1-3mo. More frequent treatment was performed when purulent discharge observed. In complicated cases, gentamicin, dexamethasone, hyaluronidase or mitomycin C was used accordingly in addition to treatment mentioned above. The self-made silicone tubes were removed at 1-4wk after the LDP when patients reached criteria for "success". Clinical follow-up was at 6-, 12-, 18-month and once a year thereafter to assess any recurrence of symptoms and the need for further intervention.

Outcomes Success was defined as the passage being patent on irrigation and complete resolution of symptoms (epiphora or pyorrhea).

Improvement was defined as the passage being patent on irrigation but epiphora remained in varying degrees.

Failure was defined as being non-patent or patent with high resistance, and pyorrhea remained.

Statistical Analysis Statistical analyses were carried out using SPSS Software (version 21.0; SPSS, Inc., Chicago, IL, USA). Descriptive data were expressed as mean and range. χ^2 test was performed to compare outcomes between two groups. A significance level α of less than 0.05 was used.

RESULTS

Patient Characteristics LDP was performed in 116 eyes of 113 patients. An overview of epidemiological data can be found in Table 1. There were 25 male patients (25 eyes) and 88 female patients (91 eyes). The mean age was 42y (range, 15-80y), and the duration of symptoms ranged from 3mo to 33y.

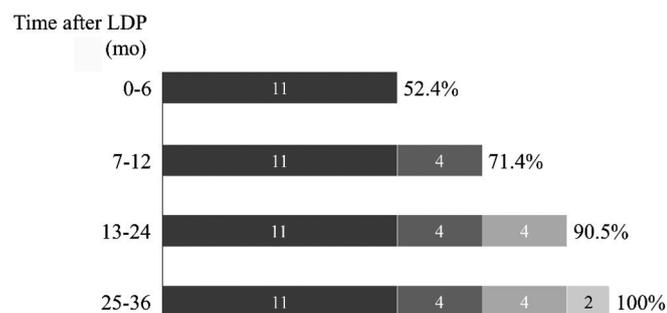


Figure 3 Number of cases and accumulated occurrence rate of chronic dacryocystitis after LDP. Number inside the bar indicates the number of cases. Number outside the bar indicates the accumulated occurrence rate. LDP: Laser dacryoplasty.

Table 2 Long-term outcomes of LDP and intubation with a self-made silicone tube

Outcome	n (%)		
	All (n=116)	Complicated cases (n=52)	Uncomplicated cases (n=64)
Success	81 (69.8)	37 (71.2)	44 (68.8)
Improvement	21 (18.1)	9 (17.3)	12 (18.8)
Failure	14 (12.1)	6 (11.5)	8 (12.5)

LDP: Laser dacryoplasty.

In all cases the cause for obstruction was nasolacrimal duct obstruction while three eyes also combined with obstruction of the lower canaliculus or common lacrimal canaliculus.

Outcomes The mean procedure duration of LDP was 12min. The follow-up time was 15y. The outcomes are shown in Table 2. As per our aforementioned definition, the overall success rate was 69.8% (81 eyes); improvement rate was 18.1% (21 eyes); and failure rate was 12.1% (14 eyes). For complicated cases, correct positioning of the tube was possible in all 52 eyes. Success was achieved in 37 eyes (71.2%); improvement in 9 eyes (17.3%) and failure in 6 eyes (11.5%). The success rate for uncomplicated cases was 68.8%. Improvement rate was 18.8% and the failure rate was 12.5%. No statistically significant difference was observed between two groups ($\chi^2=0.079$, $P=0.961$). For cases combined with obstruction of the lower canaliculus or common lacrimal canaliculus, success was observed in all three eyes.

In all unsuccessful cases, 21 eyes suffered from chronic dacryocystitis again. Figure 3 shows the relation between relapse rate and time occurred. Totally 52.4% of chronic dacryocystitis re-occurred within the first 6mo after LDP; and another 19.0% re-occurred during the second 6mo. Overall, 90.5% of recurrence occurred within 24mo after LDP, while no further recurrence was observed after 36mo. Factors contributing to the relapse or failure included history of lacrimal surgery (11 eyes), history of acute dacryocystitis (3 eyes), no-show during the first month follow-up (2 eyes), persistent nasolacrimal duct obstruction for the whole time (5 eyes). After proactive treatment, 2 out of 21 eyes relapse cases

met the criteria for success; 5 eyes got improved and 14 eyes were still defined as failure.

Complications With respect to the intra-operative complication of LDP, no false passage formation nor laceration of lacrimal punctum was observed in all cases. In 3 eyes, hemorrhage occurred when inserting the cannula. Blood was drained out through cannula. Hemorrhage stopped spontaneously with no further intervention. No hemorrhage from the nasal cavity observed. With respect to postoperative complications, no infection, hemorrhage nor acute dacryocystitis was observed. For complicated cases, intubation was possible in all cases with no related complications observed.

DISCUSSION

In this study, we are reporting on our 15-year experience in LDP treatment for lacrimal obstruction with chronic dacryocystitis. The procedure delivered promising performance in 116 eyes with long-term success rate of 69.8%. Postoperative complications were mild. In addition, when combined with intubation using our self-made monocular silicone tube to treat complicated cases, it showed satisfying results beyond expectation with a success rate of 71.2%, suggesting potential benefits of silicone intubation in lacrimal duct obstruction.

Improvements in fiberoptic technologies have allowed for delivery of laser energy *via* the canaliculus which makes the laser excision possible without external incision. In 1997, Emmerich *et al*^[16] used an Er-YAG laser to rechannel the lacrimal systems of 53 patients after dacryoendoscopies. The term “laser dacryoplasty” is used for this procedure since then. LDP has clear advantages in competence to conventional surgical interventions of the lacrimal drainage system. First, it is a minimally invasive procedure without any skin incision. In case LDP fails, the option to perform any types of conventional surgery is still available as before. Second, the patency is achieved *via* re-canalization instead of creating a new passage, which means the structural integrity and normal physiological function of the entire efferent lacrimal pathway are preserved. Third, the less operative time and faster recovery make LDP an outpatient procedure^[17-20].

Emmerich *et al*^[16,19] reported on treatment outcomes of LDP in 53 patients. At 3mo of follow-up, 49.1% got marked improvement, 22.6% for slight improvements, 15.1% for no change and 7.5% for deteriorations. Another study reported all cases (19 eyes) were successful at 6mo, and 84.2% (n=16) remained intact canaliculi at 14mo (8-17mo)^[21]. The largest sample size for LDP was more than 200 patients with success rate of 80% at mean follow-up of 20.4mo^[11]. Furthermore, higher success rate was found for presaccal canalicular obstruction, comparing to nasolacrimal duct obstruction

(93.3% vs 66.7% at 3-6mo, 89.66% vs 64.71% at 9-12mo)^[13-14]. Völkerling *et al*^[15] reported longest-term outcomes of LDP before the current study. The total success was 59.1% at mean follow-up of 55 (31-77)mo. However, this study only enrolled 14 patients. Our study reported the 15-year follow-up outcomes with success rate of 69.8%. These longer-term outcomes will help to evaluate the overall benefits and complications of the LDP, especially for a disease easy to relapse.

Based on our experience, LDP success depends on proper patient selection, thorough preoperative syringing, good technique and appropriate postoperative medications and regular follow-up. To begin with, we found that patients' past history and their adherence to follow-up contributed to overall outcomes. As such, patient selection and education are primary issues. Detailed inquiry of past medical history is essential. Patients with implanted nasolacrimal stent or with history of nasal fracture should be excluded. Patients with a history of acute dacryocystitis and those who have undergone previous lacrimal surgery are not very good candidates for LDP^[22]. Decision should be made with caution when treating these patients. Preoperatively, sufficient lacrimal syringing should be initially performed, since it contributes to a higher success rate and fewer complications by providing a purulence-free operative space for LDP. With respect to the procedure itself, accurate and gentle manipulation is always important to avoid the formation of a false passage. The laser power and duration should be strictly controlled. Lacrimal syringing the next day should be performed carefully, because the mucosa is still edematous. Postoperative syringing is of paramount importance because it can reduce the inflammatory stimuli that may create after the procedure. Medications used included gentamicin, tetracycline and tobramycin, since the most frequently isolated Gram-positive bacteria were *Staphylococci*, *Pseudomonas meltophilia* and *Pseudomonas alcaligenes* for Gram-negative bacteria, and Bacteroid for anaerobic micro-organism^[23-25]. In addition to antibiotics, dexamethasone or cortisone ointment was also injected to decrease inflammation and to support the lacrimal duct.

The routine use of stenting for lacrimal duct obstruction in the absence of canalicular disease is still controversial. Advocates for stenting reported an increased patency rate by preventing adhesion of the mucosal lining of the channels^[5,26-29]. It is a useful adjunct when there is partial or complete canalicular obstructions, since re-stenosis of the canaliculus is the most common reason for failure^[10,30-31]. This is especially important for complicated cases whose relapse is usually related to aggressive healing response of tissues^[7-8,32-35]. Advocates against routine intubation believed there is no strong evidence in the literature to suggest improved anatomical patency^[36-40]. Furthermore, intubation related morbidity such as puncta

or canalicular cheese wiring, granuloma formation, nasal irritation, corneal erosion and displacements have been reported, although the overall frequency of complications is less than 5%^[5,41-42]. None of such complication was observed in the current study.

Our results showed that long-term outcomes of the LDP in complicated cases were not statistically different from that of uncomplicated cases when combined with intubation, suggesting potential benefits of silicone intubation in lacrimal duct obstruction. Our self-made silicone tube used in this study has its own strength. First, there are two coaxial side holes near the medial blind end, where traction string can pass through. This allows the tube to be removed from the nasal cavity and thereby avoiding retrograde infection of the lacrimal system^[43]. Second, side holes (including the two side holes mentioned before) distributed along the tube facilitate a thorough syringing and sufficient medication treatment. Third, the trumpet-shaped opening at the distal end enables convenient application of medications. All of these features make intubation a safe, simple and fast process.

Our study had several strengths. First, we reported on the 15-year outcomes of LDP, which provided evidence to assess the overall benefits and complications of the LDP in a disease easy to relapse. Intubation with our self-made mono-canalicular silicone tube facilitated the management of complicated cases with few complications. It may inspire future tube design. Limitations of this retrospective observational study include the absence of a control group in which another surgery was used^[44-51]. Intubation was only performed in complicated cases and postoperative care varied among different cases, which limited the comparison. This is a retrospective observational study. Prospective, random controlled study is required to provide solid evidence.

In conclusion, our results indicated that LDP is a well-tolerated and viable treatment option for lacrimal duct obstruction in selected patients. Besides, the appropriate use of intubation following LDP, especially in the complicated case, may help in improving the surgical outcome and patient satisfaction with rare complications which are easy to manage. Of course, prospective, random controlled study is required to provide solid evidence.

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