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Endoscopic Dacryocystorhinostomy

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1. Introduction

Endoscopic DCR has gained a lot of attention among otolaryngologists since the outcomes are comparable to the external approach. Advances in surgical technique and a better understanding of the anatomy have resulted in improvement of outcomes.

The main goal of this chapter is to acquaint readers with the anatomy and function of lacrimal system, the newly emerged technique of endoscopic DCR and its related topics.

In this chapter, the anatomy of the lacrimal system will be discussed in detail. Then, the conditions needing surgical manipulation will be noted in addition to assessing the patients with such problems. Surgical indications and techniques of DCR will be explained. Some topics such as the advantages, results and complications of the surgery and the role of Mytomycin C are included, too.

2. Anatomy

2.1 Lacrimal gland and excretory system

2.1.1 Lacrimal gland

The main lacrimal gland is located in a shallow depression along the superior lateral orbit. There is fibroadipose tissue between the gland and the orbit. The gland is divided into 2 parts by a lateral expansion of the levator apeunorosis. An isthmus of glandular tissue occasionally exists between the palpebral lobe and the main orbital gland[1].

Many accessory lacrimal glands can be found along the inner surface of the eyelids. A variable number of thin-walled excretory ducts, blood vessels, lymphatics, and nerves pass from the main orbital gland into these accessory lacrimal glands. The ducts continue downward, and about 12 of them empty into the conjunctival fornix approximately 5 mm above the superior margin of the upper tarsus. Because the lacrimal excretory ducts pass through the palpebral portion of the gland, biopsy of the lacrimal gland is usually performed on the main part to avoid sacrificing the ducts[1].

The lacrimal glands are exocrine glands, and they produce a serous secretion. The body of each gland contains 2 cell types:

- acinar cells, which line the lumen of the gland

- myoepithelial cells, which surround the parenchyma and are covered by a basement membrane

The lacrimal artery, a branch of the ophthalmic artery, supplies the gland. The lacrimal gland receives secretomotor cholinergic, vasoactive intestinal polypeptide (VIP)-ergic,and sympathetic nerve fibers in addition to a sensory innervation via the lacrimal nerve (CN V1). Cyclic adenosine monophosphate is the second messenger for VIP and β-adrenergic stimulation of the gland; cholinergic stimulation acts through an inositol 1,4,5-triphosphate-activated protein kinase C. The gland also contains α_1-adrenergic receptors. Extremely complex, the gland's neuroanatomy governs both reflex and psychogenic stimulation[1].

2.1.2 Accessory glands

The accessory lacrimal glands of Krause and Wolfring are located at the proximal lid borders or in the fornices and are cytologically identical to the main lacrimal gland, receiving a similar innervation. They account for about 10% of the total lacrimal secretory mass[1].

2.1.3 Lacrimal excretory system

The lacrimal excretory (drainage) system includes the upper and lower puncta, the lacrimal canaliculi, the lacrimal sac, and the nasolacrimal duct. It is important to note that the first 2 mm of canaliculi are perpendicular to the lid margin but the distal 8 mm are parallel to the

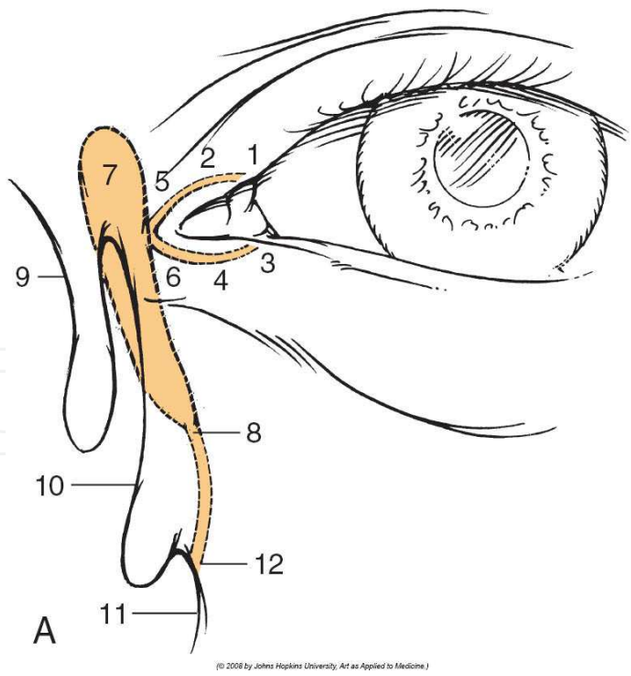

Fig. 1. Anatomy of the left lacrimal apparatus
1.superior punctum 2.superior canaliculus 3.inferior punctum 4.inferior canaliculus 5.medial canthal ligament 6.common canaliculus 7.lacrimal sac 8. Lacrimal duct 9.middle turbinate 10.lacrimal bone 11.inferior turbinate 12.Hasner's valve

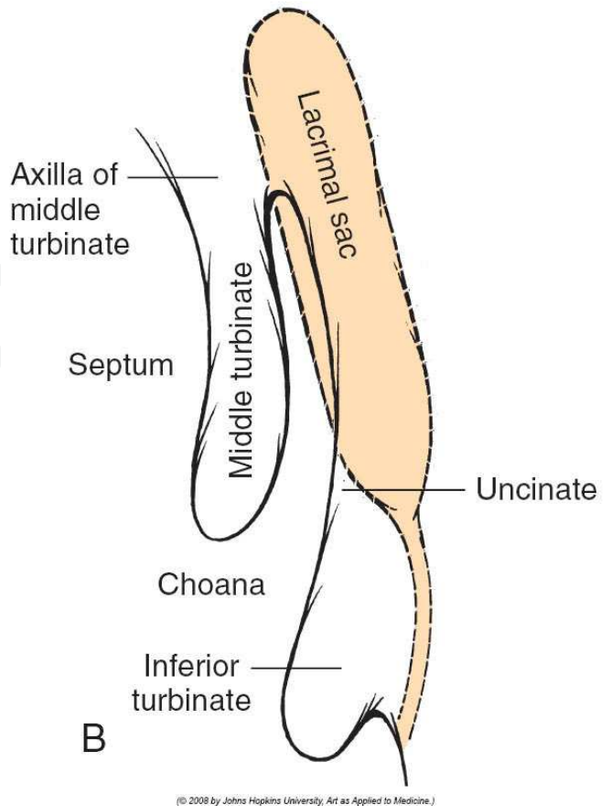

Fig. 2. Position of lacrimal sac as seen during endonasal visualization

lid. In 90% of people, the two canaliculi join to make a common canaliculus before entering the lacrimal sac. The lacrimal sac is placed in an oval-shaped fossa measuring 15 mm in height and 10 mm in width. This fossa is bounded by anterior and posterior lacrimal crests which fuse at a suture line that crosses the lacrimal fossa in a vertical manner. The lacrimal sac opens into nasolacrimal canal which is formed by the maxillary, lacrimal, and inferior turbinate bones. The nasolacrimal duct passes through this osseous canal for approximately 12 mm. Then it turns into a membranous duct for 5 mm before entering the inferior meatus[2]. The duct orifice is often covered by Hasner's valve to prevent reflux of secretions. In about 30% of full-term neonates, the outlet of the nasolacrimal duct is closed for up to 6 months. Occasionally, probing may be necessary to achieve patency.

The lacrimal puncta and the canaliculi are lined with stratified squamous nonkeratinized epithelium that merges with the epithelium of the eyelid margins. Near the lacrimal sac, the epithelium changes into 2 layers: a superficial columnar layer and a deep, flattened cell layer. Goblet cells and occasional cilia are present. In the canaliculi, the substantia propria consists of collagenous connective tissue and elastic fibers. The wall of the lacrimal sac resembles adenoid tissue and has a rich venous plexus and elastic fibers.

3. Etiologies and predisposing factors of lacrimal obstruction

Patients with obstruction of lacrimal system usually complain of excessive tearing or epiphora. When dacryocystitis occurs, purulent drainage or inflammation can be noticed in

the medial canthal region. It is important to ask patients about any nasal airway obstruction, drainage or epistaxis, which may suggest intranasal causes of lacrimal obstruction, such as polyps or neoplasms. Sometimes, the nasolacrimal duct is injured secondary to prior sinus surgery, particularly a large maxillary antrostomy.

Lacrimal excretory system foreign bodies are rare but they can impair draining function and might be presented as epiphora, recurrent attacks of acute dacryocystitis and in some patients, chronic dacryocystitis[3]. Exogenous foreign bodies in most patients lodge in lacrimal sac or nasolacrimal duct after external manipulation[3]. Foreign bodies in some patients have endogenous origin and in the form of dacryoliths may lead to lacrimal flow obstruction[3]. In both forms, surgical removal of foreign bodies is necessary[3]. Classic surgical approach is external dacryocystorhinostomy (DCR) but in recent years with rapid improvement of endoscopic techniques intranasal approaches introduce themselves as an effective substitute for external DCR[3]. These approaches are helpful for preoperative diagnosis and effective for surgical removal of lacrimal foreign bodies.

We had an experience with foreign bodies which was published in Iranian journal of ophthalmology. In our case, the lacrimal sac foreign body was a piece of silicon tube that was used as a stent in previous external DCR. On retrospective enquiry we found that at the time of silicon tube removal, it was pulled forcefully out through the lacrimal canaliculi and when it was impacted at the given site it was cut and the remaining part could not be found through the nose. The presenting signs and symptoms of this case were completely similar to the failed DCR procedure, so she was referred to our department for more evaluation. Anterior rhinoscopy is normal in many of such cases, so we should emphasize on the role of the nasal endoscopy as a safe and rapid diagnostic method. In the nasal endoscopy, the condition of rhinostomy site can be evaluated and any foreign body, granulation tissue, scar formation or synechia between middle turbinate and lateral nasal wall can be found and appropriate treatment plan can be established[3].

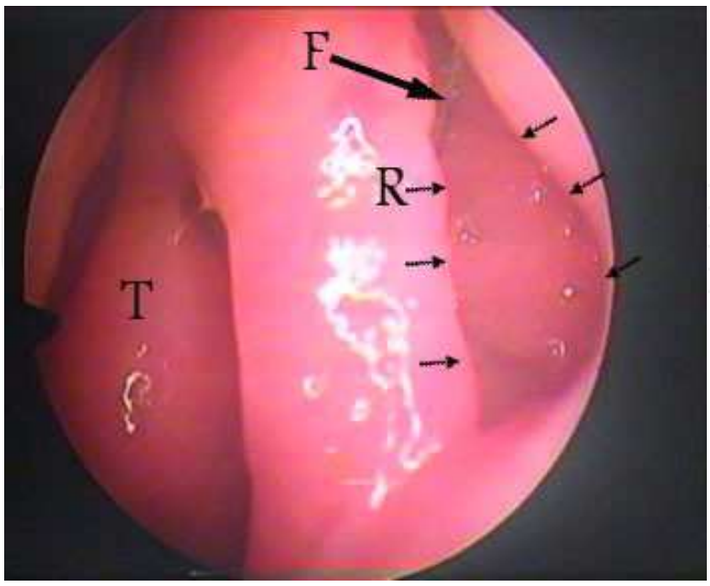

Fig. 3. Rhinostomy site with foreign body T: Middle turbinate, R: Previous rhinostomy site, F: Foreign body

Dacryoliths (lacrimal stones) or "calculi" of the nasolacrimal ducts were described by Cesoni in as early as 1670[4], and have been reported to occur in between 6 and 18% of patients with nasolacrimal duct obstruction who undergo dacryocystorhinostomy (DCR). Dacryoliths may occur in any part of the nasolacrimal system, albeit most commonly in the lacrimal sac. Several predisposing factors have been suggested, such as increased occurrence in females, patient age below 50 years, association with cigarette smoking and facial-sinonasal trauma, and increased frequency subsequent to previous occurrence of dacryocystitis. However, other studies have indicated increased frequency in males and patients aged above 50 years. Therefore, it seems that both genders are involved to nearly the same extent. Dacryoliths usually become symptomatic when they obstruct the nasolacrimal system. This can result in epiphora, acute dacryocystitis, protrusion of the lacrimal canthal region, and partial closure of the lacrimal passage (recognized during syringing by the ophthalmologist). Interestingly, dacryoliths occur more often in patients with partial and incomplete closure of the lacrimal passage (i.e., patients with epiphora despite patent lacrimal passages on syringing). Scanning electron microscopy has shown that dacryoliths are composed of lobes and lobules built on an amorphous core material[5]. Atomic absorption spectrophotometric investigations demonstrate that dacryoliths consist almost entirely of organic proteins and, to a much lesser extent, of inorganic material[5]. According to Lew et al., lacrimal fluid from patients with dacryoliths contains a reduced amount of lysozyme and a lower calcium concentration than normal lacrimal fluid. It is important to recognize that daryoliths are not calcified or composed of any other "hard" substances. Some stones reveal hyphae-like structures, although no fungi were recovered by culturing[5].

4. Assessment of the patient

4.1 Physical examination

A comprehensive ophthalmologic examination is mandatory in the primary evaluation of every patient with lacrimal system obstruction. An examination with the slit lamp can reveal the normal or abnormal tear film over the conjunctiva and if the thickness of the tearfilm is more than usual, it can be a sign of lacrimal drainage system obstruction. In addition, the ocular surface, eyelid structures, visual acuity, extraocular motility, and visual field should be tested and documented before surgery.

Gentle pressure over the sac produces reflux of mucopurulent material suggestive of lower sac obstruction (regurgitation test).

Irrigation test is another useful test in assessing patients. In this test, an appropriate lacrimal syringe is passed through the inferior lacrimal punctum and 2-5 ml of sterile distilled water is injected and pushed though the inferior canaliculus. If the water passes easily into the nose and the patient senses that, the patency of the system is confirmed. Otherwise, it is one of the most reliable signs of lacrimal system obstruction. Some authors recommend that after either external or endoscopic DCR, this test can be performed indicating the patency of the system.

Nasal examination, especially nasal endoscopy, should be obligatory for every lacrimal obstruction patient. The examination of the lacrimal area with the nasal speculum and headlight provides only a poor view of this region and is not sufficient; Endoscopy provides a clear diagnostic look for nasal polyps, imporant anatomic variations, tumors, and other pathological endonasal conditions such as septal deviation.

Diagnostic nasal endoscopy is performed with a rigid endoscope or flexible endoscope which can be used without any difficulties in small children, too.

The rigid endoscopes are 4-mm in diameter, with 0 or 30° viewing angle. The 2.7-mm diameter endoscope can be advantageous, especially in children and some adults with narrow nasal cavities. The inferior and the middle meatus are better viewed if some decongestants are introduced into the nose.

4.2 Radiologic evaluation

Radiological tests should be done before DCR which include dacryocystography (DCG), nuclear lacrimal scintigraphy (dacryo scintillography), computed tomography (CT), and magnetic resonance imaging (MRI).

Dacryocystography is an anatomical investigation and is indicated if there is a block on syringing in the lacrimal system, and thus it can help in creating an image of how the internal anatomy of the lacrimal system looks.

Scintigraphy is a functional test and is useful in assessing the site of a delayed tear transit, i.e., it is useful only if the lacrimal system is patent on syringing.

Both CT and MRI are used very seldom and are reserved only for some patients with preceded trauma, facial surgery, tumor, or in whom sinus diseases are suspected.

4.3 Dacryocystography

Dacryocystography is a method in which injection of the radio-opaque water-soluble fluid is instilled into either lower or upper canaliculus taking magnified images. The digital subtraction technique is preferred because it gives an image of better quality. A DCG better evaluates the lacrimal sac and duct anatomy, but it evaluates worse canalicular anatomy. It outlines diverticulae and fistulae, and shows intrasac pathology (dacryoliths or tumor) and the sac size. A DCG is not routinely performed. It is seldom necessary with a complete obstruction in the non-traumatic situation. It can be especially useful in patients with previous trauma to localize the position of bone fragments or, after previously unsuccessful lacrimal surgery, to determine the size of the sac. With patency to syringing, the DCG helps to determine whether the stenosis is in the common canaliculus or sac, and it can rule out the presence of a lacrimal sac diverticulum[6]. A DCG can often find drainage abnormalities present in patients with "functional obstruction"[6].

4.4 Nuclear lacrimal scintigraphy

Nuclear lacrimal scintigraphy is a simple, non-invasive physiological test that evaluates patency of the lacrimal system. Scintigraphy uses a radiotracer (technetium-99m pertechnetate), which is very easily detectable with a gamma camera. While a DCG is usually preferred especially in a complete obstruction, scintigraphy is useful only in those patients whose lacrimal system is patent to syringing in the presence of constant epiphora. The test is more physiological than DCG, anatomical information is lacking, and fine anatomical details are not available in comparison with DCG[7]. Correlation of the anatomical study (DCG) and functional study (scintigraphy) may be necessary in planning surgery[8]; However, it is important to bear in mind that a normal result is considered to be a

contraindication to any surgical intervention[7]. Nuclear lacrimal scan has been found to be helpful especially in difficult cases with incompletely obstructed pathways in which DCG could not be interpreted in a satisfactory manner to determine whether surgery should be undertaken or not[9].

4.5 Computed tomography and MRI

Computed tomography (CT) can be helpful in assessing the structures intimately associated with the nasolacrimal drainage system. The CT scanning is used mainly when an extrinsic disease is suspected and is of great help to the patients with paranasal sinus or facial pathology associated with the lacrimal system (tumor, rhinosinusitis, facial trauma, following facial surgery, etc.)[10].

Magnetic resonance is not used in practice in lacrimal diagnostics and is reserved only for the special cases, e.g., for differentiation of masses of the lacrimal sac[8].

5. Surgical indications

DCR is the treatment of choice for those patients who present with persistent epiphora or chronic dacryocystitis from nasolacrimal duct obstruction. The obstruction is usually due to a primary acquired condition of unknown etiology. The other causes are trauma, infection, neoplasm, and lacrimal stones.

6. Surgical technique

Dacryocystorhinostomy can be performed both externally and as an endoscopic approach. The external approach is commonly done by ophthalmologists. In external approach, an incision is made between the medial canthus and the nasal dorsum. Then the lacrimal sac is exposed and elevated from the lacrimal fossa. The lacrimal bone with an almost diameter of 1 cm is drilled. Hence, two anterior and posterior lacrimal flaps are created which are sutured to the flaps made from nasal mucosa. Finally, two silicone tubes (Budkin's tubes) are passed through the superior and inferior canaliculi and fixed in the nose.

The endoscopic approach, however, has gained much attention among ENT surgeons. Endoscopic DCR can be performed under either local or general anesthesia. It is recommended to have a video camera attached to the endoscope so that the assistant surgeon can observe the maneuvers on a video monitor.

The patient is placed in a supine position with the head slightly elevated to decrease the venous pressure at the operation site. To decongest the mucosa, vasoconstrictors are applied through pledgets in the nose. Then, injections composing of 1% lidocaine and 1:100000 epinephrine must be performed. Usually, superior to the axilla and anterior to the uncinate process are injected.

Sometimes, an endoscopic septoplasty is needed to reduce the complexity of the procedure[11, 12]. If required, appropriate injections in the septum must be done, too. The septoplasty is usually limited and just the superior and anterior portions of the bony septum are corrected.

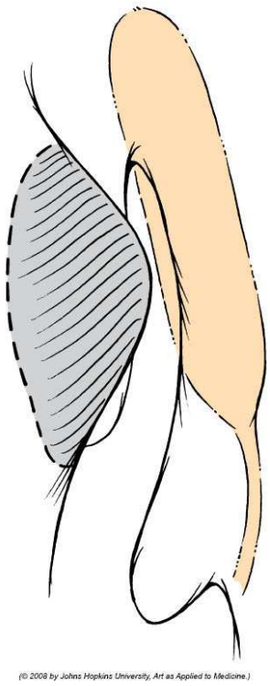

Fig. 4. High endoscopic septoplasty. Ideal area of removal is indicated by a dashed line.

A 30-degree scope is used through the procedure to have adequate visualization around the frontal process of the maxilla. A DCR flap must be created considering the lacrimal sac in mind. The superior incision must be 5mm posterior and 10mm superior to the axilla. It is brought 10mm anterior to the middle turbinate to be able to marsupialize the lacrimal sac fully. The inferior incision would be at the insertion of the inferior turbinate.

An elevator is used to make a subperiosteal plane along the incisions towards the frontal process of the maxilla. The flap must be mobilized over the frontal process of the maxilla until the lacrimal bone is identified. The best place to identify the lacrimal bone is the region adjacent to the inferior horizontal incision just above the inferior turbinate. Superiorly, the flap is elevated on to the insertion of the middle turbinate and posteriorly, it is elevated past the lacrimal bone onto the uncinate process. When the flap is completely elevated, its inferior pedicle is cut off the superior aspect of the inferior turbinate and its insertion to the uncinate.

A round knife is used then to identify the junction of frontal process and lacrimal bone and to flake off the lacrimal bone. The posterioinferior aspect of the lacrimal sac and adjacent nasolacrimal duct would be exposed this way. Then, a punch is used to remove the frontal process of maxilla. Superiorly, the bone thickens and it would be difficult for the punch to grip the bone. Therefore, drilling with a DCR diamond bur may be required. Care must be taken to ensure that excessive pressure is not placed on the sac wall. When the lacrimal sac is opened, it will lie flat on the lateral nasal wall. It would be marsupialized. By removing the bone from the posterolateral region of the lacrimal sac, the mucosa of the agger nasi cell will be exposed. There is a pyramid-shaped bone between the anterior aspect of the agger nasi cell and the lacrimal sac which must be completely removed. The agger nasi mucosa is opened by a sickle knife.

The next step would be checking the lacrimal puncta and dilating them by a probe if required. A sinus endoscope would be helpful for lighting the region. By passing the lacrimal probe, its metallic part can be seen within the translucent sac wall.

Then the mucosal flap is positioned to approximate nasal mucosa to the lacrimal mucosa. The common canaliculus should be visible in the lateral sac wall. Then, stenting of the system would be done. If the lacrimal probes pass easily without any resistance in the canaliculus and the common canaliculus valve of Rosenmuller, lacrimal probes need not be placed. However, if there is tightness of common canaliculus, stents should be placed through the superior and inferior canaliculi and brought out of the common canaliculus. It must be considered that the sac should stay open without the stenting action of the tubes.

Finally, the end of the tubes can be knotted and cut. The nose can be packed lightly. If there is minimal risk of epistaxis, no packing is needed.

7. Revision endoscopic dacryocystorhinostomy

The principles are similar to those of primary DCR. As far as the bone along the lateral nasal wall has already been removed, endoscopic revision DCR is much easier than the primary procedure. The important point in revision DCR is the size of the lacrimal sac.

If the sac is normal in size, the rate of success is high (89%)[11, 12]. If there is scarring and cicatrizaion of the sac, the success rate is lower because only a small amount of lacrimal mucosa can be marsupialized.

In severe stenosis and scarring of the lacrimal sac, the agger nasi mucosa can be used as a free graft to create functional mucosa surrounding the common canaliculus-sac junction.

8. Postoperative care

If nasal packing is placed at the end of surgery, it is removed the following morning. Patients must irrigate their nose with saline at least twice a day. The patient must be visited one week later and intranasal debris must be removed then.

The silastic tubing is removed 1-12 months after surgery. According to our experience, we recommend removing the tube in about 4 weeks after surgery. Exposed tubing at the medial canthus is cut with scissors and the stent is withdrawn through the nose. In revision cases with scarring the stent can be left in the place for 6 months or even longer.

During surgery sufficient opening from the lacrimal sac into the nose is made, but the final size of the healed surgical ostium is 1 to 2 mm in diameter on average.

9. Complications

Complications of endonasal DCR surgery can be divided into intraoperative and early or late postoperative. Early postoperative (up to one month) complications include hemorrhage, crusting, perirhinostomy granuloma, and transnasal synechiae; 1 - 6 months side effects of surgery include surgical failure from impacted tubes, rhinostomy scarring, granuloma, and synechiae. Most of these later complications occur between one and three months after surgery[13].

In endonasal surgery, complications are greater with inexperienced surgeons. The complications of endoscopic DCR are similar to those for endoscopic sinus surgery. Excessive bleeding during surgery precludes visualization and accounts for major intraoperative complications such as blindness and cerebrospinal fluid leakage. If excessive bleeding is encountered in endoscopic surgery, the procedure must either be terminated or converted to an open DCR. Severe postoperative epistaxis occurs in less than 5% of cases. Bleeding usually occurs within one week of surgery and is caused by a branch of the sphenopalatine artery supplying the remnant of a partially resected middle turbinate.

Sometimes, during bone removal to uncover the lacrimal sac, orbital fat is exposed. This fat should not be disturbed, otherwise orbital contents such as blood vessels, nerves, and the medial rectus muscle would be injured.

Nasal or orbital infection following DCR is rare. Nevertheless, perioperative antibiotics are administered to avoid this complication.

One of the most common causes of surgical failure for both endoscopic and external DCR is postoperative adhesions. These adhesions usually cause obstruction of the surgically created ostium. In order to decrease this complication, surgical trauma to the turbinate mucosa should be avoided and the anterior end of the turbinate should be resected so that it is not near the ostium. Correction of the deviated septum also reduces the likelihood of postoperative adhesion formation.

10. Advantages of endoscopic DCR

The advantages of intranasal endoscopic DCR in comparison to classic external DCR are as follows[13]:

1. Providing better visualization.
2. Avoiding the external scar and damage to the angular vein.
3. Preserving the normal function of lacrimal pump.
4. Identification of the sac and correct placement of the opening between the sac and the nasal cavity
5. Immediate correction of surgical mistakes such as immediate control of brisk epistaxis after anterior ethmoidal artery trauma by its direct cauterization
6. Reduction of surgery time
7. Diagnosis and treatment of coexistent intranasal disturbances.

11. Outcomes of surgery

The result of surgery, no matter the technique, depends on the type of obstruction. In a study by Tsirbas and Wormald, 95% of anatomic obstructions and 81% of fuctional obstructions became asymptomatic. Although the rate of getting asymptomatic in functional obstructions is lower, still most of them state that their situation is improved.

In one of our studies, the success rate of endoscopic DCR with mechanical devices was 91.4% in 6 months followup and 88.5% in a year followup. Intraoperaive bleeding in 88.6% of patients was mild to moderate and epistaxis during the first three days after surgery was noted in 21% of patients which was mild. In 3% of patients, the intranasal bleeding was

moderate. 18% of patients had moderate pain in the first three days and 6%of them had that much pain in days 4 to 7 [13].

12. Mytomycin C and DCR

Mitomycin C is a chemotherapeutic antibiotic isolated from the broth of *streptomyces caespitosus*. Mitomycin C is an alkylating agent that is widely used systemically for the treatment of malignancies, and has also gained popularity as a topical adjunctive in the treatment of ocular surface neoplasia. The ability of this drug to modify the normal wound healing pathway by inhibiting fibroblast and endothelial cell growth and replication has made it an attractive adjunct in glaucoma and pterygium surgery, as well as in DCR surgery[14].

The primary cause of failure in DCR surgery is closure of the surgical osteotomy due to fibrosis, scarring, and granulation tissue. The intraoperative application of the anti-metabolite mitomycin C to the surgical anastamosis can theoretically inhibit such closure, and has been previously shown to increase the ostium size. Mitomycin C application varies in different published articles according to duration, manner and procedures[14].

Liao et al. by a randomized trial of 88 eyes undergoing external DCR, showed a significant increase in the number of symptom-free cases from 70.5% to 95.5% with the use of mitomycin C at 10-months follow-up and You and Fang showed increases in both ostium patency and size with the use of mitomycin C during external DCR at a mean follow-up of 3 years. Based on our study, it appeared that patients with nasolacrimal obstruction who underwent endoscopic DCR did not benefit from adjunctive topical application of mitomycin C. However, we suggest further multi-central trials for comparing results in different hospital settings[14].

13. Setup of endoscopic DCR

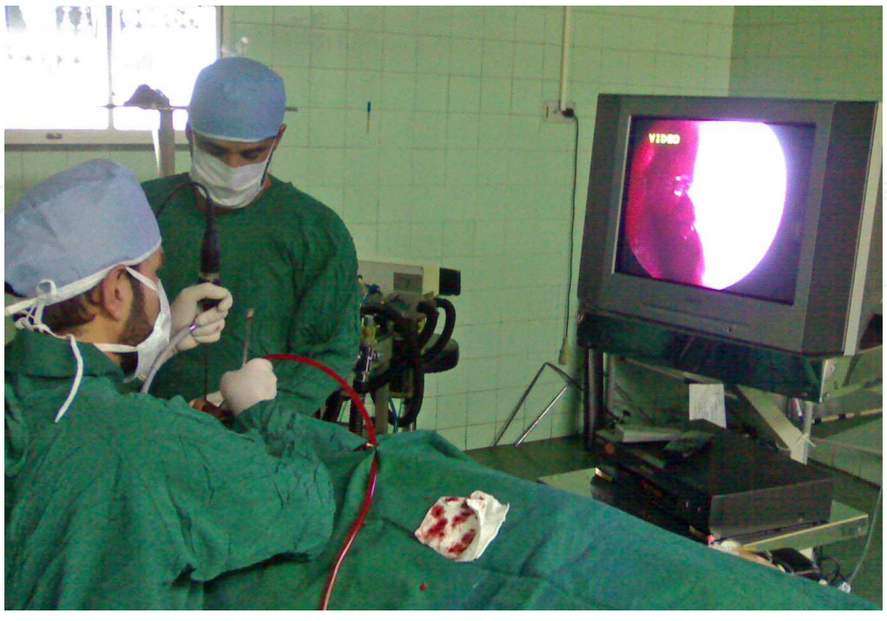

Fig. 5.

14. Acknowledgement

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15. References

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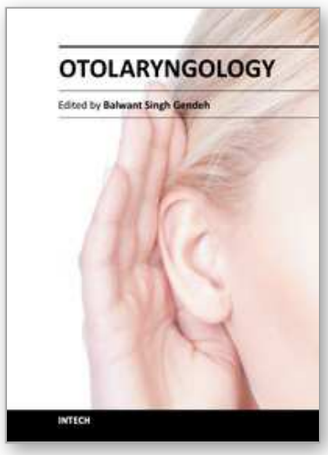

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This book emphasizes on different aspects of otolaryngology - the medical sciences of diagnosis and treatment of ENT disorders. "Otolaryngology" is divided into various clinical sub-specialities, namely otology, rhinology, laryngology, and head and neck. This book incorporates new developments, as well as future perspectives in otolaryngology. I would like to dedicate this book to those of you who will pick up the torch and by continued research, close clinical observation and the highest quality of clinical care, as well as by publication and selfless teaching, further advance knowledge in otolaryngology from this point forward. It is intended to be a guide to other books to follow. Otolaryngologists, researches, specialists, trainees, and general practitioners with interest in otolaryngology will find this book interesting and useful.

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