38 The Great Debate: External Versus Endonasal Dacryocystorhinostomy

Andre Litwin and Raman Malhotra

Introduction

The principles of standard surgery for blockage of the lacrimal outflow tract probably dates back 1,000 years now when the twelfth-century Andalusian Oculist Mohammad Ibn Aslam Al Ghafiqi described a small spear-shaped instrument perforating the lacrimal bone in a nasal direction "*until blood flows through the nose and mouth with care given not to direct the instrument downward as this would be the incorrect direction*." The probe was then wrapped in cotton that was either *dry or soaked in ox fat*. This would then be exchanged every day in order to maintain the patency of the created fistula [1]. This principle remains the same to date as that for contemporary conjunctivodacryocystorhinostomy. Modern dacryocystorhinostomy (DCR), however, dates back to the dawn of the twentieth century [1–4]. In terms of anatomic goals, the aims of surgery are simple: the lacrimal sac is connected directly to the nose by removal of the separating bone and mucosa. A fistula is hence formed that allows tears to pass directly into the nasal vault through the lateral nasal wall. This must occur at a level above the mechanical obstruction in order to bypass it [5]. The traditional popular method has been through an external approach as described by Toti [3] and modified by Dupuy-Dutemps [4]. Although the endonasal approach was described perhaps prior to this [2] it is only in recent decades with the introduction and development of the endoscope, that attention has turned to endoscopic DCR for both primary procedures and to revise failures [6]. DCR is indicated for patients with lacrimal sac or nasolacrimal duct obstruction (NLDO) causing either epiphora or dacryocystitis (infection).

Surgery may be performed through a cutaneous incision (*external DCR*) and although alternative ophthalmic approaches to avoiding skin scarring have been described [7, 8], the only effective alternative remains an endonasal approach. While maintaining the same principles as an external approach, endonasal DCR simply describes an approach through the nose rather than a specific technique. Many endonasal techniques exist by either direct visualization [6], or, more commonly, when viewed through an endoscope (*endoscopic DCR*). Endoscopic DCR has itself evolved over time. Endoscopic laser DCR progressed to mechanical endoscopic DCR [9] and powered endoscopic DCR. This shift toward "powered" instruments was because laser could not remove the thick bone of the frontal process of the maxilla and root of the middle turbinate, resulting in higher failure rates [10, 11]. The principles of the evolved "powered endoscopic

A. Litwin, FRCS
Oculoplastic Surgery,
Queen Victoria NHS Trust, London, UK

R. Malhotra, FRCS (✉)
Oculoplastic Surgery, Cadogan Clinic and Queen Victoria NHS Trust, London, UK
e-mail: raman@ramanmalhotra.com

M. Javed Ali (ed.), *Principles and Practice of Lacrimal Surgery*,
DOI 10.1007/978-81-322-2020-6_38,

DCR" have shifted forward ("back") to mechanical DCR, aiming to achieve full sac exposure whilst still creating mucosal flaps [12, 13].

Through dissection and manipulation of tissue, there is no reason why a skilled surgeon with the right tools cannot remove the same amount of bone from either approach [14]. Until the twenty-first century, external DCR was historically regarded as the "gold-standard." However, the reported success rate of both procedures in the modern literature is now similar when compared with endoscopic procedures that remove adequate bone for full lacrimal sac exposure, marsupialization, and mucosal flap apposition [11, 15–19].

Overview of the Procedures

DCR surgery can be performed under either local or general anesthesia. If local anesthesia is to be used, infratrochlear and infraorbital nerve blocks using bupivacaine 0.5 % or lidocaine 2 % with epinephrine are administered. Anesthetic may also be infiltrated along the lateral wall of the nose at the proposed osteotomy site, and nasal packs soaked in cocaine 4 %, adrenaline 1:1,000, or a mixture (e.g., Moffett's solution) may be applied, via packing, buds, or patties.

External DCR

To perform an external DCR, a 15-mm skin incision is made medial to the medial canthus. A skin-muscle flap is formed to reveal the anterior limb of the medial canthal tendon. This is divided and the periosteum opened. The periorbita is elevated to displace the lacrimal sac and duct laterally. A 3-mm up-biting right-angled Kerrison rongeur is used to break through the thin bone of the lacrimal fossa and a bony osteotomy is formed, initially proceeding anteriorly, inferiorly, and then posteriorly. An osteotomy of at least 15 mm in diameter is created. The lacrimal sac is then probed and opened longitudinally. Any grossly suspicious mucosa should be biopsied and submitted for pathologic review. The nasal mucosa is incised in a similar longitudinal fashion, with relieving incisions at either ends forming an "H" shape. A silicone stent is inserted and tied loosely to prevent cheese-wiring of the canaliculi. The posterior lacrimal sac flap is sutured to the posterior nasal flap, typically with a single continuous 6/0 Vicryl suture. Three sutures are then used to appose the anterior nasal mucosal and anterior lacimal sac flaps. Where possible, these are suspended by attachment to the overlying orbicularis. The anterior limb of the medial canthal tendon is reapproximated and the skin is typically closed with a 6-0 polypropylene suture.

Endonasal Non-endoscopic DCR

When carrying out endonasal, non-endoscopic DCR, surgeons often utilize a 20-gauge disposable vitrectomy light pipe threaded through the upper canaliculus to guide placement of the osteotomy [6]. After decongestion, an elliptical nasal mucosa incision down to bone, centered over the transilluminated light target is made. Mucosa is stripped from underlying bone and peeled away. An osteotomy is fashioned with an attempt to rongeur sufficient bone superiorly and anteriorly to easily visualize the entire width and most of the length of the lacrimal sac and duct. Care is taken to remove sufficient bone superiorly to ensure that the target light pipe when held horizontally across the common canaliculus can be visualized tenting the lacrimal sac within the nose. A posteriorly hinged U-shaped oval flap is made and reflected posteriorly and the lacrimal system is usually intubated.

Early Mechanical Endoscopic DCR

Standard functional endoscopic sinus surgery (FESS) scopes were commonly used, in addition to keratomes, standard blades, Freers elevators, Blakesley forceps, and up-biting Kerrison rongeurs. Lacrimal probes or a light pipe passed into the lacrimal sac were often used to guide placement of the osteotomy. The nasal mucosa was incised and excised overlying the planned osteotomy site before carrying out the osteotomy with up-biting Kerrison ronguers. The inferior two-thirds (or less) of lacrimal sac was often all that was exposed. The sac was incised and its mucosa either reflected anteriorly and posteriorly, or trimmed. Silicone tubes were passed and the nose was often temporarily packed [15, 20, 21].

Powered Endoscopic DCR

After decongestion, the nasal mucosa is usually infiltrated with 2 ml of lignocaine 2 % with 1:80,000 epinepherine using a dental syringe above and anterior to the middle turbinate. A mucosal incision with a small-angled crescent blade is made on the lateral nasal wall, 2–3 mm posterior to the maxillary line, starting 8 mm above the insertion of the middle turbinate and extending vertically down to a level just below the body of the middle turbinate. Using a number 15 scalpel blade, two horizontal incisions are made, 8 mm above the insertion of the middle turbinate and just below the body of the middle turbinate, respectively. This creates the posterior nasal mucosal flap, which is reflected using a Freer elevator, exposing the junction of the hard frontal process of the maxilla and the thin lacrimal bone. The lacrimal bone is removed off the inferior half of the sac using a Freer elevator or a forward-biting up-cutting 40° Kerrison rongeur. The frontal process of the maxilla, overlying the anterior and inferior portions of the lacrimal sac is removed and the osteotomy continued superiorly until it is no longer possible using the standard Kerrison. A burr or drill is utilized at this stage, exposing the fundus of the sac. The agger nasi air cell (the anterior most ethmoid cell) is often exposed as the fundus extends above the axilla of the middle turbinate [22].

The medial wall of the sac is then tented with a probe to ensure that all bone at least 5–10 mm above the common canalicular opening has been removed. The medial wall of the sac is incised vertically with a crescent blade to create large anterior and smaller posterior flaps. Small additional relieving incisions allow the flaps to be reflected onto the lateral nasal wall and sit "flat." Good mobility and marsupialization of the lacrimal mucosal flaps has been associated with better outcomes [23]. A silicone stent can be passed and tied loosely to protect the internal ostium.

Modern Nonpowered Endoscopic DCR with Flaps

A posterior [12] or inferiorly hinged [13] nasal mucosal flap is formed along the frontal process of the maxilla. The mucosal flap (which will form the anteriornasal mucosal flap) is elevated using a Freer elevator, maintaining the tip of the elevator on the bone, reflecting it out of the surgical field. The technique proceeds the same as powered endoscopic DCR until the osteotomy can no longer be continued superiorly using a standard Kerrison rongeur. A modified bone nibbler may be used at this time to aid bone clearance at the fundus of the sac [13].

Considerations for Both Approaches

The goal of DCR surgery is to create a functioning fistula, by means of adequate bone removal to allow the lacrimal sac to be fully marsupialized into the lateral nasal wall. Primary intention wound healing of all mucosa should be the aim. Trauma to adjacent tissues should be avoided to minimize the scarring response and reduce the risk of closure of the *soft-tissue ostium* (the entire marsupialized lacrimal sac when viewed endonasally) or the internal ostium of the *common canaliculus*.

Anatomic Factors

In order to achieve an absolute cure, a large fistula between the lacrimal sac and the nose is required leaving the canaliculi as the only zone of residual tear resistance [24]. It is generally agreed that exposure of the inferior and superior parts of the lacrimal sac should be accomplished, usually requiring an osteotomy of at least 15 mm, even approaching 20 mm [22, 24, 25]. Whether the new *soft-tissue ostium* of the entire marsupialized lacrimal sac remains stable in size beyond the first few postoperative weeks is unclear. It appears to reduce a small amount, with one endoscopic study measuring an average *soft-tissue ostium* size 12 months after surgery of 10.1 by 6.6 mm [26]. This is most in keeping with our own experience. Some have suggested that the *soft-tissue ostium* may shrink by 50 % at 6 months or even smaller [27, 28]. Others have found no significant relationship between *bony ostium* size and outcomes of surgery [23].

Biological (Healing) Factors

The main cause of failure in DCR surgery is fibrosis of the intranasal soft-tissue ostium, both in external DCR and endonasal DCR [11]. For the surgery to be successful, the mucosa of the lacrimal sac must anastamose to the nasal mucosa with the fistula remaining patent. The natural response from a surgical insult means granulation tissue can grow over the surgical ostium, rendering the procedure a failure. In successful surgery, once the lacrimal and nasal epithelium have healed together, the signal for secondary intention healing is turned off [14]. In a recent article looking at 20 failed DCRs, all had rhinostomy sites that were closed with fibrous tissue. None had canalicular or common internal ostium obstructions before undergoing revision surgery [29]. Presuming we should aim for anatomic surgery, we can maximize the success of DCR surgery by any means that helps tip the balance toward primary intention healing of the mucosa and away from secondary intention granulation [14]. The benefits of anatomic surgery may be difficult to prove, with many studies comparing different techniques or simple flap removal, but the concept should be sensible to any contemplative surgeon. Many authors have found that creation of mucosal flaps does not seem to increase the success rate of endoscopic DCR and can be technically challenging or time-consuming [5]. Others have described successful results with simple flap removal [30, 31]. It is only when endonasal DCR began to emulate the approach of external DCR that success rates improved [22].

Intubation

The evidence base either in favor of or against the practice of routine intubation remains lacking [32]. Certainly, in experienced hands it does not appear to be necessary to intubate every patient, but until very recently, the majority of surgeons still routinely did [18, 32–35]. Silicone tubes are inserted with the aim of reducing the risk of fibrosis of the internal ostium of the *common canaliculus* while epithelial migration and repair takes place. In the absence of definitive canalicular disease, there is no clear evidence that intubation in routine DCR is superior to nonintubation. In the setting of canalicular disease, nonintubation may not be appropriate [36]. Other situations prompting intubation, but for which evidence is also currently lacking, include previous acute dacryocystitis, poor flap creation, revision surgery, excessive bleeding, inflammatory disease, and small lacrimal sacs [32].

Mitomycin-C (MMC)

A retrospective study has attempted to compare surgical outcomes in a group of 48 endonasal laser DCR procedures without MMC to outcomes in a group of 123 consecutive procedures in which MMC (0.5 mg/ml) was applied to the intranasal ostium for 5 min. The success rate in the MMC-treated group was statistically significantly greater than that of the controls (99 % vs. 90 %) [37]. Assessment of outcomes with or without MMC further blurs true differences. MMC cannot always deliver success from a poor procedure and should not be regarded as the solution for poor primary surgery. "The MMC Dilemma" chapter in this volume has analyzed in depth the usefulness of MMC in DCR surgery.

Time Taken to Perform Surgery

It may be fair to say that in experienced hands, there is no significant difference in the time taken to perform a successful DCR. Any technique that inadequately removes bone and incompletely excises mucosa would be faster, hence endoscopic laser DCR is arguably the quickest surgery [21].

Efficacy

Success rates for external DCR have historically been quoted as over 90 % [38], and often over 95 % [11, 16]. These high success rates are similar for both anatomical patency and resolution of patient symptoms. Early mechanical endoscopic DCR could not match these figures: in an early series of 123 patients, 83 % success was reported [39]. Subsequent smaller series claimed to have improved upon this (86–100 %) [40, 41].

Due to the perceived inferiority and technical complexities of endoscopic DCR, it remained unpopular with Ophthalmologists when compared to external DCR [42]. The development of surgical lasers was thought to hold the key, as a less invasive form of lacrimal surgery that would improve success. Despite early promise (100 % success in ten patients) [43], it became accepted that success was still lower than conventional surgery (77–83 %) [42, 44]. The high failure rate of endoscopic laser DCR was attributed to scarring (nasal and medial lacrimal sac mucosa was excised or obliterated) and the small size of the bony osteotomy. It is not possible to remove the thick bone of the frontal process of the maxilla with most lasers, leading to a small and inadequate osteotomy [45]. This led others to focus on mechanical means of creating a larger osteotomy, with slightly greater success (86 %) [46, 47].

Modern endoscopic DCR respects anatomic surgical principles key to all successful DCR surgery. A large osteotomy is created with preservation of mucosa so that flaps can be fashioned to achieve a mucosal anastomosis with the lacrimal sac, minimizing secondary intention healing and scarring response [22]. Endoscopic anatomical success could finally be achieved and replicated at other centers in 95 % (or more) of cases [10, 13].

Long-term analyses have reported 91 % success with external DCR (437 cases, average follow-up 71 months) [48]. Long-term studies of endoscopic DCR describe 82–94 % success (108 and 165 cases, average follow-up 49 and 92 months) [49, 50]. Grouping endoscopic DCR as a single entity, one can see is unhelpful. It does not distinguish between types of endoscopic techniques, nonstandard osteotomy, or flap formation. There are many individual variations. Published success rates, therefore, do not allow direct comparison of techniques. Success itself is a loosely applied term. Subjective dependence on symptoms is unreliable and some early papers based their outcomes on this [36]. It is rare for symptoms to completely resolve in elderly patients, yet these papers report a high level of symptom "resolution."

Attempts to be more objective by incorporating syringing into the assessment, does not necessarily provide a straightforward "black or white" success or failure. Syringing is not physiological and papers that report "obstructed" or "completely patent" may either have excluded those with a small (10–20 %) degree of regurgitation on syringing or are ignoring subtleties before or after surgery. Other objective tests such as fluorescein dye retention testing or functional endoscopic dye test have been inconsistently utilized. Patient selection is not standard. It is easy to offer and predict a good outcome for patients with complete obstruction, but less so for those with partial obstruction, canalicular disease, or that *overused* and *loosely defined* term, the group with "functional epiphora." [51] The lack of agreed or standardized outcome measures or even duration of follow-up, highlights how difficult comparisons actually are.

Resolution of mucocele or dacryocystitis is the probably the only true outcome measure that is absolute and not relative. The symptoms and findings of stenosis lie more along a spectrum. The most practical measure of success is the control of symptoms, although this can be at odds with anatomic outcome [24]. Should we therefore be purists and ignore symptoms as a marker of success? Is this defying the initial indication and aim of surgery?

Comparative studies have tried to tackle some of these inconsistencies but often failed to demonstrate a significant difference between techniques [19]. This is not surprising, considering to adequately power a study seeking a 5 % difference (e.g. 90 % vs. 95 % success), a sample size of approximately 900 patients would be required [52]. Of the published studies, anatomic success of endoscopic DCR has therefore been found to be similar to that of external DCR (97 %) [11], although occasional comparative series have suggested higher success rates for endonasal DCR [5].

This means we are left with other ways of deciding where the role of external and endoscopic DCR lies.

Advantages of External DCR

External DCR is an ideal option for elderly patients not suitable for general anesthesia. Although many centers perform endoscopic DCR under local anesthetic with sedation, there is valid concern that sedation reduces or dampens the gag reflex and raises the risk of aspiration during the procedure.

External DCR avoids potential need for a septoplasty in patients with narrow nasal passages. An external approach allows lacrimal sac masses to be biopsied prior to osteotomy and may also be preferred if there is previous fracture with abnormal bone anatomy [53].

In patients with proximal or mid-canalicular disease, external DCR has an obvious advantage, allowing for retrograde intubation. This will alleviate or reduce epiphora in the majority of patients and could also spare a proportion of patients from requiring Jones canalicular bypass tubes [54].

Disadvantages of External DCR

Risks common to all forms of DCR surgery include bleeding, wound infection, and damage to the lacrimal punctae by silicone stents. Cerebrospinal fluid leaks occur exceedingly rarely in DCR, with only a few case reports in the literature [55].

Noticeable scar is a potential complication unique to external DCR. In a survey of 263 patients who underwent external DCR, visible scars were reported by 19 %, with 10 % describing their scars as cosmetically significant [56].

Damage to the facial nerve during external DCR is also a proven risk [57]. This complication is likely to be caused by an insult to peripheral fibers of the zygomatic and buccal branches of the facial nerve as they course in the medial canthal area and provide innervation to the upper eyelid orbicularis muscle in a subset of individuals. Amongst a cohort of 215 patients, 7 % demonstrated abnormalities of eyelid closure (lagophthalmos or hypometric blink), 20 % of which were permanent [57]. This risk should be included when counseling patients as to which approach is suitable.

Advantages of Endoscopic DCR

Advantages of endoscopic DCR include the absence of any skin incision and lack of significant trauma to orbicularis. This results in a faster soft-tissue recovery, with preservation of the lacrimal pump mechanism. It also allows nasal or paranasal sinus abnormalities to be addressed at the same time (e.g., septoplasty may be of help where patients have problems breathing through one side of the nose) [50].

In the setting of dacryocystitis, endoscopic DCR offers rapid resolution of symptoms, converting an anaerobic abscess cavity into an aerobic cavity through noninfected tissue planes with associated drainage and long-term control of epiphora [45, 58, 59].

Given a common cause for failed DCR is formation of membranous scarring at the internal ostium (at the common canalicular opening), it appears to make logical sense that the most direct means of addressing this problem would be endoscopically. Good success rates have been safely demonstrated through both endoscopic and external approaches [29, 60, 61].

Disadvantages of Endoscopic DCR

Risks of endoscopic DCR surgery include damage to the nasal mucosa with adhesion formation, orbital fat prolapse, and rarely a potential damage to the medial rectus muscle. The latter complications would only occur where a surgeon mistakenly loses orientation of the location of the sac and operates posterior to it. This is a risk for any procedure that removes bone behind the sac and inadvertently breaches the periorbita.

A historic disadvantage of endoscopic DCR is the suggestion that biopsy of the lacrimal sac is not achievable. Although the rate of unsuspected sac tumors is low [62, 63], it is possible to take a sac biopsy (or nasal mucosal biopsy) when performing an endoscopic DCR [11]. Blakesley or fine nasal biopsy forceps can be used to submit nasal or lacrimal mucosa to pathology, and dacryoliths or pus can also be sent for culture [6].

Conclusion

Despite recent acceptance of equivalent success between external and endoscopic DCR, more surgeons still prefer and perform greater numbers of external procedures, whilst reporting higher success rates [64]. Is the tide turning amongst Ophthalmologists? Approaches to DCR surgery may no longer represent such a great debate, but a division of experience and training between generations of surgeons!

References

1. Al-Ghafiqi M. Ophthalmic guide. Madrid: El-Escorial Museum; d. 1165 AD.
2. Caldwell GW. A new operation for the radical cure of obstruction of the nasal duct. N Y Med J. 1893;58:476.
3. Toti A. Nuovo metodo conservatore di cura radicale delle suppurazioni croniche del sacco lacrimale (dacriocistorinostomia). Clin Mod Firenze. 1904;10:385–7.
4. Dupuy-Dutemps L, Bourguet M. Procede plastique de dacryocystorhinostomie et ses results. Ann Ocul. 1921;158:241–61.
5. Ben Simon GJ, Joseph J, Lee S, et al. External versus endoscopic dacryocystorhinostomy for acquired nasolacrimal duct obstruction in a tertiary referral center. Ophthalmology. 2005;112:1463–8.
6. Dolman PJ. Comparison of external dacryocystorhinostomy with nonlaser endonasal dacryocystorhinostomy. Ophthalmology. 2003;110:78–84.
7. Adenis JP, Robert P-Y. Retrocaruncular approach to the medial orbit for dacryocystorhinostomy. Graefes Arch Clin Exp Ophthalmol. 2003;241:725–9.
8. Robert M-C, Maleki B, Boulos PR. Endocanalicular laser dacryocystorhinostomy with mucosal flaps. Ophthal Plast Reconstr Surg. 2013;29:294–7.
9. McDonogh M, Meiring JH. Endoscopic transnasal dacryocystorhinostomy. J Laryngol Otol. 1989;103:585–7.
10. Tsirbas A, Wormald PJ. Mechanical endonasal dacryocystorhinostomy with mucosal flaps. Br J Ophthalmol. 2003;87:43–7.
11. Tsirbas A, Davis G, Wormald PJ. Mechanical endonasal dacryocystorhinostomy versus external dacryocystorhinostomy. Ophthal Plast Reconstr Surg. 2004;20:50–6.
12. Codère F, Denton P, Corona J. Endonasal dacryocystorhinostomy: a modified technique with preservation of the nasal and lacrimal mucosa. Ophthal Plast Reconstr Surg. 2010;26:161–4.
13. Patel V, Ross JJ, Malhotra R. Early experience using a new modified bone nibbler for superior osteotomy during endonasal dacryocystorhinostomy. Ophthal Plast Reconstr Surg. 2011;27:15–20.
14. Goldberg RA. Endonasal dacryocystorhinostomy: is it really less successful? Arch Ophthalmol. 2004;122:108–10.
15. Whittet HB, Shun-Shin GA, Awdry P. Functional endoscopic transnasal dacryocystorhinostomy. Eye. 1993;7:545–9.
16. Tarbet KJ, Custer PL. External dacryocystorhinostomy. Surgical success, patient satisfaction, and economic cost. Ophthalmology. 1995;102:1065–70.
17. Shun-Shin GA. Endoscopic dacryocystorhinostomy: a personal technique. Eye. 1998;12:467–70.
18. Cokkeser Y, Evereklioglu C, Er H. Comparative external versus endoscopic dacryocystorhinostomy: results in 115 patients (130 eyes). Otolaryngol Head Neck Surg. 2000;123:488–91.
19. Woog JJ, Kennedy RH, Custer PL, et al. Endonasal dacryocystorhinostomy: a report by the American Academy of Ophthalmology. Ophthalmology. 2001;108:2369–77.
20. Häusler R, Caversaccio M. Microsurgical endonasal dacryocystorhinostomy with long-term insertion of bicanalicular silicone tubes. Arch Otolaryngol Head Neck Surg. 1998;124:188–91.
21. Malhotra R, Wright M, Olver JM. A consideration of the time taken to do dacryo-cystorhinostomy (DCR) surgery. Eye. 2003;17:691–6.
22. Tsirbas A, Wormald PJ. Endonasal dacryocystorhinostomy with mucosal flaps. Am J Ophthalmol. 2003;135:76–83.
23. Davies MJ, Lee S, Lemke S, et al. Predictors of anatomical patency following primary endonasal dacryocystorhinostomy: a pilot study. Orbit. 2011;30:49–53.
24. Rose GE. The lacrimal paradox: toward a greater understanding of success in lacrimal surgery. Ophthal Plast Reconstr Surg. 2004;20:262–5.
25. Patrinely JR, Anderson RL. A review of lacrimal drainage surgery. Ophthal Plast Reconstr Surg. 1986;2:97–102.
26. Mann BS, Wormald PJ. Endoscopic assessment of the dacryocystorhinostomy ostium after endoscopic surgery. Laryngoscope. 2006;116:1172–4.
27. Linberg JV, Anderson RL, Bumsted RM, et al. Study of intranasal ostium external dacryocystorhinostomy. Arch Ophthalmol. 1982;100:1758–62.
28. Ezra E, Restori M, Mannor GE, et al. Ultrasonic assessment of rhinostomy size following external dacryocystorhinostomy. Br J Ophthalmol. 1998;82:786–9.
29. Takahashi Y, Nakamura Y, Kakizaki H. Dacryoendoscopic findings in the lacrimal passage in failed dacryocystorhinostomy. Ophthal Plast Reconstr Surg. 2013;29:373–5.
30. Türkcü FM, Oner V, Taş M, et al. Anastomosis of both posterior and anterior flaps or only anterior flaps in external dacryocystorhinostomy. Orbit. 2012;31:383–5.
31. Katuwal S, Aujla JS, Limbu B, et al. External dacryocystorhinostomy: do we really need to repair the posterior flap? Orbit. 2013;32:102–6.

32. Madge SN, Selva D. Intubation in routine dacryocystorhinostomy: why we do what we do. Clin Experiment Ophthalmol. 2009;37:620–3.
33. Saiju R, Morse LJ, Weinberg D, et al. Prospective randomised comparison of external dacryocystorhinostomy with and without silicone intubation. Br J Ophthalmol. 2009;93:1220–2.
34. Cannon PS, Chan W, Selva D. Incidence of canalicular closure with endonasal dacryocystorhinostomy without intubation in primary nasolacrimal duct obstruction. Ophthalmology. 2013;120:1688–92.
35. Chong KK, Lai FH, Ho M, et al. Randomized trial on silicone intubation in endoscopic mechanical dacryocystorhinostomy (SEND) for primary nasolacrimal duct obstruction. Ophthalmology. 2013;120:2139–45.
36. Walland MJ, Rose GE. Factors affecting the success rate of open lacrimal surgery. Br J Ophthalmol. 1994;78:888–91.
37. Camara JG, Bengzon AU, Henson RD. The safety and efficacy of mitomycin C in endonasal endoscopic laser-assisted dacryocystorhinostomy. Ophthal Plast Reconstr Surg. 2000;16:114–8.
38. Hartikainen J, Grenman R, Puukka P, et al. Prospective randomized comparison of external dacryocystorhinostomy and endonasal laser dacryocystorhinostomy. Ophthalmology. 1998;105:1106–13.
39. Jokinen K, Kärjä J. Endonasal dacryocystorhinostomy. Arch Otolaryngol. 1974;100:41–4.
40. Rice DH. Endoscopic intranasal dacryocystorhinostomy results in four patients. Arch Otolaryngol Head Neck Surg. 1990;116:1061.
41. McDonogh M. Endoscopic transnasal dacryocystorhinostomy. Results in 21 patients. S Afr J Surg. 1992;30:107–10.
42. Kong YT, Kim TI, Kong BW. A report of 131 cases of endoscopic laser lacrimal surgery. Ophthalmology. 1994;101:1793–800.
43. Massaro BM, Gonnering RS, Harris GJ. Endonasal laser dacryocystorhinostomy. A new approach to nasolacrimal duct obstruction. Arch Ophthalmol. 1990; 108:1172–6.
44. Woog JJ, Metson R, Puliafito CA. Holmium:YAG endonasal laser dacryocystorhinostomy. Am J Ophthalmol. 1993;116:1–10.
45. Madge SN, Chan W, Malhotra R, et al. Endoscopic dacryocystorhinostomy in acute dacryocystitis: a multicenter case series. Orbit. 2011;30:1–6.
46. Weidenbecher M, Hosemann W, Buhr W. Endoscopic endonasal dacryocystorhinostomy: results in 56 patients. Ann Otol Rhinol Laryngol. 1994;103:363–7.
47. Sprekelsen MB, Barberán MT. Endoscopic dacryocystorhinostomy: surgical technique and results. Laryngoscope. 1996;106:187–9.
48. Erdöl H, Akyol N, Imamoglu HI, et al. Long-term follow-up of external dacryocystorhinostomy and the factors affecting its success. Orbit. 2005;24:99–102.
49. Zenk J, Karatzanis AD, Psychogios G, et al. Long-term results of endonasal dacryocystorhinostomy. Eur Arch Otorhinolaryngol. 2009;266:1733–8.
50. Onerci M, Orhan M, Ogretmenoğlu O, et al. Long-term results and reasons for failure of intranasal endoscopic dacryocystorhinostomy. Acta Otolaryngol. 2000;120:319–22.
51. Chan W, Malhotra R, Kakizaki H, et al. Perspective: what does the term functional mean in the context of epiphora? Clin Experiment Ophthalmol. 2012;40:749–54.
52. Vicinanzo MG, McGwin G, Boyle M, et al. The consequence of premature silicone stent loss after external dacryocystorhinostomy. Ophthalmology. 2008; 115:1241–4.
53. Ali MJ, Ali MJ, Gupta H, Honavar SG, Naik MN. Acquired nasolacrimal duct obstructions secondary to naso-orbito-ethmoid fractures. Patterns and outcomes. Ophthal Plast Reconstr Surg. 2012;28:242–5.
54. Wearne MJ, Beigi B, Davis G, et al. Retrograde intubation dacryocystorhinostomy for proximal and midcanalicular obstruction. Ophthalmology. 1999;106: 2325–8.
55. Limawararut V, Valenzuela AA, Sullivan TJ, et al. Cerebrospinal fluid leaks in orbital and lacrimal surgery. Surv Ophthalmol. 2008;53:274–84.
56. Sharma V, Martin PA, Benger R, et al. Evaluation of the cosmetic significance of external dacryocystorhinostomy scars. Am J Ophthalmol. 2005;140:359–62.
57. Vagefi MR, Winn BJ, Lin CC, et al. Facial nerve injury during external dacryocystorhinostomy. Ophthalmology. 2009;116:585–90.
58. Lee TS, Woog JJ. Endonasal dacryocystorhinostomy in the primary treatment of acute dacryocystitis with abscess formation. Ophthal Plast Reconstr Surg. 2001;17:180–3.
59. Wu W, Yan W, MacCallum JK, et al. Primary treatment of acute dacryocystitis by endoscopic dacryocystorhinostomy with silicone intubation guided by a soft probe. Ophthalmology. 2009;116:116–22.
60. Tsirbas A, Davis G, Wormald PJ. Revision dacryocystorhinostomy: a comparison of endoscopic and external techniques. Am J Rhinol. 2005;19:322–5.
61. Hull S, Lalchan S-A, Olver JM. Success rates in powered endonasal revision surgery for failed dacryocystorhinostomy in a tertiary referral center. Ophthal Plast Reconstr Surg. 2013;29:267–71.
62. Anderson NG, Wojno TH, Grossniklaus HE. Clinicopathologic findings from lacrimal sac biopsy specimens obtained during dacryocystorhinostomy. Ophthal Plast Reconstr Surg. 2003;19:173–6.
63. Salour H, Hatami M-M, Parvin M, et al. Clinicopathological study of lacrimal sac specimens obtained during DCR. Orbit. 2010;29:250–3.
64. Barmettler A, Erlich J, Lelli G. Current preferences and reported success rates in dacryocystorhinostomy amongst ASOPRS members. Orbit. 2013;32:20–6.