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Balloon-Assisted Lacrimal Surgery

William L. White, Jerry K. Popham, and Robert G. Fante

Instrumentation and Principles

The use of radiologic technology for interventional application in the lacrimal system was first described by Hanafee and Dayton[1] from the University of California, Los Angeles in 1978. They dilated native nasolacrimal ducts (NLDs) with sialography cannulas under fluoroscopy. The use of radiologic instrumentation in the lacrimal system was carried one step further in 1989 when Becker and Berry[2] reported the use of balloon catheters to perform secondary dacryocystorhinostomies (DCRs). They used existing coronary artery angioplasty balloons in their series. This led to the development of what is presently the only commercially available balloon product made specifically for application in the lacrimal system, the LacriCATH lacrimal duct catheters, manufactured by Quest Medical, Inc. (Allen, TX).

The balloon catheter device is used in both nonincisional, endoscopic, balloon-assisted (EBA) DCR and nonincisional balloon dilation of the NLD, also known as balloon dacryoplasty (DCP). Both procedures are currently performed in both adult and pediatric populations. Generally, balloon DCR surgery is more often used in patients with complete NLD obstruction (NLDO) and balloon DCP is more often used in patients with partial or incomplete NLDO.

Balloon catheter dilation of the lacrimal tract as performed in most centers outside of the United States (US) still utilizes clinically available balloon catheters originally manufactured for vascular work and applies a combination of lacrimal and vascular thought to clinical applications.[3–7] In such procedures, a guide wire is passed through the punctum, canaliculus, and NLD. The guide wire is subsequently retrieved in the nose. The balloon catheter is then passed transnasally over the guide wire. Quest Medical has recently introduced the transnasal 9-mm balloon catheter to the US marketplace. This catheter is endoscopically positioned in the ostium after passing the device through the nose, not the canaliculus. It does not require a guide wire for passage.

Most non-US investigations also differ from US investigations in that procedures in the US are generally performed by ophthalmologists in the operating room, or less frequently in an office setting. Outside of the US, most procedures are performed by radiologists in a radiology suite. Long backlogs of surgical patients awaiting traditional DCR outside the US apparently led to the development of specific techniques and interventions that can be performed by non-ophthalmologists.[8] Results of such studies in the literature are difficult to interpret and compare. Most studies of balloon DCP outside the US include patients with incomplete and complete NLDOs.

Quest Medical presently has three different transcanalicular lacrimal dilation catheters with distinct indications for each. Quest Medical has also recently introduced a transnasal balloon device. Two numbers describe the transcanalicular catheters. The first is the outside diameter of the inflated balloon. The second number is the length of the inflated balloon. Both numbers are measured in millimeters. The smallest catheter is a 2×13 mm device and is designed for dilation of the native NLD in congenital NLDO. It is recommended for use in children up to the age of 30 months and is 0.8 mm in diameter before inflation. The next larger diameter catheter is a 3×15 mm catheter, which is made to treat incomplete pediatric or adult NLDO through dilation of the native tract in patients who are 30 months of age or older. It is 0.9 mm in diameter before inflation. The third and largest diameter transcanalicular catheter available is the 5×8 mm device designed primarily for use in EBA DCR in adults with complete NLDO. It is 1.0 mm in diameter before inflation and can be used for primary or secondary DCR. It is not intended for dilation of the native NLD.

It is important to avoid inflation of any balloon before passage through the canaliculus. Inflation or "testing" of the balloon before transcanalicular passage makes the catheter much more difficult, if not impossible, to pass and may increase the risk of canalicular trauma. The catheters slide through the punctum and canaliculus better when they are lubricated with a small amount of an ophthalmic ointment. It is generally advisable to have at least one more catheter available for use in a given case than thought to be necessary in the event that a balloon ruptures during inflation or is contaminated before use. This recommendation also applies to the inflation manometer devices, although they very rarely malfunction.

Each catheter has a luer-lock adapter for attachment to the inflation manometer. It is important to eliminate all of the air present in the inflation manometer before use by filling the device with normal saline or any physiologic solution. The inflation devices typically display the pressure reading within the system in digital or analog format. Clockwise rotation of a knob at the distal end of the inflation device elevates the pressure within the device. Most inflation devices also utilize a release switch for more rapid deflation of the balloon. A small amount of air will enter the manometer after the first inflation, but is typically insignificant in volume and inconsequential in achieving adequate inflation pressures.

Each transcanalicular balloon has two sets of rings outlined to provide approximate information about the depth of balloon placement during a dilation procedure. The catheters have black rings 10 and 15 mm proximal to the beginning of the balloon.

Balloon lacrimal surgery is best accomplished with a videoendoscope to ensure the correct intranasal location of the catheter. Proper placement of the catheter cannot be confirmed without intranasal visualization. Simply passing the catheter without confirming correct intranasal passage can create false channels and compromise upper system lacrimal anatomy for any subsequent procedures. In general, a 3.5-mm-diameter, 0-degree scope is most useful. Occasionally, a 30-degree scope or a smaller 2.7-mm-diameter pediatric scope can be beneficial.

Unless contraindicated, general anesthesia delivered with a laryngeal mask airway (LMA) offers the ideal method of airway management when performing all types of balloon-assisted lacrimal surgery. Because manipulation and instrumentation of the airway is minimized with the LMA as compared with endotracheal intubation, the need for larger doses of sedative/hypnotic agents and muscle relaxants is eliminated, thus reducing the occurrence of side effects. Postoperative recovery is hastened and the incidence of nausea, vomiting, and sore throat is reduced without sacrificing sufficient control and protection of the airway. Balloon-assisted lacrimal surgery can, however, be performed under local anesthesia or with local anesthesia and supplemental intravenous sedation when desired by the surgeon and a cooperative patient. Light mask anesthesia is not recommended in pediatric patients, because the irrigant solution administered after dilation can be sufficient in volume to induce bronchospasm. LMA-delivered anesthesia offers excellent airway control, as seen with endotracheal intubation, and rapid postoperative recovery as seen in local anesthesia cases with supplemental intravenous sedation. LMA anesthesia, therefore, is recommended in balloon lacrimal surgery.

Acquired Adult Dacryostenosis – Complete Obstruction

Acquired, complete obstruction of the NLD with epiphora or dacryocystitis in adults is an indication for DCR. Traditionally, DCR is accomplished through an external incision along the bridge of the nose near the lacrimal sac. A variety of endoscopic techniques have been developed to avoid incisions, scarring, and to minimize operative morbidity. The authors' EBA DCR experience has been limited to the use of the Quest Medical LacriCATH 5×8 mm balloon to create or enlarge a true DCR ostium between the lacrimal sac and the nasal antrum.

The dye disappearance test combined with probing and irrigation of the lacrimal drainage apparatus is used to diagnose the presence of complete NLDO. The Jones' dye tests may also be useful in selected patients. Contraindications to balloon-assisted DCR are generally the same as those for balloon DCP.

EBA DCR may be performed under general or local anesthesia. The authors use general anesthesia for the majority of DCR surgery. Patients are treated preoperatively with 1 g of intravenous cefazolin and 10 mg of dexamethasone. Patients are also treated in the preoperative area with three sprays of intranasal oxymetazoline. Although topical cocaine is an excellent decongestant and anesthetic, its potential interaction with epinephrine used in local anesthetic solution makes it a suboptimal choice in this setting.

After general anesthesia has been induced, the nasal mucosa is infiltrated with lidocaine with epinephrine 1 : 100,000 at the anticipated ostium site, just beneath the insertion of the anterior tip of the middle turbinate on the lateral nasal wall. This injection is usually given using a nasal speculum and direct visualization, but may also be directed using the nasal endoscope. Infiltration of lidocaine with epinephrine 1:100,000 reduces the need for larger doses of inhalational anesthetics and vasoconstricts the nasal mucosa, thereby reducing bleeding. A temporary, mild increase in blood pressure may be noted after the injection. The nasal antrum in the area of the middle turbinate is packed with 1/2 × 3 inch cottonoids soaked in oxymetazoline. The patient is then prepped and draped in the usual sterile manner.

After punctal dilation, the upper and lower canaliculi and common canalicular dilation is performed using increasingly larger lacrimal probes. Preservation of normal punctal and canalicular anatomy through atraumatic dilation is critical to successful outcomes in this operation. With the puncta and canaliculi thoroughly dilated, a no. 3 or no. 4 specially hardened stainless steel lacrimal probe (Storz Instrument Co., St. Louis, MO) is passed through the superior punctum and canaliculus to a hard stop in the lacrimal sac. The probe is directed inferiorly and posteriorly to a weak and thin point in the bony wall between the lacrimal sac and the nasal antrum. Before pushing the probe through the wall of the lacrimal sac fossa, the packing in the nasal antrum is removed.

The nasal endoscope is then passed and directed toward the anterior tip of the middle turbinate. While viewing the intranasal area around the anterior tip of the middle turbinate, the lacrimal probe already in the lacrimal sac is slowly advanced. A bulge in the nasal mucosa may be seen as the probe begins to advance. Alternatively, no change in the nasal mucosa may be seen if the probe is entering the nasal antrum beneath the anterior tip on the middle turbinate. In this scenario, an attempt is made to change the position of the tip of the lacrimal probe in order to allow creation of the ostium just anterior and superior to the anterior tip of the middle turbinate.

It is preferable to position the ostium; this may allow the surgeon to avoid any manipulation of the turbinate. At times, the ostium cannot be placed anywhere but beneath the anterior tip of the middle turbinate. In this circumstance, the middle turbinate must be infractured or conservatively resected. A biting instrument, such as size 0 Thru Bite Blakesley forceps, is particularly helpful in this regard because it tends not to strip mucosa, but to cut it sharply and precisely. In any circumstance, the mucosal lining of the turbinate and the nasal antrum in

general must be preserved with as little manipulation and trauma as possible. Any irritation of the mucosa may lead to unnecessary bleeding or formation of adhesions, which can cause obstruction of the ostium.

After the initial ostium opening is created through passage of the no. 3 or 4 lacrimal probe and the position of the ostium is optimized, the probe is repeatedly advanced out of and retracted back into the lacrimal sac in different locations to widen the ostium mechanically. The area of the intended ostium is in effect "honeycombed" with small holes in preparation for the placement of the balloon catheter device. The perforations in the bone are made contiguous with the no. 3 or 4 lacrimal probe. A lubricated 5×8 mm balloon catheter is inserted through the superior punctum and canaliculus, through the common canaliculus and lacrimal sac, and positioned in the ostium previously created with the probe. The endoscope is used to confirm correct positioning of the tip of the balloon catheter at least 2 mm past the nasal mucosa in the nasal antrum.

Once correct position is established, the balloon is attached to the inflation device and is inflated to 8 atmospheres for the first 90-second cycle. At times, the balloon device may push further into the nasal antrum during inflation. The balloon catheter tip is observed during inflation using the videoendoscope. The balloon is then deflated by releasing the pressure with the manometer. The balloon is again positioned in the ostium using the endoscope. It is reinflated to 8 atmospheres of pressure for one additional 60-second cycle. During the second inflation, mucosal or bone fragments are carefully removed from around the perimeter of the ostium and balloon using fine ear forceps. It is important to remove any such fragments to minimize the risk of closure of the ostium during the healing process. Some surgeons may want to enlarge the ostium transnasally with a nerve hook or rongeurs.

After the second inflation, the balloon is completely deflated and removed. Endoscopic observation of the balloon tip in the nose confirms complete deflation of the balloon before withdrawal of the balloon catheter through the upper canaliculus and punctum. Mild resistance may be encountered during withdrawal of the balloon device. For this reason, some surgeons elect to cut the shaft of the metal portion of the balloon catheter and remove the balloon end of the device through the nostril. This maneuver may reduce trauma to the canaliculus.

After removal of the inflation device, the lacrimal stent is prepared for use by lubricating it with an ophthalmic antibiotic ointment. The STENTube is a lacrimal stent manufactured by Quest Medical for this specific application. It is unique because of its variance in diameter. The central 22 mm of the STENTube, designed for placement in the interpalpebral fissure and in the canaliculi, is 0.86 mm in diameter. The remaining portion of the tube is 1.3 mm in diameter, allowing greater mechanical dilation and stenting of the surgical ostium. It is important to ensure that the thin portion of the STENTube is correctly positioned in the canaliculi and interpalpebral fissure. The olive tips of the stylets on the STENTube are designed to be engaged with a standard lacrimal

hook to facilitate easy removal through the nostril. It is often easier, however, to grasp the tip of the stylet with a straight hemostat under endoscopic guidance. This maneuver minimizes the risk of abrasion or laceration of the nasal mucosa. Once positioning is correct, the tubing is placed on gentle inferior traction. The two ends of the tube are tied together with a 5-0 polypropylene suture. Excess suture and tubing are cut away, allowing the knot to retract back into the patient's nose. The tubing remains in position for 3–4 months.

Systemic and topical antibiotics are administered for 10–14 days postoperatively. Antibiotic selection may be directed toward specific organisms discovered during preoperative culture and sensitivity testing. Because many patients have already started antibiotics at the time of initial presentation, empiric antibiotic selection is most often necessary. Cephalexin 250–500 mg is often used four times daily. Gentamicin is frequently selected for use as a topical ocular antibiotic and is administered every 2 hours while awake for the first 2 days and continued four times daily for an additional 8 days. Patients who develop any sign of infection while the tubing is in place after initial treatment with postoperative antibiotics are candidates for further topical or systemic antibiotics.

Systemic, topical, and intranasal steroids are administered to reduce inflammation and scarring. Oral prednisone is begun on the day of the surgery at 50 mg per day and is decreased by 10 mg per day every other day. This regimen keeps the patient on the tapering dose for 10 days. Topical prednisolone acetate 1% is used on the same schedule as the topical antibiotics. Intranasal saline spray is used to limit crusting around the ostium and on the lacrimal stent. It is started on the day of surgery and is used at least once daily preceding the nasal steroid spray. The nasal steroid spray most often used is budesonide 32 μg (Rhinocort Aqua, Astra Pharmaceuticals, Westborough, MA). The nasal saline and steroid sprays are continued postoperatively until gone, which is usually in about 2 months. Requirements for pain medication after this procedure are typically minor with acetaminophen usually being adequate in those patients requiring an analgesic.

Lacrimal stent removal is accomplished in the office 4–6 months postoperatively. The nasal mucosa is decongested using oxymetazoline. Some patients may require topical anesthesia of the nasal mucosa using Pontocaine spray. The thicker portion of a STENTube, unlike traditional lacrimal stents, cannot be removed through the canaliculus. The thin portion of the Stentube, therefore, is cut in the interpalpebral fissure and the tubing is removed transnasally. This is most easily and atraumatically accomplished with the guidance of a nasal endoscope. After tube removal, the lacrimal drainage system is irrigated to remove any mucous or debris from the system and to confirm patency of the system. Patients are once again started on the same postoperative regimen of oral and topical antibiotics and steroids and on the nasal saline and steroid sprays. Patients are scheduled for reevaluation 4–6 weeks later and 1 year after the reevaluation. If reobstruction is to occur, it typically occurs within 4–6 weeks of tube removal. Complica-

tions of balloon-assisted DCR are generally the same as those seen with traditional incisional DCR and include failed surgery, epistaxis, and canalicular stenosis.

Recurrent Dacryostenosis

The 5-mm-diameter balloon catheter can be used to perform secondary balloon-assisted DCR when traditional incisional DCR, transnasal endoscopic DCR, or primary balloon-assisted DCR fails to provide adequate lacrimal drainage. Nasal endoscopy is performed preoperatively to rule out intranasal pathology, such as severe nasal septal deviation, as a reason for procedural failure. It is also imperative to probe and irrigate such patients to ensure that the obstruction is in the area of the nasal ostium and not the canaliculi, because complete canalicular obstruction cannot typically be overcome by balloon dilation.

Secondary balloon DCRs can be performed under general anesthesia or local anesthesia with IV sedation. Regardless of the technique chosen, the medial canthal area is injected with a local anesthetic mixture containing epinephrine. The nasal mucosa in the area of the ostium is then injected with the same anesthetic mixture. The middle meatus is packed with cottonoids soaked in oxymetazoline or a vasoconstrictant-anesthetic mixture. After the patient is prepped and draped, the puncta are dilated atraumatically.

The superior canaliculus is subsequently probed to a size 3 or 4. A stainless steel size 3 or 4 lacrimal probe is then passed through the previous ostium or scar into the nose. The ostium is then enlarged in the same manner as a primary balloon-assisted DCR with special attention being given to ensure that the middle turbinate or nasal septum does not impact or occlude the ostium. The videoendoscope is critical for this part of the procedure. The 5×8 mm catheter is then passed through the superior canaliculus through the ostium and inflated to 8 atmospheres for 90 seconds, released, and then reinflated for 60 seconds. The catheter is then withdrawn 1 cm or to the distal ring on the catheter and two more inflation cycles are completed. The catheter is withdrawn to the proximal ring and two more inflation cycles are repeated. Rarely are inflations at more than two or three positions necessary. The newly created lacrimal tract is subsequently irrigated.

Some surgeons may elect to apply mitomycin C, 0.4 mg/cc on a $1/2 \times 1/2$ inch cottonoid for 5 minutes transnasally to the ostium, and then copiously irrigate the ostium transnasally. The optimal concentration, time of application, and specific therapeutic efficacy of such intervention is not currently known.[9] Most surgeons will not likely want to use mitomycin C in pediatric patients or in those in whom adequate informed consent has not been obtained. Silicone tubes are then passed and secured in the nose. Some surgeons may elect to use a traditional lacrimal stent and leave it in place longer rather than using the Stentube. The same medication regimen used in primary balloon-assisted

DCR is initiated. Complications of secondary balloon DCR are the same as those seen with primary balloon-assisted DCR. Results of clinical trials using the 5-mm balloon for repeat DCRs are quite limited.

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