Video Article

Transcanalicular Diode Laser-assisted Dacryocystorhinostomy for the Treatment of Primary Acquired Nasolacrimal Duct Obstruction

Joel M. Mor[1], Yongwei Guo[1], Konrad R. Koch[1], Ludwig M. Heindl[1]

[1]Department of Ophthalmology, University of Cologne

Correspondence to: Joel M. Mor at joel.mor@uk-koeln.de

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Abstract

Today's gold standard in the treatment of infrasaccal primary acquired nasolacrimal duct obstruction (PANDO) is external dacryocystorhinostomy (DCR), a relatively invasive procedure that can be performed after failure of recanalizing treatments. However, with progress in the field of diode laser technology, new approaches have emerged. Laser-assisted transcanalicular DCR with subsequent bicanalicular silicon intubation is a new option showing great promise as a viable minimally invasive procedure. Under permanent endoscopic visual control from the nasal cavity, a diode laser fiber is inserted into the lacrimal sac and laser energy is applied to create a bony ostium between the lacrimal sac and the nasal cavity. Since no skin incision needs to be made, advantages of this method comprise the sparing of the skin as well as the medial palpebral structures and the physiological palpebral-canalicular pump mechanism. The duration of surgery as well as reconvalescence is generally shorter than with external DCR. Complications include silicon tube prolapse, mild swelling and, rarely, canalicular infection and thermal injury. One-year functional success rates, defined as complete resolution of symptoms and ostium patency, are high, yet still range behind those of external DCR. However, secondary external DCR after failure of laser-assisted DCR can be performed without difficulty. Thus, laser-assisted transcanalicular DCR is a valid option that should be considered as a second-step procedure after failure of recanalization procedures and before external DCR.

Video Link

The video component of this article can be found at https://www.jove.com/video/55981/

Introduction

Infrasaccal primary acquired nasolacrimal duct obstruction (PANDO) is a common disorder in middle-aged and older patients leading to chronic epiphora and blepharitis as well as recurring or chronic dacryocystitis. Most commonly, patients develop an infrasaccal obstruction of one or both nasolacrimal ducts, resulting in insufficient tear drainage.

In the treatment of PANDO, external dacryocystorhinostomy (DCR) is still considered to be the gold standard, even though this procedure historically dates back over a hundred years to when it was first performed[1]. After skin incision and preparation of the nasal wall of the lacrimal sac, a drill is used to create a bony ostium leading to the nasal cavity, thus bypassing the obstructed duct. Functional success rates above 85% have been reported for this method[2,3]. These results, however, come at the cost of performing a relatively invasive procedure that puts at risk the medial structures of the eyelid including the physiological canalicular pump mechanism[4,5] and may leave patients with an unwelcome scar, although modern nasojugal skin incisions have improved results. These risks are potentially avoidable by performing less invasive techniques or choosing an endonasal approach.

In order to circumvent invasive surgery, much work has been done in the field of minimally invasive tear drainage recanalization. Two methods in particular have been established as potential first-step procedures: microdrill dacryoplasty and laser-assisted dacryoplasty. These procedures are based on transcanalicular endoscopy of the tear drainage system and can be performed to treat for short-segment membranous stenoses of the nasolacrimal duct. Though only minimally invasive and characterized by quick reconvalescence, a common drawback of these recanalizing techniques are the relatively low functional success rates with regard to long-term outcomes[6,7,8,9].

In an effort to fill the void between these first-step procedures and external DCR as a definitive treatment, new approaches have recently been developed. The most promising of which is laser-assisted DCR for the treatment of absolute infrasaccal PANDO. Like with all aforementioned approaches, patients are recommended to be put under general anesthesia for this procedure. A diode laser fiber is inserted via either canaliculus and is then advanced into the lacrimal sac. Next, laser energy is applied to the lateral nasal wall until a bony ostium is created, connecting to the nasal cavity at the height of the middle turbinate's anterior margin[10,11]. All the while, constant visual control is kept using endonasal endoscopy. The newly formed anastomosis serves as a bypass for the tear drainage. After successful irrigation, bicanalicular silicon intubation is performed to prevent early scarring of the newly formed ostium. Postoperative treatment consists of decongestant, steroidal and antibiotic eye drops to prevent swelling, inflammation, and infection, respectively.

The duration of surgery as well as reconvalescence is generally shorter than with external DCR (10 - 25 min in laser-assisted DCR vs. 35 - 75 min in external DCR). Complication rates are relatively low, the most common being discrete swelling of the eyelids and silicon tube prolapse.

Canalicular infection and thermal injury are rare events[10]. One-year functional success rates of 74 - 88% have been reported[10,11,12,13,14,15,16,17,18], thus ranging closely behind those of external DCR without suffering the disadvantages of the external surgical approach. However, long-term results remain yet to be provided. Additionally, even after failure of laser-assisted DCR, secondary external DCR can still be performed without difficulty. Consequently, laser-assisted DCR qualifies as a viable second-step procedure that should optimally be performed after failure of recanalization surgery and before external DCR.

Protocol

For this procedure, informed consent is required and has been obtained for every patient who has undergone surgery in the Department of Ophthalmology, University of Cologne, Cologne, Germany. All examinations and surgical interventions were executed in accordance with national laws and the declaration of Helsinki from 1975 in its current version.

NOTE: Unless indicated otherwise, instructions will always only refer to the side on which the procedure is being performed. Use sterilized equipment.

1. Patient Preparation

1. Perform a thorough ophthalmic examination (with special attention to eyelids, upper and lower punctum, and tear drainage) including irrigation and probing to test for PANDO[10].
    1. For standardized irrigation, insert a Bangerter probe into the upper and, subsequently, lower punctum. Begin by inserting it vertically, then tilt it toward the temple into a horizontal position to follow the physiological formation of the canaliculus. When the probe is in position, carefully inject saline to test for lacrimal duct obstruction.
    NOTE: In infrasaccal PANDO, the Bangerter cannula will easily reach the lateral nasal wall without a bouncy resistance ("hard stop"). Trying to irrigate will result in contralateral reflux through the opposite punctum without any fluid reaching the patient's pharynx[10].
2. Rule out acute infections, tumors of the tear drainage system as well as traumatic, congenital or presaccal obstruction.
    1. To rule out acute infections, look for painful reddening, swelling or purulent discharge of the tear drainage. To rule out tumors, look for indolent swelling, ulceration or pigmentation. Presaccal obstruction results in a bouncy resistance when trying to advance the Bangerter Probe into the lacrimal sac ("soft stop"). Congenital and traumatic obstruction can be ruled out by taking patient history[10,19,20].
3. Rule out intranasal rhinological pathologies, e.g. severe septum deviation. This should be done by taking the patient's history in combination with a rhinological inspection of the nasal cavity [21].
4. Put the patient under general anesthesia, e.g. by intravenous injection of propofol, remifentanil, and atracurium for induction and inhalation of desfluran plus intravenous remifentanil for maintenance, using standard weight-adapted dosing[10]. Intubation should be performed, but use of a larynx mask is also possible.
NOTE: Anesthetics as well as dosages may vary between clinics. No specific anaesthesia protocol is required for laser-assisted DCR.

2. Laser-assisted DCR

1. Insert the video-assisted endoscope into the nasal cavity by carefully advancing it through the nostril. Visualize the anterior margin of the middle turbinate by slightly tilting the endoscope towards the lateral nasal wall.
2. Set up the laser equipment and laser settings to the correct values. Put on protective glasses.
    1. Connect the laser fiber optic (diameter 400 µm) to the diode laser (wavelength 810 nm). Set the diode laser settings to 6 - 8 W, 200 ms pulse duration, 100 ms exposition pause.
    2. Fit the laser fiber optic into the hand-piece for maneuvering and through a blunt cannula. Let 2 - 3 mm of the fiber stick out at the tip of the cannula.
    3. Perform carbonization of the laser fiber tip by holding it on a wooden spatula and applying laser energy for a few seconds until the tip is sufficiently blackened.
    NOTE: This will limit unwanted energy distribution to the tissue of the lacrimal sac.
3. Position the laser fiber correctly at the lateral nasal wall.
    1. Use a lacrimal probe to dilate the lower punctum (**Figure 2a**). Insert the probe in a vertical orientation at first and then bring into a horizontal orientation before further advancing it towards the lacrimal sac. This will allow for the laser fiber to be inserted smoothly in the next step.
    2. Insert the laser fiber into the lower canaliculus (**Figure 2b, 2c**). Begin by inserting it vertically, then tilt it toward the temple into a horizontal position to follow the physiological formation of the lower canaliculus.
    3. Carefully advance the laser fiber into the lacrimal sac until it touches the lateral nasal wall, i.e. the medial lacrimal saccal wall. There, aim the tip in an antero-inferior direction so that it points to the anterior margin of the middle turbinate.
    4. Verify correct positioning endoscopically by monitoring transluminescence of the aiming beam at the height of the anterior margin of the middle turbinate (**Figure 2d**).
4. Create a sufficient nasolacrimal bypass by application of pulsed laser energy to the nasal wall.
    1. Apply laser energy (using the parameters set above), keeping constant contact to the wall without pressure, aiming for the anterior margin of the middle turbinate. The laser will vaporize the tissue directly in front of it, creating a nasolacrimal bypass (**Figure 2d, 2e**).
    NOTE: The total energy required ranges between 0.9 - 1.8 kJ and tends to vary between patients.
    2. Ensure that the fiber tip is not actively pressed against the wall. Be careful not to let the tip slip back into the metal cannula as this will cause thermal injury due to heating of the metal. Also avoid sideways movements as the tip can break off.

    3. Upon penetrating the lateral nasal wall, pull the laser fiber back a bit and enlarge the ostium by carefully vaporizing the margins in a circular manner. Try to create as large a bypass as possible (**Figure 2f**).
    4. Aim for a total diameter of 5 mm for the ostium.
    5. Stop applying energy and remove the laser fiber together with the hand-piece and the cannula by carefully retracting the equipment.

5. Verify the patency of the ostium by saline irrigation using a Bangerter probe as described in 1.1.1. If a patent ostium was created, successful irrigation should be visible endoscopically.
6. Remove the Bangerter probe.
7. Place the silicon tube (**Figure 2g**).
    1. Through the lower punctum, insert a monocanalicular silicon tube and carefully advance it until the leading metal tip passes the bony ostium and protrudes into the nasal cavity.
    2. Use Blakesley forceps to grab the tip from inside the nasal cavity and pull the silicon tube out of the nose and into position (**Figure 2h**).
    3. Use a pair of scissors to shorten the silicon tube. The end should not be sticking out of the nose.
    4. Perform silicon intubation via the upper canaliculus as well (following steps 2.7.1 through 2.7.3) (**Figure 2h**).

8. Remove the nasal endoscope.

3. Post-op Care and Follow-up

1. After surgery, initiate treatment with antibiotic eye drops (e.g. ofloxacin), decongestant eye drops (e.g. xylometazolin) and steroidal eye drops (e.g. prednisolone acetate). Antibiotics can be stopped after one week, while steroidal and decongestant eye drops should slowly be weaned off over the course of one month.
2. Follow-up at six weeks and three months after surgery. Look for resolution of symptoms, silicon tube prolapse, infection, and secretion.
3. Remove silicon tubes at three months after surgery by simply grabbing the T-shaped end at the height of the puncta and carefully pulling them out.

Representative Results

Optimal result:

The procedure as described above takes about 10 - 25 min and is usually tolerated very well. Upon examination the next day, a little swelling of the eyelid can be present in about 60% of cases. This little swelling always resolves completely within a maximum of three days. Patients do not complain about pain, silicon prolapse or signs of injury or infection. However, due to bicanalicular silicon intubation being performed during the procedure, epiphora may persist until the tubes are removed. Topical application of antibiotic, steroidal, and decongestant eye postoperatively is essential and patients need to follow instructions closely for optimal results. At three months after surgery, silicon tubes can be removed easily. In optimal cases, complete and permanent resolution of symptoms can be observed. Table 1 gives an overview of the results of this technique, previously published by Koch *et al*. in 2016[10].

Sub-optimal results:

Although relief of symptoms initially occurs in most patients, about 20 - 25% of patients, who have otherwise had little to no complications, show incomplete resolution of symptoms at the six-months mark. The most likely reason for this is scar tissue forming in the bony ostium. In these cases of recurring stenosis, secondary external DCR can become necessary.

Complicated cases:

Serious complications are rare. When the utilized laser equipment is not handled carefully, the tip of the laser fiber can slip back into the metal cannula which will cause heating of the metal. This results in thermal injury to the canaliculus or lacrimal sac. Penetrating injuries due to necrosis of the tear drainage system require suturing and, possibly, a displacement flap to close the defect. Affected patients need to be followed up more closely as the lesion facilitates scarring and an ensuing obstruction as well as infections. Secondary external DCR and canaliculus reconstruction surgery can become necessary in these cases.

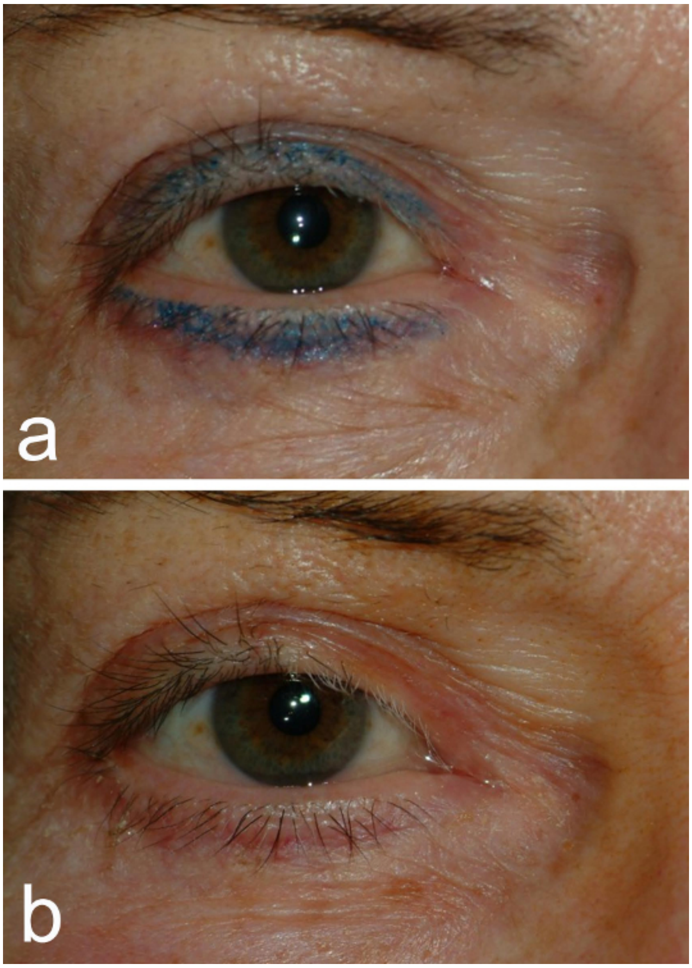

Figure 1. Pre- and postoperative portrait photos of a 73-year-old patient who underwent transcanalicular laser-assisted DCR of the left side.
a Preoperative appearance. **b** Mild swelling of the lower eyelid on the first postoperative day, resolving completely within two days. Please click here to view a larger version of this figure.

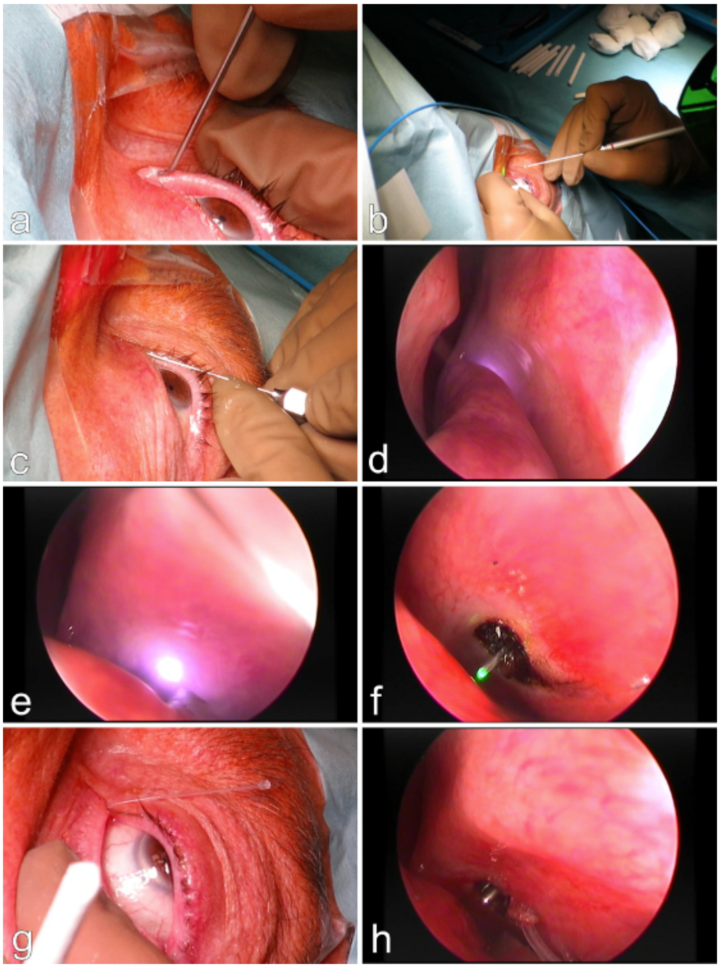

Figure 2. Experimental Walkthrough
a. Dilation of the upper punctum using a lacrimal probe. Dilation has to be performed bicanalicularly to facilitate silicon intubation later.
b. The laser fiber is inserted into the handpiece and the blunt cannula. Subsequently, it is inserted into the lower canaliculus.
c. Correct placement of the laser fiber. After inserting the cannula, the tip is pointing in an antero-inferior direction, aiming for the anterior margin of the middle turbinate.
d. The aiming beam of the laser appears approximately at the anterior margin of the middle turbinate. Laser energy is applied to create an ostium.
e. As the tissue between the lacrimal sac and the nasal cavity grows thinner, the light becomes brighter. Breaching of the wall is imminent.
f. Shortly after breaching the wall. The tip of the laser fiber can be seen sticking through the newly formed osteotomy.
g. Silicon intubation of the lower canaliculus.
h. Intranasal image during silicon intubation of the upper canaliculus. The first silicon tube is already in place (lateral side) while the leading metal tip of the second silicon tube is sticking out of the ostium. Please click here to view a larger version of this figure.

number of patients	48
male	11
female	37
mean age (years)	60 ± 11
surgical success rate*	94%
functional success rate (6 months)**	78%
postoperative lid swelling	64%
canalicular infection	2%
thermal injury	2%
silicon tube prolapse	9%
* defined as postoperative bypass patency	
**defined as complete resolution of symptoms	

Table 1.
Overview of the results of laser-assisted DCR as described in this protocol. Data previously published in Klin. Monbl. Augenheilkd. by Koch et al. in 2016[10].

Discussion

Transcanalicular laser-assisted DCR as described above is a fairly quick, minimally invasive way to treat absolute infrasaccal nasolacrimal duct obstruction effectively without the need for skin incision, thus sparing not only the skin but also the medial canthal tendon and the physiological canalicular pump mechanism. While the procedure is well suited for patients with primary acquired nasolacrimal duct obstruction, pathologies other than idiopathic stenosis do not qualify for this procedure. This is owing, in part, to the fact that it does not allow for full inspection of the lacrimal sac or biopsies of atypical findings to be taken[19,20,22,23].

In terms of functional success, it ranges closely behind the current gold standard of external DCR with early functional success rates of 74 - 85% at one-year follow-up [10,11,12,13,14,15,16,17,18,19] for the transcanalicular approach compared to >85% for external DCR[2,3,19]. However, studies providing long term results are somewhat scarce. In one study, Kaynak et al. found that functional success rates of laser-assisted DCR can drop to 63% within the first year and further drop to 60% within the first two years[24]. In contrast, Dogan et al. found functionally successful results in up to 84% of cases over a mean follow-up time of 18.1 months[17]. The relatively wide range of outcomes may be due to the fact that laser-assisted DCR is not yet a standardized technique and most protocols found in literature show certain fundamental differences. These differences encompass varying laser settings and wavelengths, Teflon vs. silicon intubation, local vs. general anaesthesia and the additional use of adjuvant substances like mitomycin C (MMC) or endonasal trephination[15,17,25,26,27,28]. Compared to external DCR, complication rates in laser-assisted DCR are relatively low and duration of surgery as well as reconvalescence is kept to a minimum[10].

In order to improve functional success rates, a number of additional steps have been proposed, adding to the mere formation of a lacrimal bypass. For one thing, in the above mentioned protocol, bicanalicular silicon intubation is included to facilitate epithelization of the bypass and prevent early scarring of the newly formed osteotomy[10,11,12,13,14,15,16]. This step (as either monocanalicular or bicanalicular intubation) is commonly used in a variety of protocols and techniques including external DCR[2,3,19]. However, the data found on this matter in current literature is conflicting and no consensus on whether patients benefit from silicon intubation in lacrimal bypass surgery has been reached to date[25,26].

Furthermore, to inhibit scarring of the osteotomy, the topical application of the antimetabolite mitomycin C, known for its use in glaucoma surgery, has been proposed. Several studies investigating the alleged profit of additional topical MMC application to the bypass right after osteotomy could not show a significant advantage of this adjunctive procedure[17,27,28].

The most critical step in the provided protocol is the correct formation of a sufficient osteotomy in the optimal location. When inserting the laser fiber optic, it is recommended to take the approach via the lower canaliculus as this will grant the highest maneuverability later. In a recent study of laser-assisted DC[10,11], the laser fiber was advanced through the upper canaliculus in 20 of the participating patients. In three of those, correct positioning of the laser proved impossible due to prominence of the upper orbital rim, in turn leading to unfavorable positioning of the osteotomy later. Furthermore, after successful positioning of the tip and before applying energy to the lateral nasal wall, it is of paramount importance to ensure the tip has not slid back into the cannula. In one reported case[10,11], retraction of the tip resulted in heating of the metal cannula, which in turn led to thermal injury that required plastic reconstruction.

It is important to note that the osteotomy created with a 300 - 400 µm diode laser fiber is markedly smaller than that of a drill in external DCR. After enlargement of the osteotomy as described above, ostium diameters of up to 5 mm can be achieved. However, the ostium diameter in external DCR ranges around 1 cm. Logically, a bigger osteotomy is less susceptible to early scarring. It is therefore recommended to aim for as big an ostium as possible while at the same time avoiding unnecessary tissue damage. It has to be noted that the induction of fibrosis as a late complication of the laser procedure is possible. However, the degree to which this happens cannot be estimated yet.

In summary, transcanalicular laser-assisted DCR, if performed as delineated above, provides good results as a viable option before invasive lacrimal surgery in cases of PANDO. Because of low complication rates and short convalescence and surgery time, patient satisfaction is high, while at the same time, functional success rates range closely behind those of external DCR.

Disclosures

No conflict of interest.

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