ELSEVIER
SAUNDERS

Otolaryngol Clin N Am
39 (2006) 539–549

OTOLARYNGOLOGIC
CLINICS
OF NORTH AMERICA

Powered Endoscopic Dacryocystorhinostomy

P.J. Wormald, MD, FRACS, FCS (SA), FRCS, MBChB

Department of Surgery–Otolaryngology, Head and Neck Surgery, Adelaide and Flinders Universities, The Queen Elizabeth Hospital, 28 Woodville Road, Woodville, South Australia 5011, Australia

Over the past 10 years the interest in endoscopic dacryocystorhinostomy (DCR) has increased with improved instruments and endoscopic sinus surgery skills. Although endoscopic DCR was first described in 1989 [1], the technique has evolved over the past 15 years as the understanding of the anatomy [2] and ability to achieve reliable and consistent results has improved [3–6].

Assessment of nasolacrimal duct obstruction

The patient presenting with epiphora is evaluated clinically to ensure that other causes of epiphora, such as lid malposition, entropion, ectropion, punctal abnormalities, and inflammatory causes such as blepharitis, have been excluded. The medial canthal region is palpated for a mucocele. Pressure is placed on the medial canthal region and the puncta inspected for reflux of mucous or purulent material, which would indicate obstruction of the nasolacrimal system. The inferior or superior punctum is dilated and a Bowman's lacrimal probe is gently slid along the canaliculus toward the lacrimal sac. A hard stop normally means that the probe entered the sac and stopped on the medial bony wall of the sac. A soft stop means that the probe stopped at the entrance to the sac, which may either indicate a tight common canaliculus sac junction or a stenosis of the common canaliculus. The patency of the nasolacrimal system is assessed by syringing. A blunt lacrimal needle (25-gauge) is introduced into the inferior punctum

P.J. Wormald receives royalties for the design of instruments from Medtronic Xomed.

E-mail address: peterj.wormald@adelaide.edu.au

doi:10.1016/j.otc.2006.01.009

and saline is injected. If the lacrimal system is obstructed, reflux of saline will occur through the upper punctum. If saline passes into the nose without reflux, the lacrimal system is patent. Clinicians should remember that syringing generates abnormal pressures in the lacrimal system and the ability for saline to penetrate into the nose may not reflect an underlying symptomatic narrowing of the nasolacrimal system.

Depending on the patency of the nasolacrimal system, obstruction can be either anatomic or functional [6]. Anatomic obstruction occurs when the nasolacrimal system is obstructed, usually between the lacrimal sac and nasal cavity, and is indicated by reflux on syringing and impeded flow of radiopaque dye during a dacryocystogram (DCG) (Fig. 1). Functional obstruction is less common ($\pm$30%) and is believed to be a narrowing of the nasolacrimal apparatus, a failure of the lacrimal pump system, or a combination of the two [6]. Functional obstruction is diagnosed when the nasolacrimal system is patent on syringing and DCG (Fig. 2A). In these patients, function of the lacrimal system is assessed using a lacrimal scintillogram. A radioisotope is placed in the conjunctiva and the progress of this isotope through the nasolacrimal system is monitored for 30 minutes. Inability to penetrate the nasal cavity indicates a functional nasolacrimal obstruction (Fig. 2B) [6]. The scintillogram can provide further diagnostic information by identifying if the isotope collects in the lacrimal sac. If isotope collection is seen, then the cause is less likely to be a failure of the lacrimal pump than a narrowing in the nasolacrimal system that is preventing the normal progression of tears into the nose, and a DCR should be beneficial. As shown in the ''Results'' section, the diagnosis of either an anatomic or functional obstruction affects the prognosis of the DCR [6]. This ability to define the type of nasolacrimal obstruction allows the patient to be informed of the prognosis and have realistic expectations about what can be achieved through surgery.

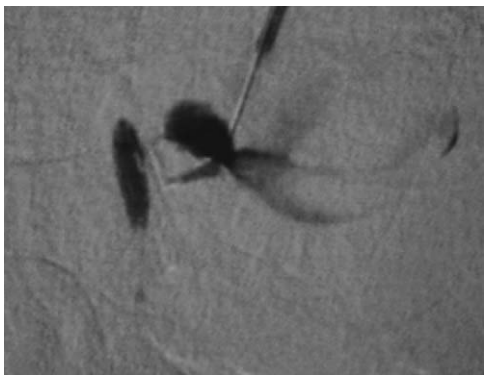

Fig. 1. Left DCG showing obstruction of the nasolacrimal duct with reflux of contrast into conjunctiva.

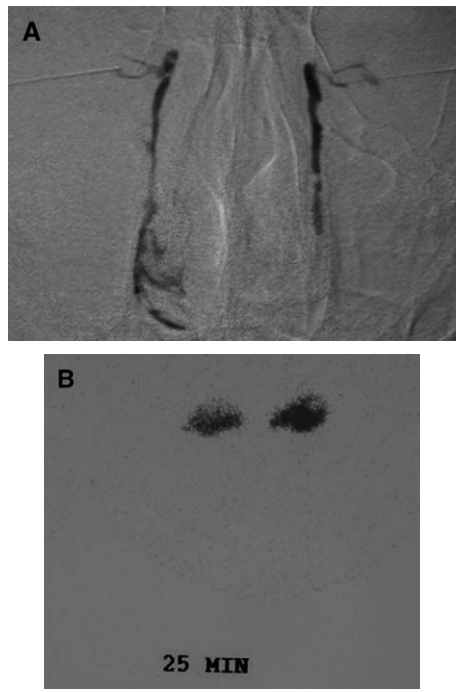

Fig. 2. (*A*) Bilateral DCGs illustrating patency of the nasolacrimal system bilaterally with penetration of contrast into the nasal cavity. (*B*) Bilateral lacrimal scintillography showing bilateral obstruction of tear flow with no nasal penetration of isotope at 25 minutes into the nasal cavity.

Development of endoscopic dacryocystorhinostomy

In the early 1990s, endoscopic DCR was performed by identifying the frontal process of the maxilla–lacrimal bone junction and then removing the frontal process of the maxilla superiorly with a rongeur up to the level of the insertion of the middle turbinate onto the lateral nasal wall (the so-called ''axilla'' of the middle turbinate) [7]. In most cases the bone became progressively thicker as the dissection proceeded up the lateral nasal wall and the dissection had to stop (because the surgeon was unable to engage the rongeur) well short of the axilla of the middle turbinate. The success of this technique was in the low 80% [6], causing some criticism of the technique by the oculoplastic surgeons who were able to achieve results in the low 90% [8]. The major difference between the techniques seemed to be that the oculoplastic surgeons achieved complete exposure of the lacrimal sac and then achieved lacrimal mucosa to nasal mucosa apposition through suturing the lacrimal and nasal mucosa [3]. To achieve complete exposure of the lacrimal sac, a better understanding of the intranasal siting of the lacrimal sac was necessary. We conducted a study in which we filled the lacrimal sac with radio-opaque dye and performed CT scans of the lacrimal

apparatus and nasal cavity [2]. This procedure allowed accurate definition of the position of the lacrimal sac relative to the axilla of the middle turbinate. This study placed the major portion of the lacrimal sac above the axilla of the middle turbinate rather than anteroinferior to the axilla as was previously believed (Fig. 3).

This knowledge has allowed us to develop a new surgical technique that has imitated the external DCR procedure by allowing exposure of the entire lacrimal sac during endoscopic dissection, thereby allowing creation of the biggest possible opening in the lacrimal sac [3–5]. The creation of the largest possible ostium minimizes the risk for subsequent stenosis and closure of the lacrimal ostium [9]. The technique described later also imitates the external procedure in that the lacrimal and nasal mucosa are closely approximated, allowing first-intention healing rather than second-intention (granulation tissue) healing [3]. The absence of postoperative granulation tissue lessens the risk for subsequent fibrosis, stenosis, and closure of the ostium.

Surgical technique

Surgical technique [3–5] begins with assessment of the nasal septum. Any significant deflection of the septum in the region of the axilla of the middle turbinate should be handled with a limited septoplasty and resection of the cartilage or bone in this region. When the surgeon creates the space to operate, the risks for poor surgical technique with limited exposure of the sac and for postoperative adhesion formation between the septum and the lateral nasal wall are minimized. After the nose has been decongested, the lateral nasal wall is infiltrated with 2% lidocaine and 1:80:000 adrenaline above and anterior to the axilla. A 30° endoscope is preferred for this procedure

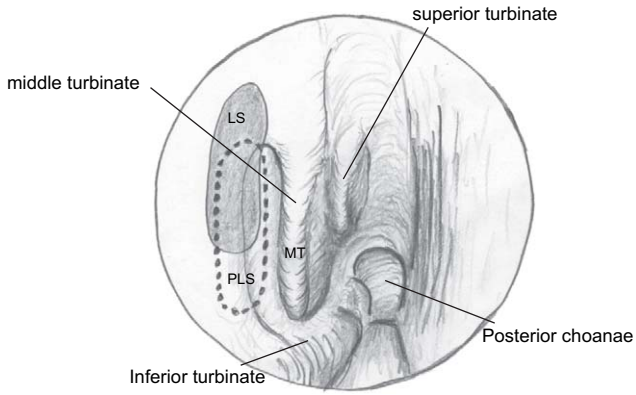

Fig. 3. Endoscopic view into the right nasal cavity showing the previous incorrect lacrimal sac (PLS) position (outlined with a broken line) and the correct lacrimal sac (LS) position (shaded) above and anterior to the middle turbinate (MT).

because most of the surgery occurs on the lateral nasal wall and the angulation of the endoscope allows improved visualization of the lateral wall. During surgery the 30° endoscope is always held above the surgical site looking directly laterally with all instruments passed below the endoscope.

A #15 scalpel blade is used to make the superior horizontal mucosal incision starting 3 to 5 mm posterior to and about 8 to 10 mm above the axilla of the middle turbinate (Fig. 4). This incision is brought 10 mm anterior to the axilla onto the frontal process of the maxilla. The incision is turned vertically and brought inferiorly toward the insertion of the inferior turbinate. If measured against the middle turbinate, this incision extends about two thirds of the length of the anterior end of the middle turbinate. Just above the insertion of the inferior turbinate on the lateral nasal wall the scalpel is turned horizontally and the incision continued posteriorly under the middle turbinate up to the insertion of the uncinate. The placement of this mucosal incision is crucial to the success of the procedure; an incision that is placed too low will not allow full exposure of the sac and an incision that is not brought far enough anteriorly will result in a short flap that will get sucked into the drill during removal of the bone over the sac.

Once the incision has been made, a suction Freer elevator is used to raise the flap (Fig. 5). When the flap is raised and the bone falls away, care should be taken to keep the tip of the elevator on the bone as the dissection proceeds over the prominence of the maxilla's frontal process to its junction with the thin lacrimal bone. This junction must be identified because it provides a critical landmark for removal of the maxilla's frontal process and subsequent identification of the lacrimal sac (Fig. 5). This junction is best identified just above the insertion of the inferior turbinate because the lacrimal bone ends about 5 mm below the axilla.

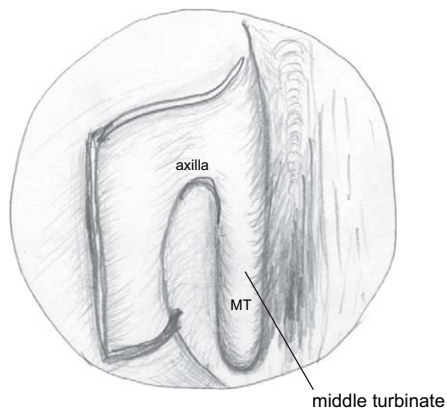

Fig. 4. Incisions for raising mucosal flap starting 8 to 10 mm above axilla of middle turbinate (MT) and coming 10 mm anterior to the axilla.

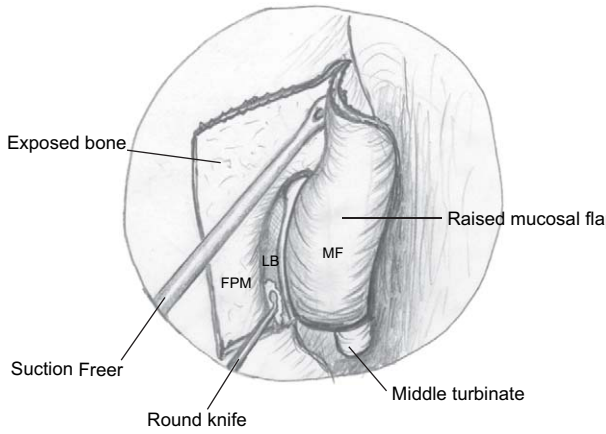

Fig. 5. Elevation of the mucosal flap (MF) by a suction Freer. The hard bone of the frontal process of the maxilla (FPM) and its junction with the lacrimal bone (LB) are clearly identified before the round knife is used to remove the lacrimal bone from the posterior inferior portion of the lacrimal sac.

A round knife (from the ear instrument set) is used to fracture the thin lacrimal bone and remove as much of it as possible (Fig. 5). This procedure allows introduction of the Hajek-Koeffler punch and engagement and removal of the free edge of the frontal process of the maxilla (Fig. 6). This bone removal is continued as far superiorly as possible until the bone becomes too thick for the punch to engage the bone. However, this bone removal usually finishes well short of the axilla of the middle turbinate. To

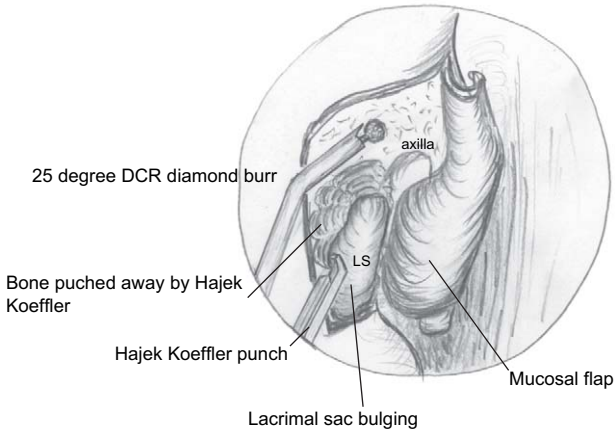

Fig. 6. The rongeur is used to remove as much of the frontal process of the maxilla as possible before the curved DCR diamond burr is used to expose the remaining lacrimal sac (LS) and agger nasi cell above the axilla of the middle turbinate.

avoid pinching the wall of the sac and tearing the sac with the rongeurs, the jaws should be opened after each bite, allowing any sac wall that may have become caught to be released before the bone is removed. The powered endoscopic microdebrider with a Rough Diamond 2.5-mm DCR Burr (Medtronic Xomed, Jacksonville, Florida) is used to first thin down the remaining bone and then to remove it by following the sac superiorly until the edge of the superior mucosal incision is reached (Fig. 6). Care must be taken to ensure that the burr does not slip under the bone edge adjacent to the sac mucosa during this dissection because the mucosa of the sac is thin and prolonged contact with the burr will result in a hole in the sac wall. As the posterosuperior bone is removed, the mucosa from the agger nasi cell is seen (Fig. 7). In most cases the agger nasi cell will be exposed as the superior sac is exposed.

Once the sac has been completely exposed, the inferior or superior punctum is dilated and the lacrimal sac cannulated with a lacrimal probe. The tip of the probe must be clearly visualized behind the very thin lacrimal sac wall. Often the sac wall will move with the probe placed at the common canaliculus entry to the sac and the probe will appear to be in the sac. The surgeon must not make an incision into the sac wall until the tip is clearly seen because this could result in damage to the common canaliculus opening as the incision is made onto the tip of the probe. Once the tip of the probe is clearly seen tenting the medial sac wall, the Lacrimal Spear Knife (Medtronic Xomed, Jacksonville Florida) is used to make a vertical incision into the sac wall (Fig. 7). The sac is opened from top to bottom and the lacrimal probe should be seen coming through the common canaliculus opening. The lacrimal mini-sickle knife is used to make a releasing incision at the top of the vertical incision and at the bottom of the incision, which should

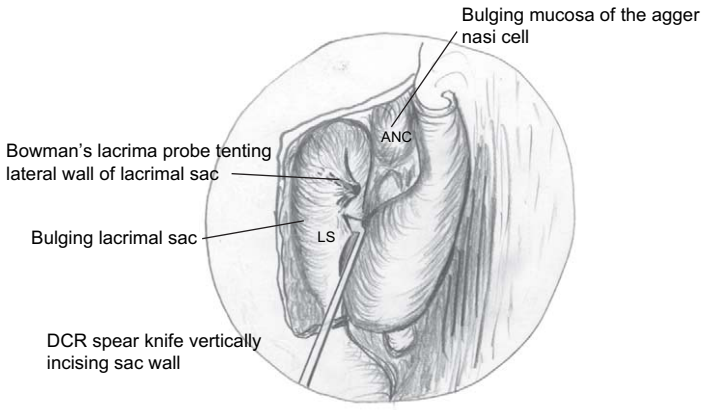

Fig. 7. A Bowman's lacrimal probe is placed into the lacrimal sac and the medial wall of the lacrimal sac (LS) is tented. A DCR spear knife is used to incise the sac vertically from top to bottom. The exposed mucosa of the agger nasi cell (ANC) is visible above the axilla.

allow the anterior lacrimal flap to be rolled out and remain flat on the lateral nasal wall (Fig. 8). The soft tissue scissors are used to make similar cuts in the posterior flap, allowing the posterior flap to be rolled out until it is also flat against the lateral nasal wall. The mucosa of the agger nasi cell is opened vertically and the edge of this mucosa approximated to the posterior superior lacrimal mucosa. The original nasal mucosal flap is trimmed so that this flap mucosa approximates the lacrimal mucosa along the superior, posterior, and inferior edges of the opened lacrimal sac (Fig. 9). This approximation allows the lacrimal sac and nasal mucosa edges to heal through primary intention and lessens the amount of granulation tissue that forms, thereby lessening the risk for scar tissue formation and procedure failure.

Silastic O'Donaghue tubes (B.D. Visitec, Bidford-Upon-Avon, UK) are placed through the upper and lower canaliculus and brought out of the common canaliculus. These tubes are placed to dilate the common canaliculus opening into the lacrimal sac, which is important especially in patients who have functional (ie, a patent system on DCG but with impaired nasal penetration on lacrimal scintilography) epiphora. As the lacrimal sac is widely marsupialized into the nasal cavity, these tubes are placed specifically to dilate the common canaliculus entry into the lacrimal sac rather than to keep the sac open. A 4-mm diameter, 1-cm long piece of Silastic tubing is slid over the Silastic tubes as a spacer. A loop of Silastic tubing is pulled in the medial canthus region to ensure that no tension is placed on the tubing (Fig. 10). Tension on the Silastic tubing can cause the tubing to cut through the puncta, resulting in a loss of function. A 1.5 $\times$ 1.5-cm piece of Gelfoam (Pharmacia & Uphjohn Company, Kalamazoo, Michigan) is placed over the tubes and slid into position to hold the flaps in place. Ligar clips are placed just below the spacer and the Silastic tubes cut. The Gelfoam is lifted and the position of the flaps checked before the Gelfoam is replaced.

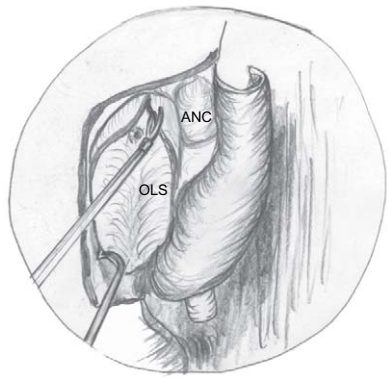

Fig. 8. To allow the lacrimal sac mucosal flaps to be rolled out to fully open the lacrimal sac (OLS), a DCR mini-sickle knife is used to make anterior releasing incisions inferiorly and superiorly and the soft tissue scissors is used to make posterior releasing incisions superiorly and inferiorly. ANC, agger nasi cell.

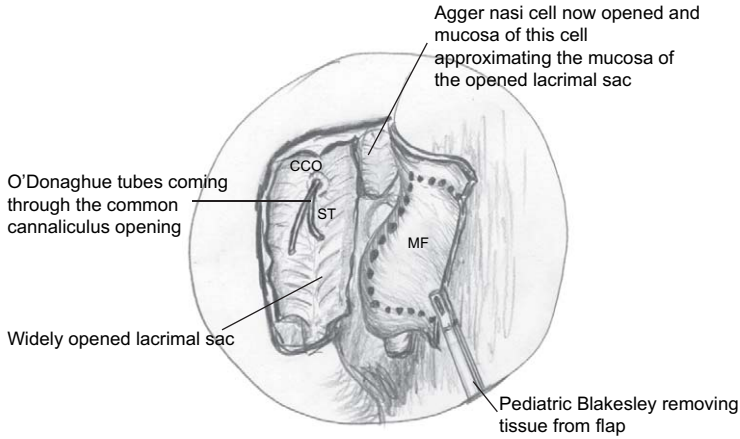

Fig. 9. After the lacrimal sac has been fully opened and the agger nasi cell has been opened, inferior and superior mucosal flaps are created by removing the tissue within the broken line of the mucosal flap (MF) using a pediatric Blakesley forceps. The Silastic tubes (ST) are placed through the common canaliculus opening (CCO), which is clearly visible in the lateral wall of the lacrimal sac.

The patient is given broad-spectrum antibiotics for 5 days and Chloromycetin eye drops for 10 days. Saline nasal douches are started postoperatively. The O'Donaghue tubes are removed at 4 weeks.

Results

When reporting results, *success* must be defined accurately [3–6,10]. In our published studies [3–6,10], a successful DCR was defined as a patient

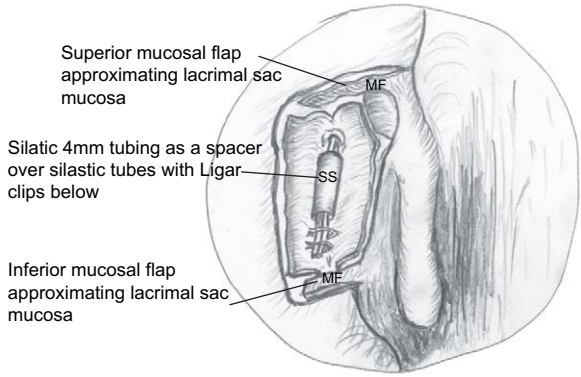

Fig. 10. The superior and inferior mucosal flaps (MF) are placed over the raw bone ensuring mucosa-to-mucosa apposition. Note the posterior superior lacrimal mucosa is apposed to the opened agger nasi cell mucosa. A Silastic spacer (SS) is placed over the Silastic tubes and Ligar clips applied below the spacer.

Fig. 11. Right postoperative picture of marsupialized lacrimal sac. Note bubbles from common canaliculus opening.

who is asymptomatic and has a healed patent lacrimal ostium with a free flow of fluorescein from the conjunctiva to the nose. Fig. 11 shows a typical result with a complete marsupialization of the right lacrimal sac into the nasal wall. The results with powered endoscopic DCR have been consistently successful for functional and anatomic obstruction in approximately 95% of patients [3–6,10]. Separating the results into anatomic versus functional obstruction, the success rate for anatomic obstruction is 97% but drops to 84% for functional obstruction [6]. Although 84% may seem low, most of the patients (>80%) in whom treatment was considered to have failed because they experienced ongoing symptoms, underwent a technically successful operation. These patients also form a small proportion of the total number of powered endoscopic DCRs, thereby decreasing the average success rate of all DCRs to 95% [3–6]. In this functional group, these patients (those who experienced treatment failure) still had symptoms, but most claimed these symptoms were much improved after the surgery. This technique has also been very effective in revision and pediatric DCR [10].

Summary

Powered endoscopic DCR is a reliable and effective technique for managing primary nasolacrimal duct obstruction in adults and children and for revision DCR.

References

[1] McDonogh M. Endoscopic transnasal dacryocystorhinostomy. Results in 21 patients. S Afr J Surg 1992;30:107–10.

[2] Wormald PJ, Kew J, van Hasselt CA. The intranasal anatomy of the naso-lacrimal sac in endoscopic dacryocystorhinostomy. Otolaryngol Head Neck Surg 2000;123:307–10.
[3] Wormald PJ. Powered endonasal dacryocystorhinostomy. Laryngoscope 2002;112:69–71.
[4] Tsirbas A, Wormald PJ. Endonasal dacryocystorhinostomy with mucosal flaps. Am J Ophthalmology 2003;135(1):76–83.
[5] Tsirbas A, Wormald PJ. Mechanical endonasal dacryocystorhinostomy versus external dacryocystorhinostomy. Ophthal Plast Reconstr Surg 2004;20(1):50–6.
[6] Wormald PJ, Tsirbas A. Investigation and endoscopic treatment for functional and anatomical obstruction of the nasolacrimal duct system. Clin Otolaryngol Allied Sci 2004;29(4): 352–6.
[7] Wormald PJ, Nilssen E. Endoscopic DCR: the team approach. Hong Kong Journal of Ophthalmology 1998;1:71–4.
[8] Hartikainen J, Antila J, Varpula M, et al. Prospective randomised comparison of endonasal endoscopic dacryocystorhinostomy and external dacryocystorhinostomy. Laryngoscope 1998;108:1861–6.
[9] Welham R, Wulc A. Management of unsuccessful lacrimal surgery. Br J Ophthalmol 1987; 71:152–7.
[10] Tsirbas A, Davis G, Wormald P. Revision DCR: a comparison of endoscopic and external techniques. Am J Rhinol 2005;19(3):322–5.