DACRYO CYSTO RHINOSTOMY

FROM DARKNESS TO LIGHT

AIOS

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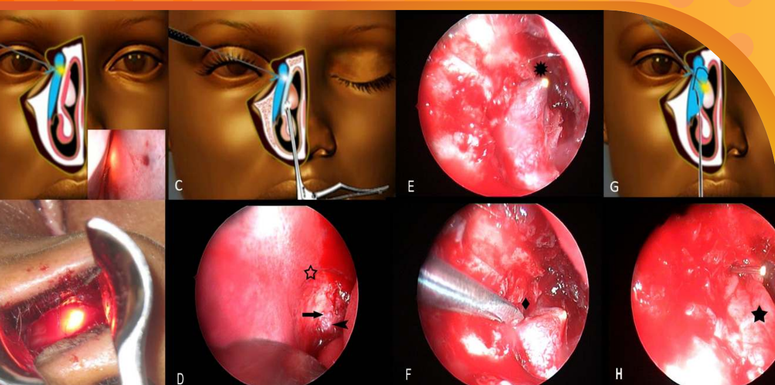

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DCR

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FOREWORD

Dacryo Cysto Rhinostomy (DCR) must classically be next only to cataract surgery, when considering the armamentarium of a general ophthalmologist. Though the epiphora it causes & the occasional severe infection may just be considered a nuisance and not vision threatening, a well done DCR offers immense relief to the patient. Sadly, not all ophthalmologists are equipped to handle this relatively straight forward procedure adequately.

Against this back ground, this excellent treatise on DCR is timely & welcome. Starting from the basics, to the technique of the procedure, the complications & the recent advances & innovations this covers the subject in its entirety. With several high quality illustrations this is a practical guide to mastering the procedure in all its aspects.

While internet, downloads & computers might have changed the way we acquire knowledge, sometimes the BOOK is still the best way to comprehensively cover a subject. On behalf of the membership of AIOS, my sincere thanks to the authors & TEAM ARC.

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PREFACE

"You can't cross the sea merely by standing and staring at the water"

- Tagore

Lacrimal surgery has evolved rapidly over the past decade, as a special wing of Oculoplastic Surgery. Scientific advancements have made it possible to give improved results of this very common disease and Dacryocystorhinostomy (DCR) is being used currently with various modifications by different surgeons worldwide.

Through this edition of CME Series of All India Ophthalmological Society, we attempt to give a comprehensive overview of the basics and newer modifications of the DCR surgery. The initial chapters cover in detail the anatomical and physiological details of the lacrimal system, the understanding of which is invaluable to understand the surgical nuances. Chapters 3-11 cover in detail the surgical aspects of the DCR surgery in its various forms, and its applications in special cases.

I would like to congratulate our Masters of Oculoplasty for putting together this manual, which I am sure will become a handy tool for all oculoplasty colleagues and general ophthalmologists alike. I am grateful to all the authors who have given their valuable time and efforts in writing the chapters. Intensive proofreading and plagiarism checks have gone into the making of this manual.

Hope you find this CME series a boost to your everyday practice.

Dr Partha Biswas
Chairman, Academic & Research Committee,
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Dacryo Cysto Rhinostomy – An Update

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Anatomy of the Lacrimal System

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The lacrimal apparatus (Fig 1) comprises of structures involved in the

- Production (the main and accessory lacrimal glands) and
- Transport of tears (puncta, canaliculi, lacrimal sac and nasolacrimal duct)

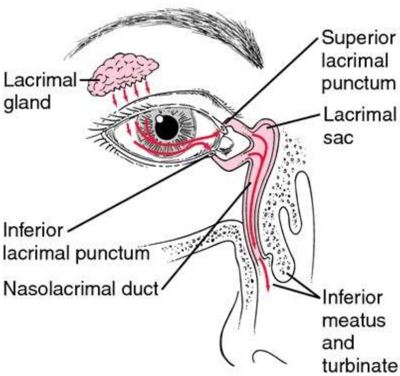

Figure 1: The lacrimal apparatus

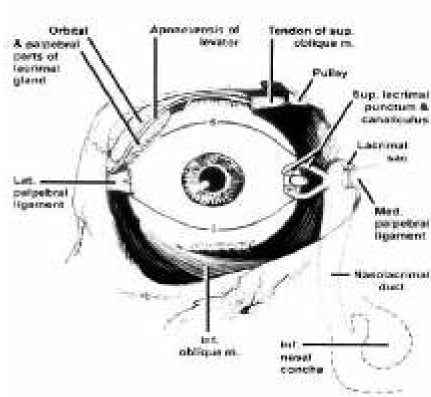

Figure 2: The main lacrimal gland

A. Lacrimal Glands

1. *Main Lacrimal Gland*

Location: lacrimal gland fossa, formed by the orbital plate of frontal bone in the anterolateral part of the roof of the orbit (Fig 2).

Parts: Lacrimal gland is divided into two parts - orbital part and palpebral part – divided by the lateral horn of aponeurosis of levator muscle. Orbital part is larger; nearly 2/3rds of the total lacrimal gland. The palpebral part can be seen on eversion of the lids.

Ducts of the lacrimal gland: 10-12 ducts pass from the lacrimal gland and open into the lateral part of the superior fornix. 1-2 ducts also open into the lateral part of the inferior fornix. All the ducts pass through the palpebral part of the gland. Excision of the palpebral part can destroy the secretory function of the gland.

Structure of the lacrimal gland: The lacrimal gland is a branched tubule alveolar gland (serous acinous gland) similar in structure to the salivary glands (Fig 3). It has an outermost capsule. Microscopically it consists of glandular tissue and stroma. The glandular tissue consists of acini and ducts arranged in lobes and lobules separated by fibrovascular septa. The acini is lined by a single layer of pyramidal cells resting on a basement membrane. The pyramidal cells are serous and secrete the tears. They are surrounded by a layer of flattened myoepithelial cells which contract to expel the tears. The acinar cells are drained by connecting channels which are initially intralobular, then become extralobular and drain into the ducts. The stroma is formed by mesodermal tissue which contains connective tissue, elastic tissue, nerve terminals and blood vessels.

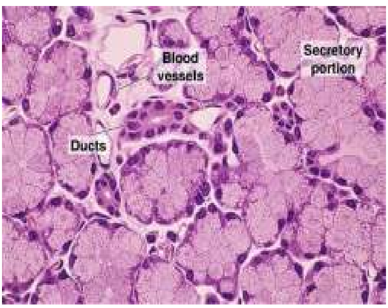

Figure 3: Microscopic structure of the lacrimal gland

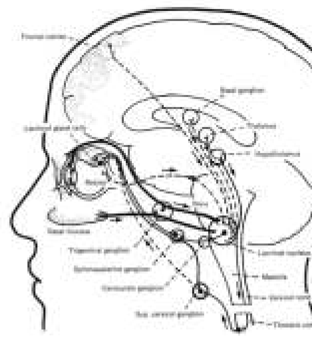

Figure 4: Nerve supply of the lacrimal gland

Blood supply: The main lacrimal gland is supplied by the lacrimal artery, a branch of the ophthalmic artery. The lacrimal veins draining the gland join the ophthalmic vein.

Lymphatic drainage: The drainage is into the pre- auricular lymph nodes.

Nerve supply: Sensory: lacrimal nerve, branch of the ophthalmic division of trigeminal nerve; Sympathetic: carotid plexus of cervical region; Secretomotor: from the superior salivary nucleus (Fig 4)

2. Accessory Lacrimal Glands

These include the
- Glands of Krause
- Glands of Wolfring
- Glands in the caruncle and plica semilunaris

Glands of Krause: there are 40-42 in the upper fornix and 6-8 in the lower fornix. These glands unite to form a long duct which opens in the fornix (Fig 5)

Glands of Wolfring: these are present in the upper border of the superior tarsus (2-5) and lower border of inferior tarsus(2-3)

Rudimentary accessory lacrimal glands are present in the caruncle, plica semilunaris and infraorbital region.

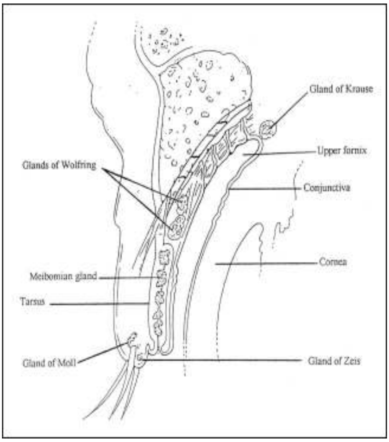

Figure 5: Accessory lacrimal glands

B. Lacrimal Passages

1. *Lacrimal puncta*

The puncta are located at the junction of the ciliary and the lacrimal portion of the lid margin upon a slight elevation called lacrimal papilla. The upper and lower puncta lie about 6 mm and 6.5 mm lateral to the inner canthus. The puncta are directed backwards towards the eye. The puncta are surrounded by a ring of dense fibrous tissue which keeps them patent. With each blink the puncta slide in the groove between the plica semilunaris and the eyeball (Fig 6)

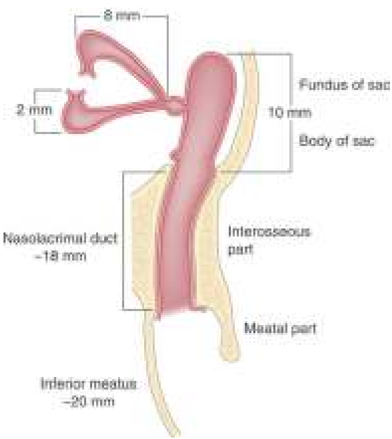

Figure 6: Lacrimal passages

2. *Lacrimal canaliculi*

The canaliculus has two parts, vertical 2mm and horizontal 8 mm which lie at right angles to each other. At the junction of the two is a slight dilatation called the ampulla. The canaliculus pierces the lacrimal fascia separately and then unites to form a common canaliculus which opens in a small diverticulum of the sac called the lacrimal sinus of Maier. The opening lies about 2.5 mm from the apex. The valve of Rosenmuller prevents reflux from the sac to the canaliculus.

Structure

- **Epithelium:** stratified squamous
- **Corium:** rich in elastic tissue, dilatation possible with a probe
- **Fibres of orbicularis:** surround the corium called pars lacrimalis, these draw the lid inwards

3. *Lacrimal sac*

Location: in the lacrimal fossa (Fig 7) formed by the lacrimal bone and the frontal process of the maxilla, bounded by the anterior and posterior lacrimal crests

Lacrimal fascia: the periorbita splits at the posterior lacrimal crest enclosing the sac and unites at the anterior lacrimal crest. Between the sac and the fascia lie the alveolar tissue and venous plexus which continues around the nasolacrimal duct.

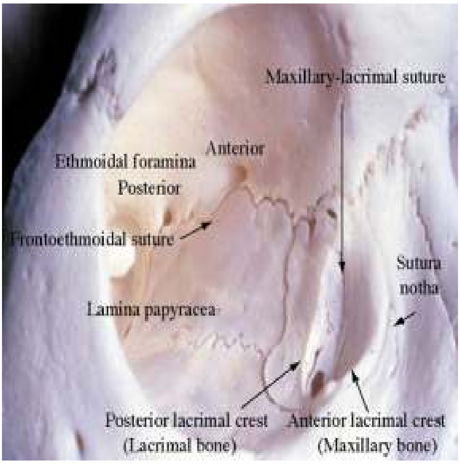

Figure 7: Lacrimal fossa

Dimension: about 15 mm length and 5 mm breadth, capacity 20 cc.

Parts: Fundus – above canalicular opening 3-5 mm, body – 10-12 mm, neck

Relations

- **Medial:** anterior ethmoidal sinus superiorly and middle meatus inferiorly
- **Posterior:** lacrimal fascia, lacrimal fibres of orbicularis, septum orbitale – which separates the sac from the check ligament of the medial rectus
- **Anterolateral:** from anterior to posterior
    - o Skin
    - o Angular vein – located 8 mm from medial canthus, important landmark to avoid bleeding during external DCR surgery
    - o Palpebral fibres of orbicularis
    - o Medial palpebral ligament – covers upper part of sac, due to this resistance abscess will open in the lower part of the sac

- o Lacrimal fibres of orbicularis muscle
- o Lacrimal fascia

4. Nasolacrimal Duct (NLD)

This opens in the inferior meatus of the nose. It is about 18 mm(12-24) in length and 3 mm in diameter. The direction of the NLD is downwards, backwards and laterally. It has 2 parts: an intraosseous part (12.5 mm) and an intrameatal part (5.5 mm). The intraosseous part lies in the nasolacrimal canal formed by the maxilla and the nasal concha. The nasolacrimal canal lies lateral to the middle meatus and lesions in the maxillary sinus often cause epiphora. Intrameatal part of the NLD lies in the mucous membrane of the lateral wall of the nose. The opening of the NLD is situated about 30-40 mm from the anterior nares. The NLD has numerous valves, the most important one is the valve of Hasner which prevents the entry of air in to the lacrimal sac when air is blown out of a closed nose. Canalization of the NLD occurs late in the fetus and in about 30% of infants this is delayed and presents with epiphora and congenital nasolacrimal duct obstruction.

Structure

- Epithelium: superficial layer non-ciliated columnar cells with goblet cells and deep flattened cells
- Subepithelial tissue- lymphocytes
- Fibroelastic tissue- becomes continuous with that of the canaliculi
- Plexus of vessels- engorgement of these can lead to epiphora

Blood supply

- **Arterial:** superior and inferior palpebral arteries (branches of ophthalmic), angular artery, infraorbital artery and nasal branches of sphenopalatine.
- **Venous drainage:** angular vein and infraorbital vein from above and nasal vein from below.
- **Lymphatic drainage:** submandibular and deep cervical nodes

Nerve Supply: Sensory supply by the infratrochlear nerve and anterior superior alveolar nerves.

Evaluation of a Patient with Epiphora

Dr Raksha Rao, Ms Yogita Kadam
Dr Aftab Zaman, Dr Santosh G Honavar

The lacrimal system constitutes structures that are involved in the production and drainage of tears. The main lacrimal gland along with the accessory glands of Krause and Wolfring are responsible for the secretion of the aqueous layer of the tear film. The tear film also comprises two other components, the lipid layer and the mucin layer, and functions to protect the ocular surface from dessication. Periodic blinking helps in an even distribution of the tears in the conjunctival cul-de-sac (lacus lacrimalis), as also in propelling them towards the final excretory pathway. The average tear flow rate is 30 microL/min and a complete recycling of the tear volume of 230 microL occurs over 7 minutes. The lacrimal excretory system is a mucus-lined passage with several components, and the normal drainage of tears is dependent on a coordinated interaction between the anatomical and physiological well-being of these structures. Conditions that cause disruption of this normal mechanism may result in a 'watering eye', also known as epiphora.

Epiphora is a consequence of either excessive production of tears or their inadequate drainage. In other words, symptomatic epiphora results when the tear production overwhelms the normal drainage-this may sometimes occur even in the event of normal tear production and drainage, when there is insufficient evaporation. True epiphora refers to watering due to obstruction in the tear drainage pathway and must be differentiated from pseudoepiphora which is excessive watering due to hyperlacrimation. Epiphora may be classified as anatomical epiphora (obstructive epiphora) or physiological epiphora (non-obstructive epiphora). A thorough understanding of the embryology, anatomy and physiology of the lacrimal drainage system is essential in order to diagnose the pathology of symptomatic tearing.

The lacrimal sac and nasolacrimal duct (NLD) develop as a solid epithelial cord at 5.5 weeks of gestation (Figure 1a and 1b). The cord becomes canalized to form the NLD at 12 weeks of gestation and the superior end dilates to form the lacrimal sac. The membrane at the superior punctum is usually completely canalized at 7 months of gestation when eyelids

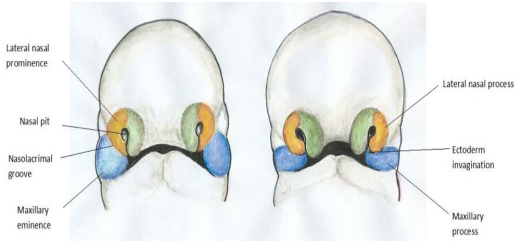

Figure: 1a

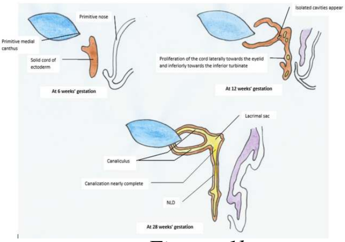

Figure: 1b

Figure 1A and 1B: *Embryological development of the nasolacrimal drainage system*

separate, and is normally patent at birth. In contrast, the inferior membrane frequently persists in the new-born. Developmental abnormalities in this region occurring typically after 4 months of gestation can result in congenital agenesis of any segment of NLD, supernumerary puncta and canaliculi, and lacrimal fistula. The distal end of the NLD often has a membrane, and in about two-thirds of the newborns this remains imperforate at birth. This is the most common cause of congenital NLD obstruction (CNLDO) in children.

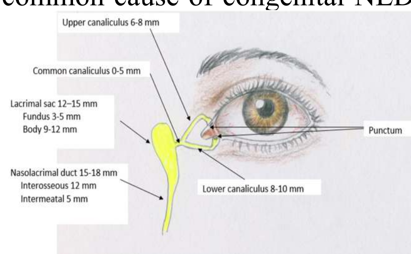

Figure 2: *Anatomy of the nasolacrimal drainage system*

The nasolacrimal system begins at the punctum, located 6 mm lateral to the medial canthus in the upper lid, and 6.5 mm lateral to the medial canthus in the lower lid (Figure 2). The punctal opening is 0.2–0.3 mm in diameter. Each canaliculus begins at the punctum and has two parts-a 2 mm vertical portion and an 8 mm horizontal portion. The internal diameter is around 1 mm and at the junction between these two portions, there is a dilatation called the ampulla that is about 1.5 mm in size. The common canaliculus is formed by the fusion of the upper and lower canaliculi which travels medially to join the lacrimal sac. Just before joining the sac, there is a dilation of the canaliculus called the sinus of Maier, followed by a valve that is formed by an infolding of the canalicular tissue called the valve of Rosenmuller. This valve functions to prevent the regurgitation of tears from the sac. The common canaliculus typically enters the nasolacrimal sac at the level of junction between the upper third and lower twothirds of the sac. The part of the sac that lies above this level, called the fundus, is dilated more than the rest of the sac and measures 4 mm in length. The rest of the sac, known as the body, measures 10 mm in length. The lacrimal sac is located in the lacrimal fossa between the anterior and the posterior lacrimal crests, formed by the frontal process of the maxillary bone and the lacrimal bone respectively.

The nasolacrimal duct begins as an inferior extension of the sac in the nasolacrimal canal located in the frontal portion of the maxillary bone. The nasolacrimal duct runs in a downward, lateral and posterior direction and measures 30-40 mm in an adult. It terminates in the inferior meatus at the valve of Hasner. In children, the inferior turbinate typically closely abuts the lateral wall of the nose but with age, it moves inferiorly and medially, thus creating space for opening of the nasolacrimal duct at the inferior meatus. Sometimes the inferior meatus is fused to the lateral nose causing a bony obstruction.

The flow of tears from the lacus lacrimalis into the NLD is governed by the tone of the orbicularis. Many theories have been proposed in this regard. It has been speculated that at the start of a blink, the canaliculi are filled with tear fluid that entered following the previous blink. As the upper eyelid descends and the lids are half closed, the papillae meet the opposing eyelid margin, which effectively occludes the puncta and prevents fluid regurgitation. Further contraction of orbicularis compresses the canaliculi and sac, causing flow of tears into the nasolacrimal duct. Once the eyelids are completely closed, the lacrimal passages are compressed and largely empty of fluid.

Thus epiphora may result from any pathological process that disturbs the normal physiology or continuity of the lacrimal drainage apparatus (Table 1). The objective of the evaluation is to identify true epiphora from pseudoepiphora, and distinguish between anatomical epiphora and physiological epiphora. It is essential to do a methodical evaluation for a step-by-step identification of the exact site of blockage in the nasolacrimal system (Table 2).

History

A good evaluation begins with a thorough history. The time of onset, laterality and type of discharge should be noted. It is important to ask about the intermittency of epiphora and the severity of the symptoms to get a true picture of the patient's functional problem (Table 3). Epiphora in a child with a history of tearing beginning shortly after birth is indicative of an imperforate Hasner's membrane or less commonly, a bony obstruction. Epiphora due to complete nasolacrimal duct obstruction (NLDO) is usually continuous and associated with intermittent mucoid or purulent discharge. Watery discharge maybe due to allergic conjunctivitis, glaucoma, reflex tearing, non-obstructive epiphora or chronic NLDO with fibrosed sac. A rapidly growing mass or bleeding from the puncta points to the diagnosis of malignancy or an ongoing granulomatous process. Unilateral epiphora is most likely due to anatomical obstruction in the lacrimal system while bilateral tearing may point to conditions like allergic conjunctivitis. History of prior facial trauma, orbital radiation, use of ophthalmic medications, any nasal allergies and previous treatment should be elicited. Any prior intranasal surgeries undertaken should also be noted.

External Examination

Certain facial features offer a clue to the cause of tearing. Epiphora due to abnormal lacrimal drainage system in facial-cleft syndromes (Figure 3A), congenital ectropion in Treacher Collin syndrome and cicatricial ectropion in congenital ichthyosis are certain examples (Figure 3B). Abnormal position of the puncta in Centurion syndrome is an uncommon cause of epiphora in young adults. In Centurion syndrome, there is an abnormal anterior insertion of the medial canthal tendon causing the puncta to be directed away from the tear lake (Figure 3C). The associated facial features include prominent nasal bridge, 'beaking' of the medial canthus and synophrys. Ectropion and lid laxity from facial nerve palsy also lead to epiphora (Figure 3D). Medial ectropion causes the punctum to rotate away from the globe, impairing tear drainage.

Any mass lesion in the caruncle or medial eyelid can block the punctum leading to epiphora. An enlarged caruncle in thyroid eye disease (TED) can

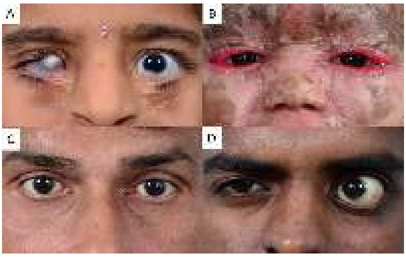

Figure 3: *External examination to look for certain facial features which offer a clue to the diagnosis of tearing. (A) Bilateral facial cleft with bilateral abnormal nasolacrimal drainage system. (B) Bilateral cicatricial ectropion of upper and lower lids due to congenital ichthyosis. (C) Centurion syndrome with bilateral abnormal anterior insertion of medial canthal tendon causing 'beaking' of the medial canthus and non-apposition of the puncta to the globes. (D) Left-sided facial nerve palsy with lid laxity and ectropion.*

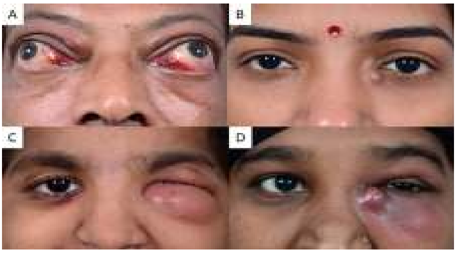

Figure 4: *External examination of ocular adnexa. (A) Bilateral enlarged caruncle in thyroid eye disease causing obstruction of tear flow through the puncta. The patient also has bilateral proptosis which can lead to epiphora by causing reduced space for tears in the conjunctival cul-de-sac. (B) Left-sided mass in the lacrimal sac area below the level of the medial canthus which is indicative of an enlarged sac due to NLDO. (C) Left-sided pre-septal cellulitis in neglected acute dacryocystitis in a child with Down's syndrome. (D) Left-sided acute dacrocystitis which has discharged through a fistula on the skin surface.*

also cause epiphora due to the same reason (Figure 4A). Mass in the lacrimal sac region below the level of medial canthal tendon is indicative of lacrimal sac mucocele due to an obstruction in the distal lacrimal drainage apparatus (Figure 4B). Mass lesion above the level of medial canthal tendon indicates malignancy or a granulomatous condition like tuberculosis, Wegener's granulomatosis (WG) or sarcoidosis. WG is also known to cause bilateral NLDO. A swelling that is hard on palpation is suggestive of a dacryolith. Presence of unilateral telecanthus may point to a swelling arising from ethmoid sinus.

Sometimes patients presenting with pre-septal cellulitis, in fact, have untreated acute dacryocystitis (Figure 4C). Any skin scar from previous surgery or fistulae in the medial canthal area should be noted. Congenital lacrimal fistula is located inferolateral to the canthus and is usually single. It is formed due to the canalization of supernumerary canaliculi and is a very fine opening, without associated scarring or fibrosis. On the other hand, acquired lacrimal fistulae following trauma or a sac infection (Figure 4D) can be situated above or below the canthus and can be multiple. Associated fibrosis and scarring is usually seen around them.

Lid laxity is yet another cause of epiphora. The degree of horizontal lower eyelid laxity is assessed by performing a "distraction" test (Figure 5A), a "snap" test (Figure 5B) and a "pinch" test (Figure 5C). In lid laxity, the patient may complain of epiphora and dye drainage on fluorescein dye disappearance test (FDDT) is delayed, but there is no evidence of punctal or canalicular stenosis or obstruction on syringing or probing (Figure 5D). This is non-obstructive epiphora. Floppy eyelids causes epiphora not only due to lid laxity, but also due to associated corneal epithelial lesions (Figures 5E-F). Lid retraction, proptosis and shallow orbits are other conditions leading to non-obstructive epiphora.

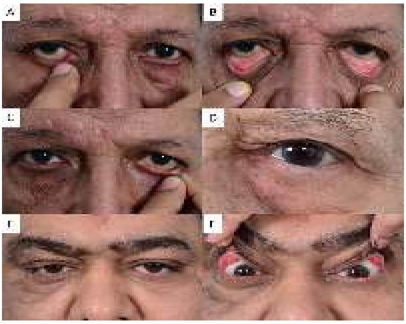

Figure 5: *External examination for lid laxity. (A) 'Distraction test' for theassessment of horizontal lid laxity. (B) 'Snap test' for the assessment of orbicularis tone. (C) 'Pinch test' for the assessment of vertical lid laxity. (D) Raised height of the tear meniscus due to lid laxity and atonic sac. (E) and (F) Demonstration of floppy eyelids in a patient with superficial punctate keratopathy and reflex tearing.*

Slit Lamp Evaluation

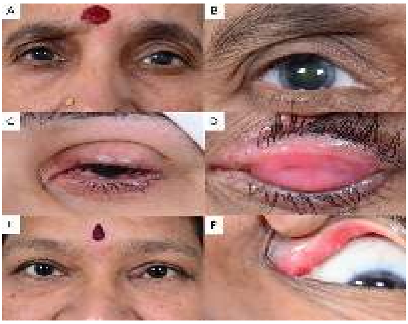

Figure 6: Slit lamp evaluation of the ocular adnexa and external ocular surface. (A) and (B) Bilateral upper lid entropion with secondary trichiasis. (C) and (D) Inflamed ocular surface with trichiasis and marginal keratinization in Steven-Johnson syndrome. (E) and (F) Left-sided upper canaliculitis with pouting of punctum and lid swelling medial to it.

Slit lamp evaluation should follow the external examination in every patient for a detailed assessment of the ocular adnexa and external ocular surface. Trichiatic lashes and entropion with secondary trichiasis cause mechanical corneal stimulation and reflex tearing (Figures 6A-B). Ocular surface abnormalities with symblepharon, entropion, trichiasis or lid margin keratinization can be seen with Stevens–Johnson syndrome (Figures 6C-D). Location, dimension and direction of the puncta are noted. A pouting punctum and a swelling of the eyelid medial to it may indicate canaliculitis, most commonly due to an actinomyces infection (Figures 6E-F). Pressure applied on such a swelling causes expression of cheesy yellow granules. Cicatricial changes like conjunctivitis and chronic blepharitis cause formation of a white ring of fibrosis around the punctum, and punctoplasty is more effective in such cases, as compared to the stenosed punctum without a white cicatricial ring seen in patients using ophthalmic medications like 5-fluorouracil and miotics. These medications cause fibrosis that commonly involves the canaliculi too and treatment by punctoplasty may not be effective. “Kissing puncta” and retained foreign body in the punctum are other unusual conditions leading to epiphora.

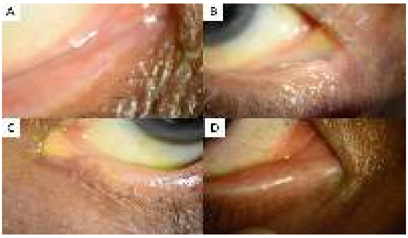

Figure 7: Slit lamp examination revealing different grades of punctal stenosis. (A) Grade 1-Stenosed punctum that is easily dilatable. (B) Grade 2-Stenosed punctum that is not easily dilatable. (C) Grade 3-Stenosed punctum with a shallow papilla. (D) Grade 4-Stenosed punctumwith a flat papilla.

Punctal stenosis should specifically be looked for and graded (Table 4). Easily dilatable puncta (Figure 7A) can be observed, provided contributing conditions like blepharitis and allergic conjunctivitis are treated simultaneously. Three-snip punctoplasty is effective in stenosed punctum which are not easily dilatable (Figure 7B). In eyes with stenosed punctum and shallow papilla (Figure 7C), punctoplasty procedure is extended to involve the horizontal portion of the canaliculus to produce a long slit. In those with a flat papilla (Figure 7D), a canaliculostomy is performed. Supernumerary puncta should be documented (Figure 8A). Conjunctivochalasis is a redundant fold of conjunctiva that can mechanically occlude punctal drainage. Inflammatory conditions of the ocular surface leading to hypersecretion of tears like conjunctivitis should be looked for. A careful assessment of meibomian glands and tear film must be a part of every examination. Blepharitis and dry eye syndrome are the most common causes of a watering eye. Corneal abnormalities (Figure 8B), ocular surface foreign bodies and contact lens wear are other conditions which can lead to reflex tearing. Intraocular inflammations can also cause abnormal tearing.

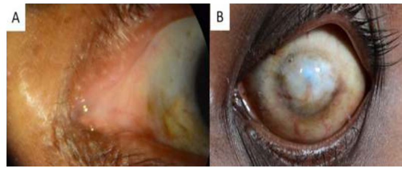

Figure 8: *Slit lamp examination for other causes of epiphora. (A) Supernumerary puncta in the upper lid. This may sometimes be associated with an internal fistula or a diverticulum. (B) Post-traumatic left corneal opacity with irregular corneal surface.*

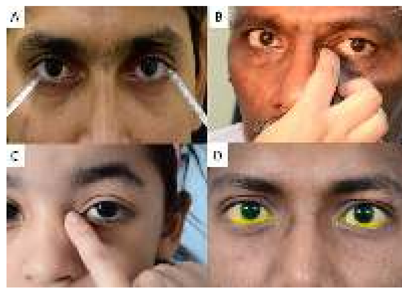

Figure 9: *Clinical tests for the evaluation of epiphora. (A) Schirmer's test which assesses the basal and reflex tear production. (B) ROPLAS in a patient who does not show any regurgitation. (C) ROPLAS in a child who has mucoid regurgitate suggestive of NLDO. (D) FDDT bilaterally positive in a patient who has grade 3 epiphora, and poorly apposed puncta to the globes.*

Schirmer's Tests

Schirmer's test is a simple clinical diagnostic procedure to rule out dry eye and hypersecretion syndromes. It consists of two parts - Schirmer's I test evaluates the gross tear production and Schirmer II the reflex tear production. Schirmer's I uses a strip of #41 Whatman filter paper, 50 mm long and 5 mm wide. A small folded end is placed in the inferior fornix at the junction of the lateral and middle thirds of the lower eyelid (Figure 9A). The amount of wetting on the filter paper is measured at 5 min. Normal values for the Schirmer I test range from 10 to 30 mm at 5 min. Schirmer's II test is performed by instilling a drop of topical anaesthetic into the eye and repeating the same test as above. The amount of wetting is an indicator of reflex tear secretion.

Tear break-up time

The tear break-up time is an important test to assess the mucin component of tear function. A drop of fluorescein is placed in the cul-de-sac and the corneal surface observed with cobalt blue filter on slit lamp. The time taken for the appearance of the first dry spot on the cornea is noted. Normal tear break-up time is between 15 and 30 seconds. A tear break-up time of less than 10 seconds indicates deficiency of mucin, which causes reflex hypersecretion of tears, leading to epiphora.

ROPLAS (Regurgitation On Pressure over the LAcrimal Sac area)

ROPLAS is a simple test to perform. A firm pressure is applied over the sac area and noted for any regurgitation. This must be performed before and after sac syringing to correlate with the findings of sac syringing and reach a diagnosis. ROPLAS maybe positive or negative (Figure 9B). When positive, the type of regurgitate is noted-watery, mucoid, mucopurulent or blood-stained. Clear watery fluid is seen in atonic sac. Reflux of mucoid or mucopurulent material is indicative of NLDO (Figure 9C). Blood-stained discharge is seen in malignancy or dacryolith. Interpretation of ROPLAS findings are as in Table 5 (before sac syringing) and Figure 10 (after sac syringing).

FDDT

The dye disappearance test gives an approximate measurement of the rate of tear flow out of the conjunctival sac. A drop of 2% fluorescein is placed in the cul-de-sac and the amount retained in the eye at 5 minutes is noted. This can be subjectively graded on a scale of 0 to 4+, with 0 representing no dye remaining and 4+ representing all the dye remaining (Figure 9D). When there is no anatomical or physiological abnormality of the lacrimal drainage pathway, there is a complete disappearance of all the dye. The test cannot distinguish anatomical obstruction in the drainage pathway from pump failure, nor can it localize the site of blockage. However, it a useful adjunct in the diagnostic evaluation of the lacrimal system, especially in children with congenital NLDO, who are too young and uncooperative for sac syringing in the office. Sometimes the dye may trickle and a small sheen of fluid maybe visible in the lacrimal sac region which is diagnostic of a lacrimal fistula.

Sac Syringing

Lacrimal sac syringing is the most important procedure in the evaluation of epiphora. Lacrimal irrigation can be performed with the patient reclining in the examination chair. The conjunctiva is anaesthetized with topical anaesthetic drops. A 2 cc glass syringe filled with sterile water (Figure 11A),

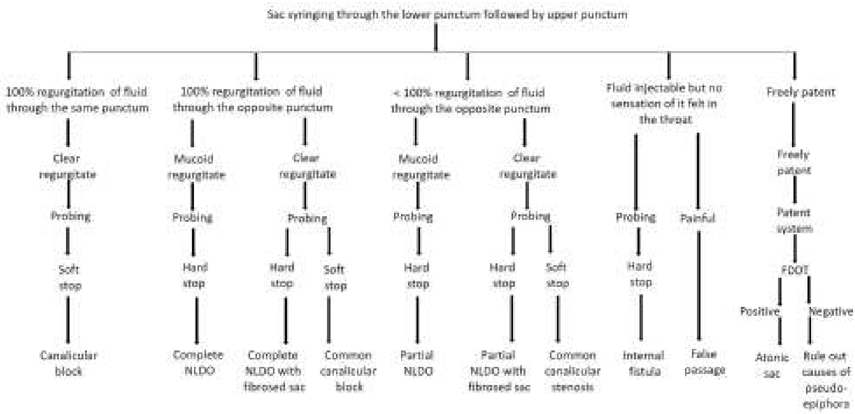

Figure 10: *Systematic interpretation of sac syringing and diagnostic probing*

fitted with a 15° smoothly curved 24G cannula (Figure 11B) is used for the procedure. Before syringing the puncta are dilated, first with a sharp-tipped dilator (Figure 11C) followed by a blunt-tipped dilator (Figure 11D). Patient is asked to look up and with lateral traction on the lower lid, the cannula is inserted into the punctum (Figure 11E) and advanced into the canaliculus till a hard or a soft stop is felt. If a hard stop is felt, the cannula is in the sac lumen against the bony wall of the lacrimal fossa, and intrasac syringing is then performed. Soft stop indicates canalicular obstruction and a gentle attempt to overcome the stenosis is made. If the canalicular resistance cannot be overcome, intracanalicular irrigation is performed. A small amount of fluid is pushed into the system (Figure 11F).

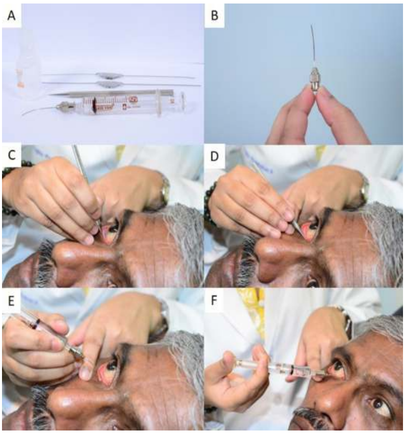

Figure 11: *Lacrimal sac syringing. (A) A 2 cc glass syringe filled with sterile water and fitted with (B) a round-tipped 15° smoothly curved 24G cannula. (C) Punctal dilatation with a sharp-tipped punctal dilator followed by (D) dilatation with a blunt-tipped punctal dilator. (E) and (F) Intrasac syringing through the lower punctum with a gentle lateral traction of the upper lid asthe patientlooks in upgaze.*

Free passage or regurgitation of the fluid is documented. Thesite, amount (in percentage) and type of regurgitation are noted. Patient is then asked to look down, and the same procedure is repeated through the upper punctum. Interpretation of the sac syringing findings are as in Figure 10.

Diagnostic Probing

Probing is indicated when an obstruction is encountered in the lacrimal drainage apparatus at the time of sac syringing. It is useful in the identification of the exact site of blockage. A well-lubricated '0' size Bowman's probe is used for this purpose. Probes smaller than this have a risk of creating a false passage. The probe is passed along the canaliculus in which the obstruction was identified at the time of syringing, or any canaliculus when the obstruction was notedbeyond the common canaliculus. The probe is gently advanced till a hard or a soft stop is felt. A hard stop indicates that the probe has passed beyond the common canaliculus and into the lumen of the sac. A soft stop indicates an obstruction at the level of the canaliculus. Care is taken to avoid a 'false soft stop', which can occur if the probe causes an inadvertent kink in the canaliculus while passing through it. When a soft stop is documented, the distance (in millimetre) of the obstruction from the punctum is noted, which is essential to plan the appropriate surgery. Proximal canalicular obstruction is when resistance is felt at less than 3 mm from the punctum, mid-canalicular obstruction is between 3-8 mm and distal canalicular obstruction is beyond 8 mm. In distal canalicular obstruction, there is a movement of the medial canthus as the probe pushes the canalicular tissue medially. Interpretation of the diagnostic probing is included in Table 6.

Three-probe-test is performed by passing three probes-through both the canaliculi and the fistula. All three probes meet at a common point in congenital fistula. In acquired fistula, the probe passed through the fistula enters the sac lumen and a hard stop is felt.

Endoscopic Nasal Examination

A good nasal examination is essential to rule out the common nasal conditions which cause epiphora, as also impede in the success of a good surgery. The commonly used nasal endoscope for the diagnostic office procedure is a 2.7 mm, 30° endoscope. This provides a good view of the lateral nasal wall.The health of the mucosa is assessed as significantly hypertrophied mucosa can cause blockage of the lower end of NLD. Presence of any nasal pathology including nasal polyps and anatomical variation of nasal structures are documented.

Darcyocystography (DCG)

Dacryocystography is an anatomical investigation and is indicated in complex cases to localize the exact site of blockage in the lacrimal apparatus. It is indicated in multiple failed surgeries, post-traumatic epiphora and suspicious lacrimal sac tumors. It is done at a radiology service, and uses a radio-opaque water-soluble fluid. The DCG is performed in the supine position under topical anesthesia, and the procedure for injecting the dye into the lacrimal apparatus is same as that for sac syringing, with the syringe containing the water-soluble contrast medium. Once the contrast is injected into the canaliculus, films are taken and visualized by the digital subtraction technique. DCG evaluates the lacrimal sac and duct anatomy well, however, the canaliculi are not visualized accurately.

Dacryoscintigraphy

Nuclear lacrimal scintigraphy is a non-invasive physiological test for the evaluation of the lacrimal system. This is performed at a nuclear medicine service and uses a radiotracer, which can be detected with a gamma camera. Scintigraphy is useful in studying tear dynamics, and its main use is in the evaluation and confirmation of lacrimal pump dysfunction. A drop of technetium-99m is instilled into each conjunctival sac of a patient sitting in front of a gamma camera and images recorded at frequent intervals. Anatomical details are not clearly visualized, but the transit time for the passage of the dye from the canaliculi to the nasal cavity is an indicator of the physiological health of the lacrimal system.

Computed Tomography (CT) and CT-DCG

The lacrimal system is closely associated with many orbital and facial bones. CT is a very useful diagnostic modality in the assessment of the lacrimal anatomy in relation to the surrounding bones in facial trauma and suspected malignancies. CT-DCG is a relatively new technique which uses a water-soluble radio-opaque dye. In an unpublished comparative case series of 21 patients, we used the technique of 'Drop-CT-DCG' for the evaluation of the lacrimal system. This included normal controls (10) (Figure 12A), and complex cases of lacrimal sac fistula (2) (Figure 12B),

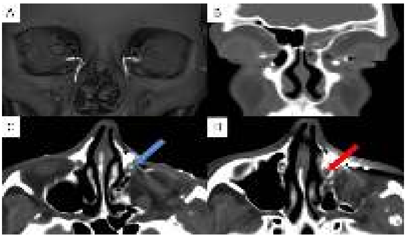

Figure 12: *CT-DCG done at a radiology service. (A) Bilaterally patent lacrimal system in a patient with normal nasolacrimal system. (B) Bilateral congenital lacrimal fistula (not evident on the image) with patent NLD in the right eye and distal NLDO in the left eye. (C)Proximal and (D)distal axial cuts in a patient with left-sided repaired orbital floor fracture. Right NLD is patent, while left nasolacrimal system shows dye filling the lacrimal sac (blue arrow) and no dye in the distal NLD (red arrow) suggestive of NLDO.*

malignancy of the lacrimal sac (2), facial trauma (3) (Figures 12 C-D), encysted mucocele (1), dacryocystocele (4) and a patient uncooperative for sac syringing (1). In this imaging technique, a drop of Iodixanol dye is instilled in the conjunctival cul-de-sac (diluted with sterile water in the ratio 1:1 to a concentration of 135 mg/mL), and serial films taken. We obtained 100% correlation between the CT-DCG readings and intra-operative findings in all 10 patients who underwent surgery. The authors emphasize its usefulness in all inconclusive and complex cases of obstructive epiphora.

Magnetic Resonance Imaging (MRI) and MR-DCG

MRI and MR-DCG are not routinely used for lacrimaldiagnostics and maybe indicated in certain cases requiring very fine resolution of the soft tissue structures.

Conclusion : Watering is one of the most common complaints encountered in the clinic. When evaluating a patient with watering, it is essential to perform a methodical examination to differentiate true epiphora from pseudoepiphora. All cases of obstructive epiphora require a careful identification of the exact site of blockage to plan the subsequent management. Ancillary diagnostic tests like DCG, lacrimal scintigraphy, CT and MRI are not regularly done, and indicated only in complex cases of epiphora. With an accurate diagnosis, the management options can be narrowed down and an appropriate surgery undertaken to achieve maximal patient satisfaction and avoid post-operative surprises.

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Tables:

Table 1: Etiology of Epiphora

Pseudoepiphora	**Anatomical (Obstructive) Epiphora**	
(I) Lacrimal gland hypersecretion A. Supranuclear etiology: Emotional distress CNS disorders B. Infranuclear etiology: Aberrant regeneration. Cerebellopontine angle tumor C. Direct LG stimulation: Inflammation Tumor (II) Disorders of eyelashes Trichiasis Distichiasis (III) Disorder of lids Epiblepharon Meibomian gland dysfunction Entropion Infrequent blinking Floppy eyelid syndrome (IV) Disorders of ocular surface Tear film abnormality Contact lens wear Corneal abrasions Corneal epithelial defect Keratitis Conjunctivochalasis	(I)Punctal abnormalities A. Congenital: Agenesis Atresia Supernumerary puncta Lacrimal fistula B. Acquired: Trauma Chronic conjunctivitis Inflammatory conditions such SJS Topical medications like pilocarpine Radiation Chemotherapeutic agents Ectropion (II) Canalicular abnormalities 5. Congenital: Agenesis Atresia Supernumerary puncta with canaliculus B. Acquired: Canaliculitis Chronic blepharitis Inflammatory conditions such as SJS Radiation Topical medications Chemotherapeutic agents Ectropion	(III) Lacrimal sac pathology: Congenital Dacryocystocele Dacryocysitis Dacryolith Granulomas Neoplasia (IV) Nasolacrimal duct obstruction: Congenital Involutional Trauma Foreign body Neoplasia (V) Nasal disease: Allergy / polyps Chronic Sinusitis Neoplasia **Physiological (Non-obstructive) Epiphora** Orbicularis oculi weakness Sac atonicity Eyelid laxity Eyelid retraction

Table 2: Evaluation of Epiphora

History
External adnexal examination
Slitlamp examination
Evaluation of the tear film
- Schirmer's test
- Tear break-up time

Evaluation of the lacrimal system
- ROPLAS
- FDDT
- Sac syringing
- Diagnostic probing
- Endoscopic nasal examination

Imaging
- Dacryocystography
- Dacryoscintigraphy
- CT and CT-DCG
- MRI and MR-DCG

Table 3: Evaluation of Epiphora

Grade 1	:	Intermittent clear discharge, not causing functional problem to the patient
Grade 2	:	Continuous clear discharge, not causing functional problem to the patient
Grade 3	:	Continuous and copious clear discharge, causing blurred vision and/or skin excoriation and/or requiring constant wiping
Grade 4	:	Mucoid or mucopurulent discharge

Table 4: Grades of Punctal stenosis

Structural variation		
Type 1	:	Membrabnous block
Type 2	:	Peripunctal fibrosis
Type 3	:	Combined membranous block and peripunctal fibrosis
Functional variation		
Grade 1	:	Narrow punctum, but easily dilatable
Grade 2	:	Narrow punctum, not easily dilatable
Grade 3	:	Closed punctum with shallow punctal papilla
Grade 4	:	Closed punctum with flat punctal papilla

Table 5: Interpretation of ROPLAS

Clear, mucoid, or mucopurulent regurgitate	Nasolacrimal duct obstruction
Blood-tinged regurgitate	Dacryolith/lacrimal sac tumor/ granuloma
No regurgitate, but the distended sac empties into the nose	Atonic sac/diverticulum/internal fistula/partial NLDO
No regurgitate, and the distended sac does not empty into the nose	Encysted mucocele

External Dacryocystorhinostomy Tips and Tricks

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Hyderabad

1. Introduction

Dacryocystorhinostomy or DCR is the commonest oculoplastics surgery performed. It is a bypass procedure that creates an anatomosis between the lacrimal sac and the nasal mucosa via a bony ostium. It may be performed through an external skin incision or intranasally with or without endoscopic visualization. This article will discuss the indications, goals and simple techniques for a successful outcome of an external DCR.

2. Goals of Surgery

There are two clear goals of DCR procedure. One is to make a large bony ostium into the nose and that remains so. Secondly to have a mucosal lined anastomosis. Since both these purposes are well served by an external route, it is a preferred approach by many surgoeons with high success rates.

3. Indications

a) Persistent Congenital lacrimal duct obstructions unresponsive to previous therapies.
b) Primary acquired nasolacrimal duct obstructions (PANDO).[1]
c) Secondary acquired nasolacrimal duct obstructions (SALDO).[2]

4. Preoperative Requisites

a) Confirmation of the diagnosis and clinical findings.
b) Hemoglobin levels.
c) Bleeding and clotting times.
d) Blood pressure measurement.
e) Random blood sugars.
f) Additional general anesthesia investigations when required.

Fig 1: Pre-operative nasal packing.

5. Surgical Steps

5.1 Anaesthesia

The surgery can be done under general anesthesia or local anesthesia.[3] The latter is most commonly employed modality. Local anesthesia is given by both infiltration as well as topical application. For infiltration 2% lignocaine with 0.5% Bupivacaine with or without adrenaline is used. Infratrochlear nerve that supplies the lacrimal apparatus is blocked first. The non-dominant hand marks the supraorbital notch and the needle is inserted into the lateral edge of the medial third of the eyebrow and advanced to just medial to medial canthus and 2cc of the drug injected. The anterior lacrimal crest is infiltration subcutaneously and the needle enters deeper at about 3 mm medial to medial canthus, and without withdrawing the needle the drug is injected into deeper tissues upto periostium both superiorly and inferiorly. A drop of topical propracaine is placed in conjunctival cul de sac for intraoperative comfort. Nasal mucosa is sprayed with 10% lignocaine 1-2 puffs followed by packing with 4% lignocaine. The forceps should guide the pack from the external nare superiorly and backwards so that it reaches the middle meatus, the site of ostium opening.

Fig 2: *A typical curvilinear incision*

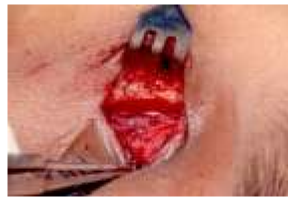

Fig 3: *Sac dissected laterally to expose the bony lacrimal fossa*

Fig 4: *Kerrison punch being used to create a bony ostium*

Fig 5: *A large bony osteum exposing the nasal mucosa*

Fig 6: Lacrimal sac incision being taken by a 11 number blade using the probe as a guide

5.2 Incision

Though various incisions have been described, the authors prefer the commonly used curvilinear incision of about 10-12 mm in length, 3-4 mm from the medial canthus along the anterior lacrimal crest.

5.3 Dissection of the Lacrimal Sac

Blunt dissection is carried on to reach the periostium. A Freer's elevator is used to separate the periostium from the bone and reflect it laterally along with the lacrimal sac to expose the lacrimal fossa. All efforts should be made to preserve the medial canthal tendon and dissected only when needed.

5.4 Bone Osteum

Once the lacrimal fossa is exposed, bony punching should be started at the junction of lamina paparycea of the ethmoid and lacrimal bone. The Kerrison bone punch should be gently inserted between the bone and the nasal mucosa and the ostium sequentially enlarged. The extent of the ostium which the authors follow is:

a) Anteriorly till the punch cannot be inserted between the bone and the nasal mucosa.
b) Posteriorly till the posterior extent of the lacrimal sac.
c) Superiorly till 2 mm above the medial canthus.
d) Inferiorly till the superior portion of nasolacrimal duct is partially de-roofed.

5.5 Flap Formation

The first step is to create sac flaps. To do this a Bowman's probe is passed through the lower punctum and bent in such a way to tent the sac as posterior as possible to create a large anterior and small posterior flap. Using the probe as guide a 'H' shaped incision is made with the help of a number 11 or 15 blade right across the sac from the fundus to the nasolacrimal duct. Flaps are raised and the posterior one is cut.

The second step is to fashion nasal mucosal flaps. With the help of number 11 blade incisions are made in the nasal mucosa along the bony ostium except superiorly to have a superior-hinged flap. The large anterior flap is raised and the posterior small residual flap is cut.

5.6 Flap Anastamosis

It is important to appose nasal mucosal and sac flap edge to edge. Excess nasal mucosa can be excised in a controlled manner so as to avoid sagging of the flaps which may compromise the tear drainage later.

5.7 Wound Closure

Once flaps are secured, the orbicularis is sutured back with 6-0 Vicryl followed by skin with 6-0 silk.

Fig 7: *Raising a large nasal mucosal flap*

Fig 8: *Intubation: Upper canaliculi intubated. The bodkins are being retrieved by a transnasal artery forceps.*

Fig 9: *Intubation: Tubes in place before flap anastomosis*

Fig 10: *Intubation: Tubes being secured in the nose*

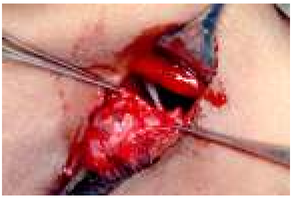

Fig 11: *Taut flap anastomosis*

5.8 Tips for Hemostasis

a) Good preoperative assessment to rule out bleeding diathesis.
b) Preoperative blood pressure assessment.
c) Use of adrenaline along with local anesthetics provided there is no medical contraindication.
d) Good nasal packing and nasal decongestion right in the beginning.
e) Raising the head end of the table.
f) Avoid known blood vessels.
g) Well powered suction.
h) Judicious use of cautery.
i) Keep materials like gel foam or bone wax in the armamentarium.

5.9 Adjunctive Measures (Use of Mitomycin C and Intubation)

Mitomycin C in a concentration of 0.02% is used if there are intra-sac synechiae, soft tissue scarring like in failed DCR's and in the presence of complicated surgery. Intubation is also advisable for similar indications but in addition it is also used in the presence of canalicular problems and inadequate flaps.[4]

5.10 Immediate Post-operative Steps

Once wound is closed, reassure the patient that the surgery went fine. Place a fresh nasal pack. It is important to note that the purpose of this pack is for hemostasis only so deeper packing like preoperative one should be avoided for it risks damaging the flaps. Eye is patched and the patient is initiated on oral antibiotics and analgesics.

6. Post-operative Follow-up

After the surgery patient is seen on the first post-operative day. The nasal pack is gently removed and hemostasis assessed. The wounds are cleaned with 5% betadine, syringing to assess the patency and the patient is discharged on oral

Fig 12: *Sutured surgical wound and post-operative nasal packing*

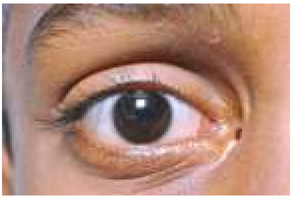

Fig 13: *Complication: Wound dehiscence*

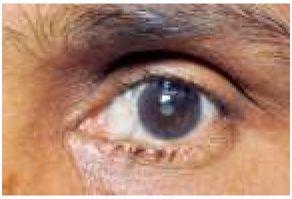

Fig 14: *Complication: Mild stent prolapse*

Fig 15: *Complication: Endoscopic view of a rapid scarring in early post-operative period*

Fig 16: *Complication: Punctal cheesewiring*

antibiotics and analgesics, topical antibiotics and steroids, nasal decongestants and steroid nasal sprays. One week postoperative the sutures are removed, oral medications discontinued, topical steroids are tapered and nasal medications continued for two more weeks. The patient is reviewed at 4 weeks for tube removal if intubated and further at 12 weeks for a final ostium evaluation.

7. Complications

Complications following DCR surgery can be divided as early (1-4 weeks), intermediate (1-3 months) and late (> 3 months).[3] Early complications include wound dehiscence, wound infection, tube displacement, excessive rhinostomy scarring and intranasal synechiae. Intermediate complications include granulomas at the rhinostomy site, tube displacements, intranasal synechiae, punctual cheese-wiring, prominent facial scar and non-functional DCR.

Late complications include rhinostomy fibrosis, webbed facial scar, medial canthal distortion and failed DCR.

8. Results of External DCR

A successful DCR is a one where there is both anatomical as well as functional patency. The passage should be patent on irrigation and the patient should be free of symptoms. The reported success rates of external DCR in literature varies between 85%-95%.[5-8] These rates are comparable to endoscopic DCR's and much higher as compared to a transcanalicular approach.

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Powered Endoscopic Dacryocystorhinostomy

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Introduction

Endoscopic endonasal dacryocystorhinostomy has gained a considerable popularity in the recent two decades with the advent of the rigid fiber optic endoscope.[1,2] There are numerous advantages of endoscopic dacryocystorhinostomy (DCR) and include, no facial incision, no disruption of the medial canthal tendon, no disruption of the lacrimal pump, less traumatic, feasibility in acute dacryocystitis etc.[1,2] Recent published meta-analysis have revealed comparable results with external DCR with lesser risks of infection and bleeding.[3] Powered Endoscopic DCR as described by Wormald et al is a technique that allows creation of largest possible osteotomy and complete sac marsupialization and hence achieve high success rates comparable to that of external DCR.[4-5] This chapter describes the set up needed, surgical techniques, advantages and outcomes of powered endoscopic DCR.

Instrumentation

The author uses Image 1 HD viewing system with xenon light source and 0 and 30 degree, 2.7 (pediatric) or 4 mm (adult) telescopes(Karl Storz, Tutlingen, Germany) (**Fig 1**). Occasionally, self-irrigating telescopes (**Fig 2**) are used by the authors in cases of lacrimal abscess, acute dacryocystitis or conditions which predispose to a little more bleeding than usual. The powered instrument consists of a console, hand piece with specifically designed diamond burrs of various sizes and angulations (Medtronic Xomed, Jacksonville, FL, USA) (**Fig 3**).

Fig 1: *Major instrumentation for a powered endoscopic DCR*

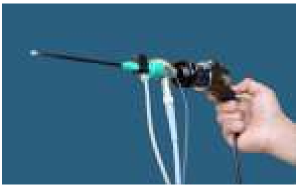

Fig 2: *Self-irrigating telescopes*

Fig 3: *The Medtronic console*

Surgical Technique

Preparation and Anesthesia

Powered endoscopic DCR may be performed under either general anesthesia or local anesthesia. The author prefers general anesthesia. The middle turbinate, axilla and adjacent lateral wall are infiltrated with 2% xylocaine with 1:60,000 adrenaline (**Fig 4**) and followed by nasal packing with ribbon gauze or preferably neurosurgical patties (**Fig 5**). The patties are medicated with 0.05% (adults) or 0.025% (pediatric) xylometazoline. It is best to leave the patties for at least 8-10 minutes for good decongestion. With the patient in supine position, patients' head should be slightly elevated and neck slightly extended so as to facilitate superior osteotomy.

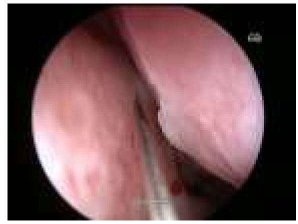

Fig 4: *Local infiltration*

Fig 5: *Topical decongestion*

Fashioning the nasal mucosa flaps

A number 15 blade or sickle knife or a radiofrequency device (**Fig 6**) is used to make the incision over the lateral nasal mucosa down to the periosteum in front of the maxillary line (**Fig 7**). The first horizontal incision of 12-15 mm length is made 10 mm above the axilla of the middle turbinate (**Fig 8**). The vertical incision begins from the anterior end of the horizontal incision and ends at of about two-thirds of the vertical height of the middle turbinate (**Fig 9**). A horizontal incision is then made at right-angle at the inferior end of the vertical incision until reaching the maxillary line, just short of uncinate process. A Freer periosteal elevator is then used to elevate the mucoperiosteal flap, baring the underlying bone (**Fig 10**) and is then tucked around the axilla of middle turbinate to keep it out of the operating field.

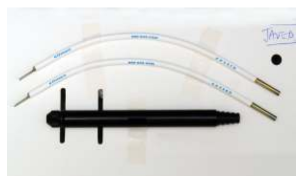

Fig 6: *Endoscopic Radiofrequency incision blades*

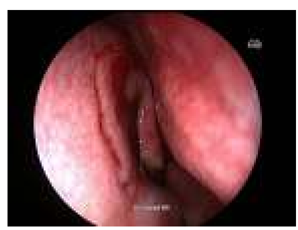

Fig 7: *A decongested nasal cavity with surfacemarkings of the incision*

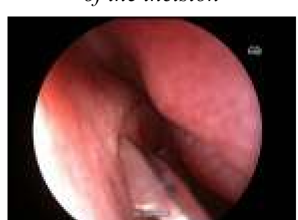

Fig 8: *Superior horizontal incision*

Osteotomy

Once exposure of the frontal process of maxilla and its junction with lacrimal bone is achieved, a small round knife is then used to remove the thin lacrimal bone from the sac before using a Hajek-Kopfler forward punch (Karl Storz, Tuttlingen, Germany) to remove the remaining bone covering nasolacrimal duct and frontal process of maxilla. Once the bone becomes thick superiorly and is not amenable to punch removal above the axilla of the middle turbinate, a curved 25^0 high speed diamond DCR burr (Medtronic Xomed, Jacksonville, FL, USA) is used to remove the rest of the bone to expose the sac completely. All bones over the lacrimal sac fundus and common canaliculus opening should be removed. Superoanteriorly, the osteotomy should extend till orbicularis oculi muscle is just exposed and superoposteriorly, the agger nasi air cells or operculum of the middle turbinate is entered to ensure full fundus exposure (**Figs 11-13**).

Fig 9: *Anterior vertical incision*

Fig 10: *Elevation of the mucoperiostium flap*

Fig 11: *Powered osteotomy*

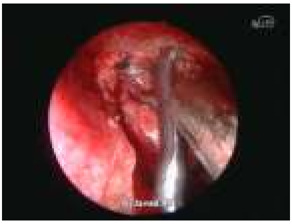

Fig 12: *Superior powered osteotomy*

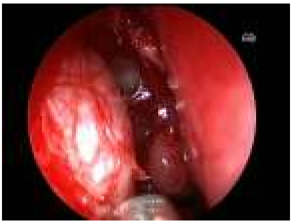

Fig 13: *Complete exposure of the sac*

Fashioning lacrimal sac flaps

The author prefers filling the lacrimal sac with fluorescein stained viscoelastic since this not only dilates the lacrimal canaliculi and sac (**Fig 14**), but also protects the lateral wall of sac and internal common opening from inadvertent trauma. The Bowman probe is passed through the upper canaliculus and is held horizontally tenting the medial wall of the lacrimal sac (**Fig 15**).

A crescent or DCR spear knife is used to make a vertical incision along the entire length of the lacrimal sac from the fundus down to the nasolacrimal duct (**Fig 15**). An "I" or "Y" shaped-incision is then completed with upper and lower horizontal releasing cuts at the top and the bottom using a sickle or spear knife (**Fig 16**). The lacrimal sac is then completely marsupialized and both the anterior and posterior sac flaps are laid opened and flat like an open book on the lateral nasal wall (**Fig 17**).

Fig 14: Tenting of sac with the probe

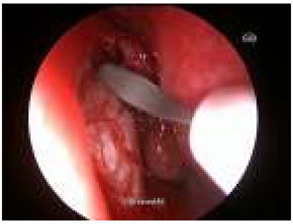

Fig 15: Crescent blade for sac marsupialization

Edge to Edge Mucosal Apposition

Once both the nasal mucosal and lacrimal sacs are fashioned, an edge to edge approximation is performed so as to achieve healing by primary intention. A ball probe is useful to spread open the lacrimal sac flaps. No bare bone should be left behind since that may incite granulation tissue. The anterior flap should be in contact with the anterior cut end of the nasal mucosa whereas the posterior flap should lie back flat in apposition with the agger nasi mucosa (**Fig 18**).

Fig 16: H shaped sac incision

Hemostasis

A correctly done endoscopic DCR rarely would have hemostasis issues! When needed it can be achieved with Merocel nasal packing (**Fig 19**), cold saline irrigation, head-up position or judicious bipolar cautery of the bleeding mucosal edges . Small piece of surgicel (absorbable hemostat, oxidized cellulose polymer) gauze can be left at the end of the surgery to maintain hemostasis.

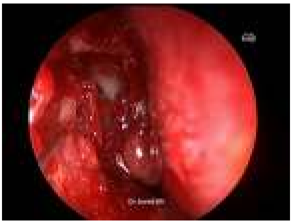

Fig 17: Completed sac marsupialization

Adjunctive Modalities

The use of silicone intubation and Mitomycin C (MMC) is controversial without concrete proof of benefit or harm. For their endoscopic DCR's, the author prefers using intubation for 4 weeks and circumostial MMC as per protocols described in literature (**Figs 20** and **21**).[6,7]

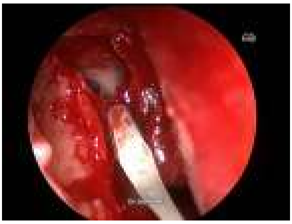

Fig 18: 360 degree mucosa-to mucosa apposition

Post-operative Management

Postoperatively, broad-spectrum oral antibiotics, nasal decongestants, and steroid-antibiotic eye-drops are prescribed. Patients are instructed to perform nasal douching to remove crusts and improve mucosal healing. The follow up of the patient is at 4 weeks for stent removal and further follow up only if needed.

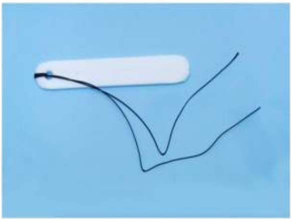

Fig 19: *Merocel pack*

Advantages of Powered Endoscopic DCR

- Easy Osteotomy
- Easy Superior osteoplasty
- Minimal heat / No necrosis
- Minimizes bleeding
- Quicker surgery
- Low Surgeon Fatigue

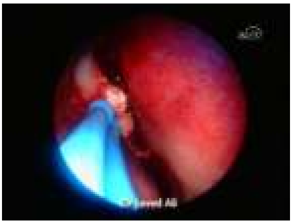

Fig 20: *Adjunctive MMC use*

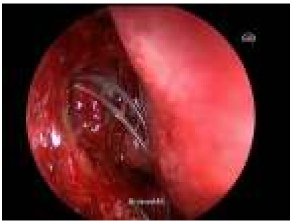

Fig 21: *Adjunctive silicone intubation*

Outcome

The outcomes of powered endoscopic DCR both in short term and long term are comparable to external DCR, both for primary as well as revision cases.[8-10] Ali MJ et al[8] studied the outcomes in 283 powered endoscopic DCR's performed over an 11 year period. At a mean follow up of 17.1 months, anatomical success was achieved in 96.9% of primary cases and 91.3% of the revision cases. The same group looked at long term outcomes of powered endoscopic DCR in primary and revision cases. At a mean follow up of 21.8 months (range: 12-103 months), anatomical success was achieved in 97.7% and functional success in 95.5% of the primary cases.[9] In their series on revision DCR's, the authors found that at a mean follow up of 26.4 months (range: 12-66 months), anatomical success and functional success were recorded as 91.3% and 86,9% respectively.[10] When comparison was performed between the trainees and the consultants, it was noted that at a mean follow up of 14.2 months, the consultants achieved anatomical success rate of 98.1% and a functional success rates 95.6%.[11] The patients operated by trainees had a mean follow up of 10.9 months with 95% achieving an anatomical success and 89% functional success. When compared there was no statistically significant difference between the two groups (p=0.3) reflecting a point that these skills could be transferred effectively to the trainees.[11]

Ali MJ et al[12] also studied the behaviours of the Powered endoscopic DCR ostia beyond 4 weeks up to 2 years by serial endoscopic monitoring and showed that the ostia remained stable and there was no statistically significant difference either in size or area of the ostia. This partly reflects on the techniques used by the authors, where a 360 degree mucosa-mucosa apposition promotes healing by primary intention and reduces the shrinkage of the ostia.

Conclusion

In conclusion, the outcomes of both the primary and revision powered endoscopic DCR are comparable with the best of external DCR. A good knowledge of intranasal anatomy, meticulous surgical techniques and lower threshold for performing adjunctive endonasal procedures where indicated could yield excellent results with powered endoscopic DCR that are maintained over a long period of time.

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Non-endoscopic Endonasal Dacryocystorhinostomy

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1. Introduction

The standard surgery for acquired and refractory congenital nasolacrimal duct obstruction is dacryocystorhinostomy (DCR), in which an ostium is created between the lacrimal sac and the nasal cavity. While an external approach has been the gold standard approach for over a century, in the past twenty five years, endonasal approaches have become increasingly popular with success rates of 90% or better, rivalling those of the cutaneous approaches.[1]

Early descriptions of the endonasal procedure involved use of lasers and mechanical drills that were expensive to purchase and maintain, and had prolonged set-up times with many safety precautions. When lasers are used, char generated at the ostium site requires extensive post-operative debridement.[2]

This chapter reviews an endonasal technique first described in 2003[1] that avoids the need for expensive lasers, ultrasound or mechanical drills, and depends on direct visualisation rather than video-endoscopy (Table 1).

Table 1: Comparision of Endonasal DCR with and without Endoscopy or Laser

	Endonasal DCR With Endoscope/Laser	Endonasal DCR Without Endoscope/Laser
Equipment	Expensive Endoscope and/or Laser units; safety measures required for Laser	Inexpensive instruments – Halogen/LED light source and 20-23G Endoilluminator
Technique	Steeper learning curve: requires endoscopy training	Easier to learn ; lacrimal sac transillumination makes procedure easier for a novice surgeon
Follow-ups	Frequent nasal lavage when laser used	Required only at time of stent removal
Portability of instruments	Difficult to transport bulky equipment	Equipment transportable and suited for remote clinics
Operation cost	Higher because of expensive equipment and consumables	No expensive equipment or consumables

2. Surgical Technique

(i) *Preoperative Evaluation*:

The preoperative evaluation prior to non-endoscopic endonasal DCR includes diagnosis of the site of blockage (usually by irrigation of the lacrimal outflow system and assessment for canalicular stenosis), inspection of the ipsilateral nasal cavity to assess for pathology or an unusually narrow nasal passage, and identification of lid malposition or facial weakness as other contributors of epiphora. The use of anticoagulants should be determined and preferably discontinued a few days prior to the surgery, with permission from the prescribing physician.[1,3]

(ii) *Operative Technique*:[1,3]

The surgery may be performed under local or general anesthesia, although the procedure is sufficiently brief that general anesthesia is well tolerated and facilitates learning. The nasal mucosa on the lateral wall anterior to the middle turbinate is injected with lidocaine with 1/100,000 adrenaline and nasal paddies soaked in cocaine 4% or xylometazoline aids hemostasis. The anesthesiologist may help hemostasis intraoperatively by maintaining a low blood pressure. During the procedure, the surgeon must avoid unnecessary trauma to the nasal mucosa distant from the site injected with epinephrine. In general, peri-operative antibiotics are unnecessary unless a concurrent cellulitis is present.

The 20 to 25-gauge disposable vitrectomy endoilluminator is placed through the upper canaliculus until it touches the bony medial wall of the lacrimal sac. The surgeon sits on the patient's side opposite to the operated side and directly views the transillumination target using surgical loupes and a nasal speculum with 5 cm blades (figures 1A). A simple set of surgical instruments needed for the procedure are shown in figure 1B and includes a light source. The endoilluminator is the only light source, thus

Figure 1. (a) Photograph showing the position of the surgeon on the side opposite of the operated side with surgical loupes. The transillumination of the lacrimal sac shows through the skin; (b) Surgical instruments used in nonendoscopic endonasal dacryocystorhinostomy - (left to right) nasal speculum with 5 cm long blades and side lock, 23G endoilluminator, Nettleship punctum dilator, lens spatula, Freer periosteal elevator, cotton tipped applicator, myringotomy sickle knife, Weill-Blakesley forceps, Kerrison rotating ronguers(3 and 2 mm). Inset - halogen light source.

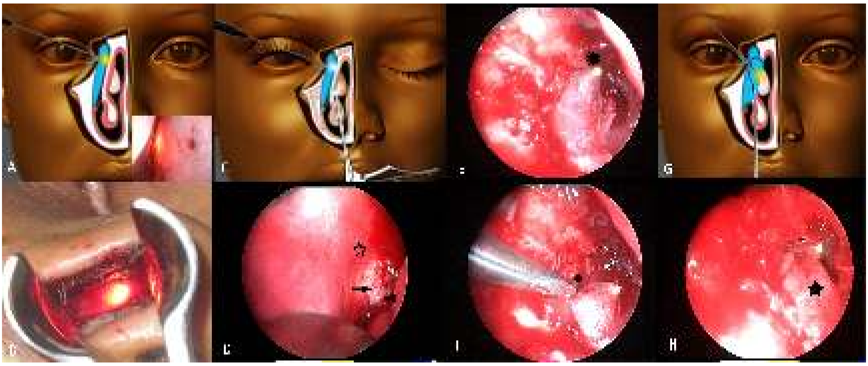

Figure 2. *(A) A graphical image showing the transillumination of the lacrimal sac with the endoilluminator touching the medial wall of the nasal cavity to give a hard-stop and (inset) the glow in the lateral wall of the nasal cavity; (B) A nasal speculum with 5 cm long blades and a side lock (guard) is used for exposure of the surgical site which shows the transillumination of the lacrimal sac (C)Graphical image showing the bony ostium being made with the Kerrison rongeur; (D) Endoscopic view showing the edge of nasal mucosa (hollow star), edge of the partially done bony ostium (arrow) and the lacrimal sac mucosa showing through the ostium (arrowhead) (E) Endoscopic view shows the large bony ostium and tenting the lacrimal sac with the endoilluminor (asterisk); (F) Endoscopic and graphical representation of the incision on the lacrimal sac wall with a myringotomy sickle knife with inside of the lacrimal sac seen (diamond); (H) Endoscopic view shows a large posteriorly hinged flap of the lacrimal sac (asterisk) and endoilluminator emanating from the common internal punctum.*

providing valuable information about the thickness of overlying bone and tissue (figure 2A-B).

A speculum with a side lock can be balanced across the face oriented with the blades pressed against the tip and base of the nostril. A myringotomy sickle knife or a bent disposable cataract crescent blade is used to incise an ellipse of nasal mucosa down to bone 8-10 mm in length centered over the transillumination target. This is typically centered over the maxillary ridge which extends above the base of the inferior turbinate, lateral to the anterior lip of the middle turbinate. A Cottle periosteal elevator strips the mucosa towards the centre of the ellipse from the underlying bone. The mucosa is then peeled free using a straight Weil-Blakesley ethmoid forceps.

The underlying bone at the osteotomy site usually has a vertical ridge – the internal portion of the frontal process of the maxilla. The tip of a 3 mm right-angled up-biting Ruggles rongeur is slipped behind this ridge of bone, out fracturing the thin lacrimal bone overlying the posterior portion of the lacrimal sac. The bone is nibbled away anteriorly through the thicker maxillary bone and then superiorly (figure 2C-D). The bone widens superiorly but sufficient bone is rongeured to allow the end of the light pipe to indent the lacrimal sac mucosa when held horizontally within the superior canaliculus (figure 2E).

Marsupializing the lacrimal sac into the nasal cavity is one of the more technically difficult stages of the endonasal DCR, and one of the more likely causes of surgical failure. The objectives are to create a large window within the medial wall of the lacrimal sac (figure 2F-G), avoiding any trauma to the lateral wall and common internal punctum. The cut edges of the lacrimal sac should also be placed as far from each other as possible to prevent them from sealing shut again. This can best be achieved by opening the sac with a large posteriorly hinged flap (figure 2H). Care must be taken to avoid making a simple slit in the sac as the cut ends will readily seal.

(iii) *Adjunctive Measures*

Mitomycin C and steroid-soaked gelfoam have been recommended to reduce failure rates by some surgeons although there are no convincing published randomized controlled studies supporting this. The use of bicanalicular silicone stents is also controversial, but a recent randomized controlled trial from Canada found a statistically better outcome in stented cases of NEN-DCR compared with non-stented cases.[4]

(iv) *Postoperative Care*

On discharge, the patient is advised to avoid exertion and nose-blowing for one week and shown how to manage nosebleeds. A steroid-antibiotic drop and saline nasal spray are recommended for a week. Systemic antibiotics are only necessary in cases of acute dacryocystitis. The silicone stents are usually removed between two and three months postoperatively.

3. Indications for NEN-DCR

Primary acquired NLDO

NEN DCR has excellent success in primary acquired nasolacrimal duct obstructions. Several authors from across the world including the LV Prasad in India (table 2) have reported good outcomes ranging from 75 – 90%.[5-7] Ophthalmologists often prefer external over endonasal DCR owing to their non-familiarity with the nasal anatomy and a longer learning curve in the endonasal approach. Preechawai et al studied the learning curve of NEN-DCR in 75 DCRs.[7] All procedures in this study were performed by the author, with no prior training in nasal endoscopy and by residents under his supervision. Functional success was achieved in 74.7% and anatomical patency in 92%.[7] It is our belief that simpler instrumentation and lacrimal sac transillumination in NEN-DCR may be responsible for easier learning of the technique.

Table 2: Outcome of Nonendoscopic Endonasal Dacryocystorhinotomy in the Literature

Series; Country (year)	Study Design; No. of eyes	Outcome (Success)	Follow-up (months)
Dolman; Canada (2003)[1]	Retrospective Comparative; n=153 External vs. 201 NEN DCR	89%	> 12
Razavi; Iran (2009)[5]	Retrospective; n=99	95%	> 6
Preechawai; Thailand (2012)[6]	Retrospective; n=42	Functional- 74.7%; Anatomical- 92.0%.	> 24
LV Prasad India[7] (2015)	Retrospective; n=134	85%	Median-6
Dolman, Canada (2016)[4]	Prospective; n=300	With stents: 94% Without stents 88%	> 12

Acute Dacryocystitis:

Acute dacryocystitis is an ophthalmic emergency characterised by acute pain, swelling and redness in lacrimal sac region. Conventional treatment of acute dacryocystitis has been warm compresses and a short course of antibiotics, NSAIDs followed by external dacryocystorhinostomy (EXT-DCR). Most ophthalmologists prefer to perform EXT-DCR 3-4 weeks after quiescence of periocular inflammation. Primary endonasal DCR achieves earlier resolution of symptoms with comparable functional and anatomical outcome in acute dacryocystitis compared to conventional treatment.[8-10] In addition conventional treatment may have recurrent attacks of ipsilateral acute dacryocystitis (13%) with an increased morbidity and cosmetically unacceptable scar (17%) in a few patients.

A retrospective comparative analysis of 46 patients presenting with acute dacryocystitis at L V Prasad Eye Institute was done.[10] Patients were divided into 2 groups of 23 patients each. Group A included those who received conventional treatment arm and group B for early primary NEN DCR.[10] Mean age and gender distribution were comparable in both groups. The mean duration from presentation to surgery was shorter for NEN DCR

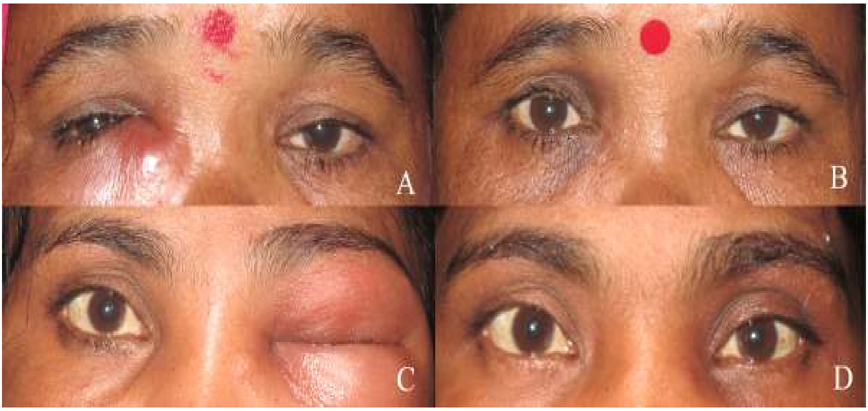

Figure 3. *Clinical photograph of the face of A. 35-year-old female who presented with symptoms of pain, swelling and inflammation in the right lacrimal sac region suggesting an acute dacryocystitis. She underwent primary nonendoscopic endonasal dacryocystorhinostomy (NEN-DCR). B. She had complete resolution of symptoms at 14 days after surgery C. A 37-year-female presented with acute dacryocystitis of the left eye with preseptal cellulitis. She underwent a left NEN-DCR with perioperative systemic antibiotics. D. A dramatic resolution of inflammation was seen at 11 days after surgery.*

(7.82± 4.65 versus 27.3± 12 days; P=0.00001, independent T test).[10] Patients who underwent NEN DCR had an earlier complete resolution of symptoms (21.4± 6 vs. 38.69± 15.8 days; P=0.000014, independent T test) than those who received conventional treatment.[10] While functional success was similar (20/23) in both, anatomical success was seen in 22/23 and 21/23 in groups A and B respectively. Complications included disfiguring scar in 4, recurrent acute dacryocystitis in 3, and punctal ectropion in one patient in the EXT-DCR group.[10]

NLDO with Mucocele

Mucocele of the lacrimal system is a benign expansile cystic formation lined by a secreting epithelium and characterized by a proximal (canalicular) and distal obstruction (nasolacrimal duct). Patients often present with a tense cystic swelling in the region of the lacrimal sac in a mucocele and with signs of inflammation in a mucopyocele. Conventional treatment is an early EXT-DCR with a short course of systemic antibiotics in perioperative period for mucopyoceles. NEN DCR offers an alternative treatment approach in patients presenting with mucocele/mucopyocele. A large bore (18G) needle may be used to decompress the lacrimal sac before surgery. For those patients where the proximal canalicular obstruction persists after decompression, a Sisler's canalicular trephine may be used for recanalization of the canalicular obstrcution. The technique of NEN DCR is similar to that described earlier. Adjuvant mitomycin C and bicanalicular intubation are often used to enhance success. Outcome is usually satisfactory with rapid resolution of symptoms (figure 4A-D) and good long-term outcome.

Figure 4. *Clinical photograph of the face of A. 16-year-male who presented with swelling in the right lacrimal sac region. There is no surface inflammation. This was diagnosed to be a lacrimal sac mucocele. He underwent primary nonendoscopic endonasal dacryocystorhinostomy (NEN-DCR). B. He had complete resolution of symptoms at 14 days after surgery. C. A 32-year-female presented with tense swelling in the right lacrimal sac region. The surface of the skin shows excoriation and signs of inflammation. She underwent primary NEN-DCR with perioperative systemic antibiotics. D. Eighteen months after surgery she has complete resolution with patency on irrigation of the right lacrmal system.*

NEN DCR in Children:

Dacryocystorhinostomy remains the procedure of choice for children with persistent congenital nasolacrimal duct obstruction (NLDO) who fail to resolve with lacrimal sac massage and probing of the nasolacrimal duct with or without intubation. In a retrospective analysis 27 (30 eyes) children who underwent NEN-DCR at L V Prasad Eye Institute with a mean age of 7.1± 2.7 (range 3-18) years, boys predominated (n=17) and a bilateral surgery was warranted in 3 children.[11] Three children had a history of probing of the nasolacrimal duct. Complete relief from epiphora (functional outcome) was achieved in 24/30 eyes (80.0%) after NEN-DCR at a median follow-up of 3.5± 2.5 (range 1-8) months.[11] All six children who failed primary NEN DCR underwent revision NEN DCR and were eventually symptom-free.

4. Complications

NEN-DCR is relatively safe procedure with few serious complications reported.[1-4] The average intraoperative bleeding is minimal in NEN-DCR. Other more serious intraoperative complications include orbital fat prolapse and medial rectus incarceration.[1] As most sharp instruments point towards the orbit in an endonasal DCR it is essential to limit all surgical manipulations anterior to uncinate process of the ethmoid bone. The most common complication of NEN-DCR is failure.[1] The varied patterns of failure described include cicatrization at ostium, synechiae between ostium and middle turbinate and/or nasal septum and granuloma formation within the ostium. Canalicular obstruction, orbital and subcutaneous emphysema, conjunctival fistula formation, and retrobulbar hemorrhage, as well as transient medial rectus paresis are other rare postoperative complications reported after endonasal DCR.[1,5,6]

5. Conclusion

Endonasal DCR is increasingly replacing the external approach as first choice for many lacrimal surgeons world-wide. Some surgeons may be hesitant to switch because of lower success rates initially reported for the endonasal approach, but recent reports find equivalent outcomes. Other surgeons have avoided endonasal surgery because of the potential expense of endoscopes and lasers or endonasal mechanical drills. However, this chapter has reviewed the non-endoscopic endonasal DCR, which is relatively simple to master, avoids expensive equipment, and has excellent outcomes based on several large independent international series.

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Balloon Assissted Lacrimal Surgeries

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Introduction

Balloon dacryoplasty is a term used for a set of minimally invasive lacrimal procedures that utilizes specially designed balloons, targeted at different points in the lacrimal system for a wide range of indications. Balloons were first used by Becker and Berry in 1989.[1] Around the same time Munk et al reported balloon catheter dilatation for adults with epiphora using an angioplasty catheter under fluoroscopic guidance.[2] **There are ongoing efforts worldwide to look for an alternative to dacryocystorhinostomy (DCR) in the management of nasolacrimal duct obstructions (NLDO). This gave impetus to the exploration of balloons in form of 9 mm balloon DCR for primary and revision cases, 5 mm balloon dilatation for internal ostium stenosis and 2 or 3 mm balloon dilatation for congenital nasolacrimal duct obstructions (CNLDO) and adult partial nasolacrimal duct obstructions.** This article would review the details of various balloons, instruments needed, indications in pediatric and adult populations, preoperative preparations, operative standards and procedures, postoperative managements and outcomes.

Balloons and Instruments

A good nasal endoscopic set up is ideal for a balloon dacryoplasty. A typical Balloon dilatation set (Atrion Corporation, Allen, Texas, USA) **(Fig 1)** consists of the following:

- 2 mm, 3mm, 5mm or 9mm balloon catheters
- Inflation device
- Lacrimal Probes
- Punctum dilator
- Dandy's Nerve hook
- Intubation set with retrieval device

Balloon catheters are specially designed with an inflatable balloon at one end of the catheter and hub with luer-lock mechanism at the other which engages the inflation device . 2 mm balloons catheters are named so since they have an outer diameter of 2 mms during an inflated stage (**Fig 1**). The length of this balloon is 13 mms. Similarly 3mm balloon has an outer

Fig 1: A complete balloon dacryoplasty set. Note the presence of the 2 mm

Fig 2: A 5 mm balloon catheter

Fig 3: A 9 mm balloon catheter

diameter of 3mms but the length is 15 mms. The 5 mm (**Fig 2**) and 9mm (**Fig 3**) balloons have outer diameters of 5 mm and 9 mm respectively but their length is 8 mms. 9 mm balloon catheter is much sturdier and is angulated at 120 degrees focused within the balloon segment. Two important markings on the 2mm and 3 mm catheters is the 10 mm and 15 mm black marks to serve as a guide when the catheters are within the nasolacrimal ducts **(Fig 1)**. The inflation device has a manometer which displays the pressure reading in atmospheres **(Fig 1)**. Proximal end of the manometer has a tube with a luer-lock adaptor for attachment to the catheters and the distal end has a locking device and a knob. When the locking device is to the left, it indicates an unlocked stage, whereas if it is to right, it indicates a locked stage. The knob when rotated clockwise with the manometer in locked stage, steadily increases the pressure within the device and inflates the balloon whereas its anti-clockwise rotation reduces the pressure and thus deflates the balloon. Preoperative and Intraoperative nasal endoscopic examination is essential for these procedures.

1. Balloon Dacryoplasty in Children

Syringing and Probing has been a standard of care for congenital nasolacrimal duct obstructions (CNLDO). Although it is a very good procedure with high success rates, the same is not true for older children.[3-4] Probing is less effective in older children because of complex blocks or diffuse narrowing of the nasolacrimal duct.[5-6] Silicone intubations are generally carried out in older children or those who fail probing but the drawbacks of these procedures in children including stent prolapse, second sitting for removal of tubes and keeping them in-situ for 2-3 months need to be taken into account.[7]

Balloon dilatation came into vogue because it achieves true dilatations of narrowed segments, easier to perform than primary silicone intubation with good success rates. A 2 mm balloon is used for patients less than 30 months of age and 3 mm for children more than 30 months of age. The indications of balloon dacryoplasty for congenital nasolacrimal duct obstructions[1,6,8,9] are:

- Failed Probing

- Failed intubation
- Older children (>12 months of age)
- Down's syndrome or any syndromic association with CNLDO
-

Surgical technique

Preoperative preparation includes decongestion of the inferior meatus with 0.05% Oxymetazoline. 2 drops can be placed half an hour before the procedure or alternatively a cottonoid soaked with the drug can be placed in inferior meatus for 5 minutes before the procedure. Following dilatation of the puncta, a probing is performed as a standard procedure and the probe is inspected in the inferior meatus to confirm that all the blocks are overcome. An I-probe (Quest Medical Inc, Allen, Texas, USA) can be used which is similar to a bowman's probe with a small eyelet near the tip to wash off the debris following probing and also to reflect on the free flow following probing. Inferior turbinate medialization may occasionally be needed along with probing if it appears to be impacted to the lateral wall.

Fig 4: *Endoscopic view of the nasolacrimal duct dilation using a 3 mm balloon catheter.*

The sleeve of the balloon is removed, it is then lubricated with either a viscoelastic or a 1% carboxymethycellulose drops and gently placed into the lacrimal system just like the procedure of probing and introduced further into the nasolacrimal duct till the 15 mm mark is adjoining the puncta or the balloon exits just beyond the valve of Hasner as seen with nasal endoscopy (**Fig 4**). In the meantime the inflation device filled with saline or fluorescent stained saline should be ready in the locked position. The air should be removed from the device after saline filling. The luer-lock hub of the inflation device is connected to the catheter and the knob is slowly rotated in the clockwise direction by the assistant while the surgeon can be visualizing the dilatation of the balloon via the endoscope.

The balloons are inflated to 8 atmospheres of pressure for duration of 90 seconds. The inflated balloon should be under constant monitoring in the nose (**Fig 4**). The knob of the inflation device is then rotated in an anti-clockwise manner to deflate the balloon. Once deflated, without disturbing the catheters position, it is re-inflated to 8 atmospheres for 60 seconds. The balloon is again deflated and pulled back till the 10 mm mark adjoins the punctum or the tip of the balloon is barely visible proximal to valve of Hasner. The two cycles of inflation and deflation are carried out again in this position. The catheter and the inflation device are then disconnected followed by gentle withdrawl of the catheter from the lacrimal system. The lacrimal passages are then irrigated with either saline or fluorescein stained saline. The fluid should flow easily and in copious amounts indicating success of the procedure. The saline from the inflation device is then emptied after unlocking the device.

The author practices the use of intravenous dexamethasone 4 mg during the postoperatively a topical steroid-antibiotic (Tobramycin-Fluormethalone) combinations are given in tapering doses over 2 weeks. Patients are examined at 6 weeks and 3 months and the outcome measures that are looked for is tear meniscus height, relief in symptoms, and occasional dye disappearance test. Numerous publications have classified the outcomes as excellent if the child has complete resolution of epiphora with normal tear drainage, good if the child has minimal residual symptoms with minimally delayed dye disappearance test, fair if there are moderate residual symptoms or delayed dye clearance and poor if there is no improvement.[1-11]

Outcomes

Balloon dacryoplasty for congenital nasolacrimal duct obstruction is a very effective treatment modality for specific indications as mentioned already. The success rates range from 76% to 83% in various large case series.[8-11] Tien DR[8] following his study of 39 lacrimal systems observed that balloon catheter dilatation is simple and atraumatic and should be considered as an alternative to silicone intubation in patients who undergo probing. Tao S et al[9] studied 73 lacrimal systems of CNLDO undergoing balloon catheter dilatation with patients whose mean age was 35.6 months. 39 (53%) of these were failed probing or post silicone intubation. The overall success rate was 76.7% but it was very interesting to note that children undergoing secondary dilatation following failed previous procedures did not show a statistically significant difference (P = 0.8165) in outcomes when compared to the primary group. Therefore it was concluded that balloon catheter dilatation appears to be successful especially for older children who fail probing or silicone intubation. Leuder et al[10] studied the outcomes of balloon dacryoplasty in 76 children above the age of 18 years. Though the procedure did not appear to benefit simple obstructions more than probing, it however was beneficial in 82% (n=28) of the patients who had stenosis of the distal nasolacrimal duct. Leuder et al[11] further studied the efficacy of balloon catheter dilatation in 32 children with persistant congenital nasolacrimal duct obstructions (CNLDO) following previous failed attempts at recanalization. Outcomes were found to be excellent and good in 28% and 47% of the patients respectively. Yuskel et al[12] studied the efficacy of balloon dilatation in older children with a mean age of 43.9 months with a mean follow up of more than 25 months and reported success rates of close to 90%. The concept of balloon dacryoplasty for older children especially post probing is steadily gaining rapid ground as an alternative to silicone intubation and dacryocystorhinostomy. The authors of the present study are conducting a study in older children who failed probing earlier. A combination of balloon dilatation and silicone intubation is performed and the initial results appear to be promising, however long term results would ascertain its efficacy.

2. Balloon Dacryoplasty in Adults

There has been a renewed interest in using minimally invasive approaches for partial and complete nasolacrimal duct obstructions in adults. This led to increased attention to the use of balloon-assisted lacrimal surgeries in adults. We will discuss this under 2 headings, Partial NLD obstructions and complete NLD obstructions

Partial Nasolacrimal Duct Obstructions

Incomplete NLDO's are usually managed with a dacryocystorhinostomy. With the advent of balloons several studies have looked at the efficacy of using 3 mm balloon dilatation in such cases. The procedure is similar to what has been described above for pediatric dacryoplasty except that probing needs to be much more meticulous to overcome the multiple blocks or diffuse narrowing of the nasolacrimal ducts. This is followed by a primary intubation under endoscopic guidance. The authors usually use Crawford tubes or I-Stents (Quest Medical Inc, Allen, Texas, USA) and retain them for 12 weeks before removal. Perry JD et al[13] reported a success rate of 73% after treatment with balloon dilatation and intubation for partial obstructions in adults. Kuchar A et al[14] reported an overall success of 90% in improvement of symptoms in adults and 56% experiencing complete resolution of epiphora. The authors in their unpublished study of 21 partially obstructed nasolacrimal ducts of 12 patients have shown an anatomical patency of 71% and functional success of 62%, 6 months after removal of stents. The later parts of this study have shown an additional benefit of doing balloon dacryoplasty under dacryoendoscopic guidance.

Complete Nasolacrimal Duct Obstructions - EBA DCR

For complete obstruction, Endoscopic Balloon assisted Dacryocystorhinostomy (EBA-DCR) using the 5 mm or more commonly the 9mm is an alternative to standard external or endonasal DCR's. One difference that needs to be kept in mind here is that unlike the 5 mm balloon which is used via the trans-canalicular route, the 9 mm can only be used transnasally (**Figs 2 and 3**). The authors use 5 mm balloon catheter only for revision DCR's and the 9 mm balloon catheter for both primary and revision DCR's. There is very scanty literature on the use of 3 mm balloons targeting the completely obstructed nasolacrimal ducts in adults.[14-16] Song et al[15] and Janssen et al[16] found initial failure rates ranging from 41-44%, however others like Kuchar et al[14] found a failure rate of 10.7% at the end of one year. The clinical use of 3 mm balloons targeting the completely obstructed nasolacrimal ducts is very limited and generally not followed, but such patients are being increasingly managed by the 9mm balloon assisted primary endoscopic DCR.

3. Primary Endoscopic Balloon DCR

Primary endoscopic DCR using the 9 mm balloon catheter **(Fig 2b)** is a good alternative to an external or endoscopic DCR. It was introduced and popularized by Silbert DI.[17] The advantages of this procedure include

a) Reduced operative trauma
b) Less bleeding
c) Faster and less time consuming
d) No need for powered endoscopic instruments
e) Less post-operative morbidity
f) Early rehabilitation
h) High success rates

Surgical Technique

Good case selection is vital for the success of any surgery and so is true for 9 mm endoscopic balloon DCR. Suspicion of any lacrimal sac tumor, severe deviated nasal septum and canalicular obstruction are contraindications, the former being an absolute and latter two being relative. Anesthesia can be general or monitored anesthesia care with sedation. Once the patient is under anesthesia, lidocaine 2% with adrenaline combination is injected in nasal sub mucosal plane, 2-3 cc, anterior and inferior to the axilla of the middle turbinate. The nose is then packed with cottonoids soaked in 0.25% Oxymetazoline, placed under the middle turbinate and in front of its insertion with the help of bayonet forceps, preferably under endoscopic guidance.

Once the patient is draped, the nasal pack is removed and the puncta are gently dilated progressively to allow number 3 or 4 reinforced bowman's probe to be passed into the lacrimal sac. The probe is directed towards the infero-posterior part of the lacrimal fossa, since it is very thin and can be easily overcome. Once the bone is overcome, the position of the middle turbinate is assessed and if needed a mild medialization of the middle turbinate is carried out. The probe is then passed inferiorly and superiorly in a honeycomb pattern initially followed by opening of the lacrimal sac in a 'filleting open' motion. A blakesly forceps is then introduced into this small opening and pulled back into the nose with its mouth wide opened. Bits of tissues around now can be gently removed. The 9 mm balloon catheter is now connected to the inflation device and introduced into the nose with the balloon end going in first. Under the guidance of the bowman's probe, the catheter is introduced into the newly made ostium and inflated to 8 atmospheres for 90 seconds. It is then pulled into the nose backwards with the balloon still inflated **(Fig 5)**. The balloon is deflated, introduced into the ostium again and reinflated for 60 seconds and again pulled back in the inflated state. This makes the ostium very big and fragments of bone and mucosa are then removed. Once the ostium is of adequate size, intubation is carried out with Crawford tube or the specially designed large diameter Stent tubes. The nose is then packed using cellulose sponges.

Soon following the surgery a single intravenous dose of 8 mg dexamethasone is administered. Postoperatively the patient is placed on systemic antibiotics, topical antibiotic-steroid combinations, nasal decongestant and saline nasal douching. The patient is reviewed at 1 day, 1 week, and 3 months. The tubes are retained for 12 weeks. The outcome measures that are looked for is tear meniscus height, relief in symptoms, and occasionally dye disappearance test. Routine syringing is not practiced by the authors unless patient complains of epiphora.

Fig 5: *Endoscopic view of a 9 mm primary EBA DCR.*

Outcomes

The results of primary endoscopic 9 mm balloon DCR's in long term are appearing to be quite encouraging. Silbert DI[17] in a large case series of 97 patients reported success rates of 92%. Among the 8 cases which failed in this series, 3 underwent repeat surgery, one of them with 5 mm balloon and were successful.[17] Longer follow up with still larger number of patients will ascertain its efficacy in long run.

4. Balloon-assisted Revision DCR

Revising a failed DCR is a challenging job. For primary external and endoscopic DCR, the failure rate has been reported to be 5-10% or less and 10-20% or less, respectively.[18-19] The most common cause of a DCR failure is occlusion of the rhinostomy site by soft tissue or cicatricial closure of the Ostium. The stenotic or occluded DCR fistula is amenable to balloon dilatation. It is of advantage since the occlusion is primarily a soft tissue and the bony window is usually adequate. The authors use both 5 mm and 9 mm balloon catheters for their failed external or endonasal cases. The 5 mm catheters (**Fig 2**) are usually used for very early failures where there is usually a stenotic fistula.

A bowman's probe is passed to identify the area in front of the common canaliculus and to clear any soft tissue. The 5 mm balloon catheter is then inserted through the upper canaliculus and under endoscopic guidance, the DCR fistula is enlarged with the standard inflation **(Fig 6)** and deflation cycles are discussed already. Following dilatation of fistula, any soft tissues in the vicinity are gently removed, mitomycin c 0.04% is applied, followed by Crawford intubation. The 9 mm balloon catheter is also used in the same fashion as already described for primary DCR. Though long term studies are not available, the initial results in the unpublished author series looks promising. What needs to be stressed is identification of all the etiological factors contributing to the DCR failure and addressing them adequately yields satisfying results.

Fig 6: *Endoscopic view of the DCR ostium enlargement using a 5 mm balloon.*

Conclusion

Balloon dacryoplasty and Balloon-assisted primary and revision DCR's are speedily gaining grounds in minimally invasive lacrimal surgeries with increasing indications for their use. These techniques are essential in the armamentarium of a dacryologist. Careful patient selection and skillful nasal endoscopy are important factors for successful outcomes. A good clinical armamentorium along with constant innovative habits helps facing challenges thrown by lacrimal disorders thrilling and profitable!

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Laser Dacryocystorhinostomy

Dr Jayanta Kumar Das

External dacryocystorhinostomy (DCR) is an incisional type of lacrimal sac surgery which still remains the gold standard procedure. It produces no thermal damage but does not provide hemostasis. **Evolving laser technologies and use of endoscopic instrumentation are the newer paradigm in DCR surgeries. This does not involve any skin incision** and a resulting scar, has shorter procedure time, adequate haemostasis and shorter patient recovery time.

In ophthalmology, typically low powered lasers (1-2 W) are used, but in laser DCR, tissue vaporization requires the use of substantially higher levels. Several high power solid-state lasers have been used to perform osteotomy as part of the DCR procedure, mostly by the transnasal approach - Holmium:Yttrium-Aluminum-Garnet (Ho:YAG) laser, potassium-tytanyl-phosphate (KTP) laser, Neodymium:YAG (Nd:YAG) laser and Erbium:YAG (Er:YAG) laser.[1,2,3,4] As an alternative, a higher powered (10-15W) semiconductor diode laser of 810-nm wavelength has been used as a substitute for these lasers in this application.[2] There are two distinct benefits over others, low cost and relatively small size.

Figure: 1a

Figure: 1b

Figure: 1c

Fig 1. Fig 1A: Surgical trolley with equipment, Fig 1B. Preparation of probe by Ceramic scissors, Fig 1C. Laser console with light source for endoscopy

Initially, laser-assisted DCR was performed by using readily available endoscopes and instruments, creating an osteotomy from the nasal mucosa into the lacrimal sac with argon, carbon dioxide or KTP laser.[5] A retinal light pipe was passed through the canaliculi to transilluminate the lacrimal fossa area, visualized within the nose through an endoscope. Laser was used to ablate the nasal mucosa, lacrimal fossa bone and lacrimal sac mucosa, creating an osteotomy.[5] Although laser-assisted endoscopic DCR surgery has distinct advantages, it has significantly low success rate. Most early studies showed on an average of 70 to 80% success, and even lower in some studies.[6]

Transcanalicular laser DCR (TCLDCR) is a minimally invasive procedure, most easily performed under local anesthesia in selected cases. Transcanalicular approach was first described in 1963 by Jack.[7] Towards the more sophisticated step in the development of DCR and canalicular surgery is transcanalicular microendoscopy, which also helps to improve our knowledge on pathophysiology of the lacrimal system.

The 980-nm transcanalicular endoscope combined laser-assisted dacryocystorhinostomy (T-ECLAD) is commonly adapted technique to the field of lacrimal surgery in our country. It is a minimally invasive quick procedure. TCLDCR with diode laser has been shown to restore and maintain patency of the nasolacrimal system in 88% of patients with primary NLDO.[1] Although the success rate is not

Figure: 2a

Figure: 2b

Figure: 2c

Fig 2. Fig 2A. Checking the sharpness of the laser beam, Fig 2B. Endoscopic view of the nasal antrum just before laser probe enters the nasal antrum, Fig 2C. Whitening of the nasal mucosa by the laser burn.

satisfactory, however there may be a hope, if we continuously improve upon and analyze the procedure.[8]

Equipment

General equipment	Endoscopic equipment	Laser equipment
Nasal speculum, nasal dressing forceps, double-ended elevator, a suction apparatus Punctum dilator A set of Bowman probes Lacrimal Cannula 2-ml syringe Topical anaesthetic drop Sterile fluorescein strips	Monitor Camera Light source Light cords Endoscopic defogging solution Electrocautery 4 to 5mm, 30-degree Hopkins rod lens endoscope	Laser console Footswitch Power cord Fiber Cannula Ceramic scissors Stripper Software for DCR applications

Selection of Patients

1. Careful preoperative evaluation is mandatory including intranasal endoscopy
2. Patient should be free from significant deviated nasal septum
3. Patients should warn about relatively lower success rate as compared to external DCR
4. Patient to be informed about the rare need to convert the procedure to an external DCR

Pre-operative Considerations

The surgery is generally carried out under local anaesthesia in adults and under General anaesthesia for paediatric age group, most of the time as an outpatient basis, provided they do not have any significant medical abnormality. As the chances of intra operative bleeding is significantly less by Laser assisted surgery, the precaution related to bleeding is very minimal. The preoperative lacrimal work up may vary from institute to institute as per particular institutional guideline. Nasal endoscopic evaluation is mandatory in all cases before deciding for any surgical intervention. Patient should be informed preoperatively about the relatively lower success rate of TC laser DCR, based on previous published data. After informed written consent obtained for nasal anaesthesia, nasal packing soaked in 4% xylocaine with adrenalin and Xylometazoline Hydrochloride nasal solution is given under endoscopic visualization 10 to 15 minutes before starting the surgery.

Operative Technique

Punctum dilation is the first step under proper visualization of light. Punctum dilator is inserted vertically 1.5mm to the punctum and simultaneously applying gentle pressure to enlarge the punctum 2-3mm and remove it. Lacrimal probe is inserted with gentle pulling of the respective eyelid laterally through the canaliculus up to the medial sac wall. Ideally the upper punctum is the first choice for this purpose, as it is thought that the lower canaliculus carries more tear flow then the upper one. But if any case encounters obstruction or resistance in the upper canaliculus or at the entrance of the sac, the lower canaliculus should be tried. As the tip reaches the medial wall of the sac the probe is withdrawn slightly. After that the transcanalicular laser probe combined with light source is introduced by adapting same technique like lacrimal probe up to the medial sac wall. Once it touches the medial wall the laser probe is slowly pivoted with an angle of 40 to 50 degree upwards with the convexity and it easily slides into proposed osteotomy site. The same time one assistant holds the nasal endoscope to visualize the tip of the laser probe by identifying red light which is incorporated with laser source. Before inserting the laser probe we have to check the sharpness of the beam whether its margins are round or irregular. If required, the middle turbinate is fractured medially to create adequate space.

Once the aiming beam is localized in the correct position, the “ready button” is pushed on and foot pedal is pressed to deliver laser energy, simultaneously advancing the fibre optics gently. If localization is difficult, intensity of the beam is increased and blinking light is used. The laser power settings (7 to 10 watt in case of diode laser) used for osteotomy depends on the age of the patient, thickness and hardness of the bone. When we fire the laser on continuous wave mode after some time there is whitening of the nasal mucosa which indicates the creation of bony osteotomy than further application of laser burn is continued until tip enters nasal antrum after ablation of nasal mucosa.

Once the laser tip is visualised in nasal antrum, the next step of the procedure is enlargement of the osteotomy. For enlargement the fibre is manipulated along with slight pull and push of the fibre around the edge of the osteotomy site. Once the osteotomy size is approximately 4 X 4 mm, it is very much essential to remove the tissue debris from the osteotomy site with the help of the blunt tipped spatula from the nasal side. After cleaning

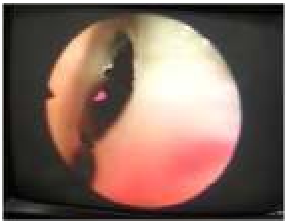

Figure: 3a

Figure: 3b

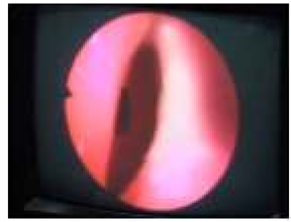

Figure: 3c

Fig 3. Fig 3A: Entering the probe in the nasal antrum, Fig 3B: Intraoperative view of the procedure, Fig 3C: View of osteotomy at the end of the procedure.

the operating site, lacrimal irrigation is performed to establish the patency as well as further cleaning of the side. Normal saline irrigation also helps cool the osteotomy site and the surrounding area. Fluorescein stained saline is also used for irrigation for better visualization. Few surgeons prefer silicon intubation stenting for better success, although the procedure may be successful without intubation. In case of silicon intubation it is recommended to remove at 2-3 months post operatively. Postoperative medication following transcanalicular laser DCR include antibiotic and steroid eye drops for 3-4 weeks, nasal decongestant for 3 months and oral antiinflammatory drugs depending on the postoperative edema. During follow-up visits, along with ophthalmic examination, endoscopic examination of the nasal cavity is strongly recommended. The standard postoperative follow-up is on days 1, 7, 28 and then three monthly for a year. On each visit lacrimal system irrigation with an endoscopic evaluation is recommended.

Complications of this approach are few; among them are pain, mild haemorrhage and surrounding tissue oedema. The significant post operative infection is not reported till now from any study, but there are some reports of visual loss following laser DCR due to injury to the optic nerve. Lid burn and canalicular burn have reported in different studies following this procedure.[9] The injury to the canaliculai and skin occurs when the surgeon fires the leaser burn without realizing the actual position of the fibre in the canula or sometimes the canula gets heated up and indirectly damaging the canaliculai and skin, if metallic sheath is not insulated enough to stop the transmission of heat. It is therefore very important to buy laser that has a good insulation sheath over the metallic canula and also there is provision of locking the flexible laser fibre into the canula so that it does not slip.[9]

Advantages of the Laser Procedure

1. Minimally invasive procedure hence bilateral DCR in a same sitting is possible.
2. With significant adnexal inflammation the procedure can be performed.
3. Cosmetically more acceptable as no external scar on the prominent part of the face.
4. Significantly less morbidity.
5. Preserve lacrimal pump function.
6. Better than external DCR for a case of previously failed DCR.

Disadvantages of the Laser Procedure

1. This procedure cannot be done when Lacrimal sac fistulectomy is required along with DCR.
2. Proper size of the osteotomy is questionable. During transcanlicular DCR the movement of the probe is restricted due to long and thin lumen of the canaliculus as a result creation of more than 5x5mm osteotomy is difficult.
3. Bony opening is not directly visualized and in case of hard bone it is difficult to make osteotomy.
4. Low success rate (50-88%) and lots of variation among the published report.

For a patient asymptomatic for NLD obstruction coming to clinic for cataract surgery laser DCR is a convenient procedure before undergoing cataract surgery. Bilateral laser DCR can be done on the same day with minimal tissue trauma and post operative inflammation.

The laser surgical technique during DCR offers precise cutting and removal of tissue by ablation with minimal trauma to adjacent tissue.[8,10] Due to the above mentioned advantages over the classical approach of both external DCR as well as in Trans Nasal Endoscopic-DCR, Laser assisted technology is becoming a treatment of choice for Lacrimal surgery in selective cases. The success rate of TCL-DCR for younger population is lower when compared with elderly population.[11] This is probably due to more active bony re-growth in younger age group which occlude the relatively small osteotomy created by TCL-DCR.

Recent evidence suggests that TCL-DCR is a well tolerated, viable treatment option for NLDO in selected patients with favourable results and shorter operative time. More recent studies seem to suggest improvements in success rates compared with older studies, although additional, well designed, comparative studies are needed.[12]

Like many lacrimal surgeons, I too was a hardcore proponent of External DCR, before I learnt and switched over to transcanalicular Laser DCR in selective cases. No doubt still external DCR is still gold standard, if we consider all points. Here, I do not propose to compare this technique with conventional External DCR, but I feel Laser technique is complementary to the existing gold standard and there is need for the two techniques to coexist. In short, Laser DCR technique is much more comfortably performed if surgeon has the adequate background of conventional External DCR.

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Pediatric Dacryocystorhinostomy

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Introduction

Epiphora in children is a commonly encountered clinical condition by ophthalmologists, affecting nearly 20% of pediatric population. This is usually due to a condition termed as congenital nasolacrimal duct obstruction. [1]A recent study using high-resolution computed tomography (CT) showed the obstruction to be either a persistence of a membrane at the distal end of the duct, bony obstruction, or narrowing of the inferior meatus with apposition of the nasal mucosa.[2] Most obstructions open spontaneously within 4-6 weeks after birth and approximately 90% canalize within the first year of life.[3] Less commonly, nasolacrimal duct obstruction in children can be acquired, and in those cases dacryocystorhinostomy (DCR) may be the only treatment option.It is also indicated in situations when a CNLDO is unresponsive to previous therapy (probing, intubation, or balloon dacryoplasty), or is associated with a mucocele and when the child experiences recurrent dacryocystitis.[4]The present article would be focused on dacryocystorhinostomy as a management option for nasolacrimal duct obstruction in pediatric population.

Definition

Dacryocystorhinostomy (DCR) is a procedure wherein an alternate passage is created between the lacrimal sac and nasal mucosa through a bony ostium in the middle meatus, bypassing the normal lacrimal pathway.

Indications

1. Congenital nasolacrimal duct obstruction (CNLDO) or dacryostenosis: Nasolacrimal duct forms from the linear thickening of the ectoderm in the floor of the groove between nasal and maxillary prominences. This thickened ectoderm separates as a solid cord which then starts canalizing cranially forming the lacrimal sac and caudally the nasolacrimal duct. The whole process of canalization is complete around at the time of birth. Any deviation from this natural process leads to incomplete canalization and a membranous block at the level of valve of Hasner; thus leading to

CNLDO.[3] Management options range from a conservative approach with Crigler's hydrostatic lacrimal sac massage, and probing of the nasolacrimal duct, to major surgical procedure in the form of dacryocystorhinostomy (DCR). **(Table I)** The success rate of conservative treatment decreases with increasing age of the child; being 92% at 12 months of age or less and 50% at 18 months or older.[5,6] If obstruction persists beyond one year of age despite adequate lacrimal sac massage, a stepwise approach to treatment is performed beginning with probing and irrigation, lacrimal intubation or balloon dacryoplasty, and ultimatelydacryocystorhinostomy (DCR).[7] DCR can be undertaken as a primary procedure in patients with complete osseous obstruction in patients with craniofacial developmental abnormalities. If bony obstruction is encountered during probing, DCR can be undertaken in the same sitting to avoid repeated exposure to anesthesia.[8]

2. Primary acquired nasolacrimal duct obstruction (PANDO) in children when there is no known cause.

3. Secondary acquired nasolacrimal duct obstruction (SANDO).The causes in children can betrauma, infections, inflammation, craniofacial abnormalities such as craniosynostosis or clefts, and rarely neoplasms. Occasionally infestation of the lacrimal sac by rhinosporidiosis can also result in secondary acquired nasolacrimal duct obstruction in children.The success rate of DCR in secondary NLDO is less than optimum, at times necessitating multiple surgeries.[5]

Contraindications

Absolute contraindication

- Lacrimal sac neoplasm

Relative contraindications

- Acute dacryocystitis (an indication for endonasal DCR)
- Rhinosporidiosis
- Dacryolith
- Allergic rhinitis
- Ectodermal dysplasia
- Bleeding diathesis and coagulopathies

Anatomical Considerations

There are considerableanatomical differences in the lacrimal system between adults and children.[5]

1. The lacrimal sac fossa, which in adults is made up of almost equal parts

of lacrimal bone and nasal process of maxilla, is poorly defined in children with minimally developed anterior lacrimal crest. As a result, there may be difficulty in selecting the site for osteotomy.
2. The ethmoid air cells are present at birth, expand until puberty and may extend into the area of osteotomy requiring a partial ethmoidectomy to allow a successful anastomosis between lacrimal sac and nasal mucosa.
3. There is close proximity of cribriform plates to the osteotomy site. Strictly restricting the osteotomy within the superior border of medial canthal tendon can avoid complications like CSF leak.
4. Sometimes the middle turbinate has direct connection with cribriform plates in children. So careful manipulation of middle turbinate is very important to prevent CSF rhinorrhoea.

Preoperative Evaluation

A. History
1. Duration of symptoms
2. Nature of epiphora
3. Prior surgical treatment
4. Seasonal allergies or sinusitis
5. H/o facial trauma
6. Medical history- bleeding diathesis, systemic manifestations of congenital syndromes

B. Clinical Examination
1. Thorough clinical examination of the eye and adnexae to rule out causes of reflex hyperlacrimation.
   a. Examination of eyelids and lashes- for any hordeolum, meibomitis, trichiasis or entropion
   b. Punctum- to look for agenesis,eversion or occlusion
   c. Ocular surface examination with slit lamp - for infection , inflammation or foreign body
2. All children with NLDO should have acomprehensive eye exam, including cycloplegic refraction, to look for anisometropic amblyopia.[9]
3. ROPLAS (Regurgitation On Pressure over Lacrimal Sac): (Fig.1) Follow the infraorbital rim medially and superiorly to reach up to the anterior lacrimal crest and then press posteriorlyover the lacrimal sac. One may need to use the little finger or an

Fig. 1: *ROPLAS: Checking for regurgitation on pressure over the lacrimal sac with an ear-bud.*

ear-bud in infants to check for ROPLAS. A negative ROPLAS, however, may not exclude the diagnosis of NLDO as it may be falsely negative if the parents have emptied the sac recently. Hence it should be repeated after some time if there is enough suspicion of NLD obstruction.

***Fig. 2:** FDDT: Fluorescein dye disappearance test positive in the left eye.*

4. Fluorescein dye disappearance test (FDDT): Fluorescein dye disappearance test is auseful tool in children, since it does not require much cooperation from the patient. Fluorescein dye is instilled into the conjunctival cul de sac and then assessed after 2 minutes. Persistence of dye in the cul de sac indicates an obstruction in the lacrimal excretory pathway. (Fig. 2)

C. Investigations

1. Anterior rhinoscopy can be done in the outpatient department to look for
   a. Hypertrophied turbinates
   b. Gross septal deviation
   c. Nasal polyps

2. Imaging, such as CT scan of the orbits or CT dacryocystography (CT-DCG) are reserved for craniofacial abnormalities or traumatic NLDO.[5] **(Fig. 3)**

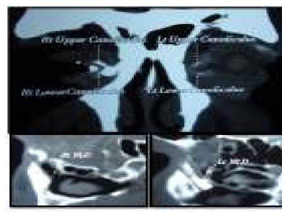


***Fig. 3:** CT-DCG: Showing pooling of dye in right lacrimal sac (above) and absence of flow of dye in right nasolacrimal duct (below left); dye is seen in the left nasolacrimal duct (below right).*

D. Counseling: This is one of the most important step before taking up the patient for surgery. The parents should be thoroughly informed about the pros and cons of the surgical procedure, the hazards of general anaesthesia , chances of failure and need for change of surgical plan on table or additional procedures such as intubation.

Surgical Procedure

A. Timing of Pediatric DCR: The usual recommendation is to wait until 18 months of age, but DCR has been successfully done as early as 2 weeks of age.[10,11]

B. Anaesthesia and Preparation: General anaesthesia with endotracheal intubation is needed for pediatric DCR.Use of hypotensive anaesthesia helps in minimizing the blood loss which is a major concern in children.[5] Other means of prophylaxis against blood loss are preoperative oxymetazoline nasal spray and nasal packing with 0.05% of oxymetazoline prior to surgery. Infiltration of the site of incision in external DCR with 0.5% xylocaine and 1:200000 epinephrine causes vasoconstriction and reduce blood loss.[5] The incision site is infiltrated right upto the periostium of anterior lacrimal crest. Usually 1-2ml is infiltrated in the sac area for hemostasis and for control of post operative pain.

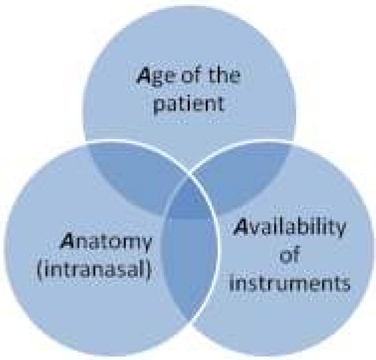
C. Magnification: A good surgical loupe or microscope provides appropriate magnification.
Fiber optic illumination mounted on the surgeon's surgical loupe gives the best visualization of the operating field.

D. Cautery and Suction: A bipolar cautery is mandatory for external DCR. The need of a proper suction cannot be over emphasized. Both these instruments keep the operating field clear of excess blood.

E. Choice of Surgery: DCR can be classified as either external or internal. In external DCR the bone of lacrimal sac fossa is accessed through a transcutaneous incision over the medial canthus. In internal DCR the normal openings around the lacrimal outflow system (puncta, canaliculus, and nasal cavity) are utilized to create the passage, without any skin incision. Internal DCR is most commonly performed through anasal approach with or without endoscopic guidance. DCRs performed through puncta and canaliculi (transcanalicular DCR) utilize lasers to open up the sac mucosa, bone of lacrimal sac fossa and finally the nasal mucosa to create the ostium.

It has been postulated that, compared to adults, children may have a higher failure rate after DCR due to rapidly growing facial bones and an aggressive healing response that leads to fibrosis and occlusion of the nasolacrimal ostium.[5,12] But studies reveal the success rates to be at par with the adults,which is approximately 90% irrespective of the route.External DCR, with its widespread use, was believed to be the gold standard for managing refractory and complicated cases of NLDO both in adults and children. The success rate in children has been reported to be 83-96%.[5,6] But with the advent of newer rigid endoscopes and fibre-optic light carrier systems, endoscopic DCR started gaining popularity. Use of endoscopic DCR in children has been reported in few case series.[13] Although these reports are limited, they have shown a success rate of 82-88%in children with no added difficulties or differences with adults.[11,13] Endoscopic nasal DCR is an effective treatment modality for congenital NLDO that compares favorably with the reported success rates of external DCR.

The choice of surgery depends on the surgeon's discretion, but it can be guided by 3 'A's:[5]



F. Special Considerations

- The ostium needs to be large (at least 10mm in diameter). If the ostium is small and centered on the suture line, bony growth may close it.[5,12]
- In children >20% blood loss may require transfusion.[5]
- Intraoperative systemic antibiotics reduce the risk of post operative infection and failure of the surgery;
- Skin closure is limited to placement of one or two subdermal absorbable sutures, with skin closure with either self-adhesive tape or cyano-acrylate glue.[8]

G. Comparison of External Vs Endoscopic DCR[5,14,15]

External DCR	Endoscopic Nasal DCR
Bettervisualization of anatomy	• No facial scar
• Precise bone removal	• Less disruption of medial canthal anatomy
• Accurate suture fixation of sac and mucosa under direct visualization	• Decreased operative time
• Helpful in cases associated with craniofacial abnormalities	• Decreased postoperative discomfort
• Inspection of the sac for coexisting pathologies possible	• Simultaneous treatment of associated nasal pathology
Creation of large osteotomy possible Especially important in children as they have a tendency of bony overgrowth and possibility of closure of osteotomy	• Can be performed bilaterally under general anesthesia as day care procedure
	• More expensive
	• Learning curve of surgeon

H. Adjunctive Procedures

1. Silicone tube intubation: Silicone intubation is a method used to keep the patency of the newly created system by DCR.[12]The disadvantages associated are canalicular trauma and subsequent stenosis and an additional procedure to remove it requiring General Anaesthesia.[6]The higher cost of the tube and need for frequent follow ups are also to be taken under consideration. The success rate of DCR along with intubation has been reported to be higher in children who undergo surgery between 1 and 4 years of age, with mild obstruction or no acute dacryocystitis.[16]After creation of osteotomy, tube is passed from the canaliculi through the osteotomy to the nose where it is secured with multiple knots. There should not be any tension at the puncta and the loop should rest midway between the puncta and corneal limbus.[5]A monocanalicular tube is easier to insert and remove.Indications for silicone tube intubations are:

1. Resistance felt during passing the probe through the common canaliculus while raising sacflap, 2. Traumatic NLDO and 3. Revision DCR.

Removal of the tube: The monocanalicular and Masterka tubes can be removed in the office by grasping the footplate with forceps and withdrawing the tube. But bicanalicular tubes should be removed through the nose under a brief general anesthetic, ideally under endoscopic visualization. If they are removed through the canaliculus, retention of part of tube (usually the knot) inside the lacrimal sac can later lead to obstruction and recurrence.

2. Antimetabolites

Mitomycin C (MMC), an antiproliferative agent thatinhibits fibrosis, is proposed to increase the success rate ofseveral ophthalmic procedures includingEndonasal or external DCR at a concentration of 0.2 to 0.5 mg/ml.[17,18] The cottonoidis placed at the osteotomy site for 5 minutes.[17] MMC may be an effective adjunctive modality in high-risk cases like revision and posttraumatic DCRs.[19]

Postoperative Care

- General care: Head end elevation to minimize bleeding, and cold compress to decrease swelling; avoid blowing nose
- Oral medications: Analgesics for 3-5 days
- Topical medications: A combination steroid-antibiotic eye drop for approximately 10 to 14 days after surgery. Antibiotic ointment over

wound and nasal decongestants for 2 weeks.

Follow-up Care

The patient is usually called after 1 week for review.Patient is then reviewed at 6 weeks, 6 months and 1 year. Tube removal is done according to surgeons' preference, usually after 6 weeks to 6 months. Children withcongenital nasolacrimal duct obstruction need to be followed to make certain they do not developanisometropicamblyopia.[9]

Complications

1. **Anaesthesia-related Complications:**

Includes all hazards of general anesthesia in children including death. A thorough preoperative evaluation for anesthesia and proper intraoperative and post extubation monitoring are the keys to prevent unwanted incidents.

2. **Intraoperative Complications:** [5,20]

a. Haemorrhage:One of the major complications of DCR surgery is hemorrhage especially when it occurs in children. A 20-40 ml blood loss in children is much larger as compared to adults. Intraopertive bleeding may start from incision to flap suturing. One has to be very careful while dissecting near angular veins and while performing osteotomy so as not to injure nasal mucosa, as these are the steps in which bleeding is most likely to occur.Measures to prevent bleeding are preoperative decongestant nasal drops and intraoperative nasal packing with epinephrine.

b CSF rhinorrhoea:Another life threatening condition is CSF rhinorrhoea which may occur due to inadvertent iatrogenic injury to the cribriform plate during creation of osteotomy. If not detected early and intervened, it can lead to dreaded complication like meningitis.

c. Injury:Injury to nasal septum or sinuses from rongeurs or drill is most likely to occur in view of the narrow working space in children. Injury to sinuses can result in subcutaneous emphysema. Sometimes damage to the orbital wall byendonasal probe can cause orbital fat prolapse or Medial Rectus dysfunction leading to squint.

3. **Delayed Complications:**

a. Infection:Post operative infection can lead to suture disruption, gaping of the woundand discharging sinus. It can also cause dehiscence of the flaps leading to failure of the surgery. Sometimes, spread of infection to surrounding tissues can even lead to orbital cellulitis. The condition should be diagnosed as early as possible and treated with appropriate broad spectrum antibiotic coverage.

b. Sump syndrome: When the ostium is higher than the lacrimal sac, secretions get collected into the sac instead of draining into nasal cavity, thus leading to a swelling in the sac area. These patients demonstrate a patent lacrimal system on syringing but are ROPLAS +VE.
c. Scarring of skin in external DCR and nasal mucosa in endonasal DCR.
d. Failure:[21,22]
   i. Due to inadequate bony opening leading to closure later on due to hyperostosis in children.
   ii. Anastomotic block by bony fragments, redundant flap, hematoma or infection
   iii. Enlarged ethmoidal air cells obstructing lacrimal flow, and excessive scarring around the rhinostomy site.
   iv. Iatrogenic common canalicular trauma
   v. Undetected nasal pathology such as hypertrophied turbinates or polyps and severely deviated nasal septum

4. **Complications of Intubation:**[23]
   a. Corneal or conjunctival abrasion
   b. Spaghetti syndrome: Prolapse of the silicone tube **(Fig. 4)**
   c. Conjunctival or nasal granulomas around the ostium: Foreign body reaction to the silicone tube can sometimes give rise to punctual granuloma. These are treated by excision and tube removal. Chances of recurrence after removal are rare.
   d. Slitting of the puncta is seen if the tube is tied too tightly.**(Fig. 5)** A close follow up can detect the complication early and is treated by removal of the tube. Usually small slits heal with normal functioning of the nasolacrimal system.
   e. Obstruction of the nasofrontal duct leading to frontal sinusitis and frontal sinus mucoceles.
   f. Persistent epiphora: Unusual after successful DCR than in adults as eyelid laxity and/or chronic lid infections are rarer in this group of patients.
   g. Suture granuloma: treated by removal of the offending suture and application of a short course of steroid –antibiotic ophthalmic ointment locally.

Fig. 4: *Spaghetti syndrome: prolapse of the tube in the conjunctival cul de sac.*

Fig. 5: *Slitting of the puncta due to bicanalicular tube tied too tightly.*

Recent Advances

Transcanalicularmicroendoscopicdacryoplasty: after the development of tools for microendoscopic diagnosis, therapeutic techniques were established, such as laser dacryoplasty (LDP) for which a laser is used and microdrilldacryoplasty (MDP) for which a drill is used. The microendoscope is passed through the canaliculus and the obstruction at the distal end of the nasolacrimal duct is opened up under direct visualization. These procedures allow for the first time the whole physiology of the lacrimal drainage system to be preserved despite surgical intervention.[24]

Conclusion

The cure rate after DCR for patients with congenital NLDO is almost 90%. Hence surgical intervention including endoscopic DCR may be performedsafely and effectively in infants and young children by experienced lacrimal surgeons.

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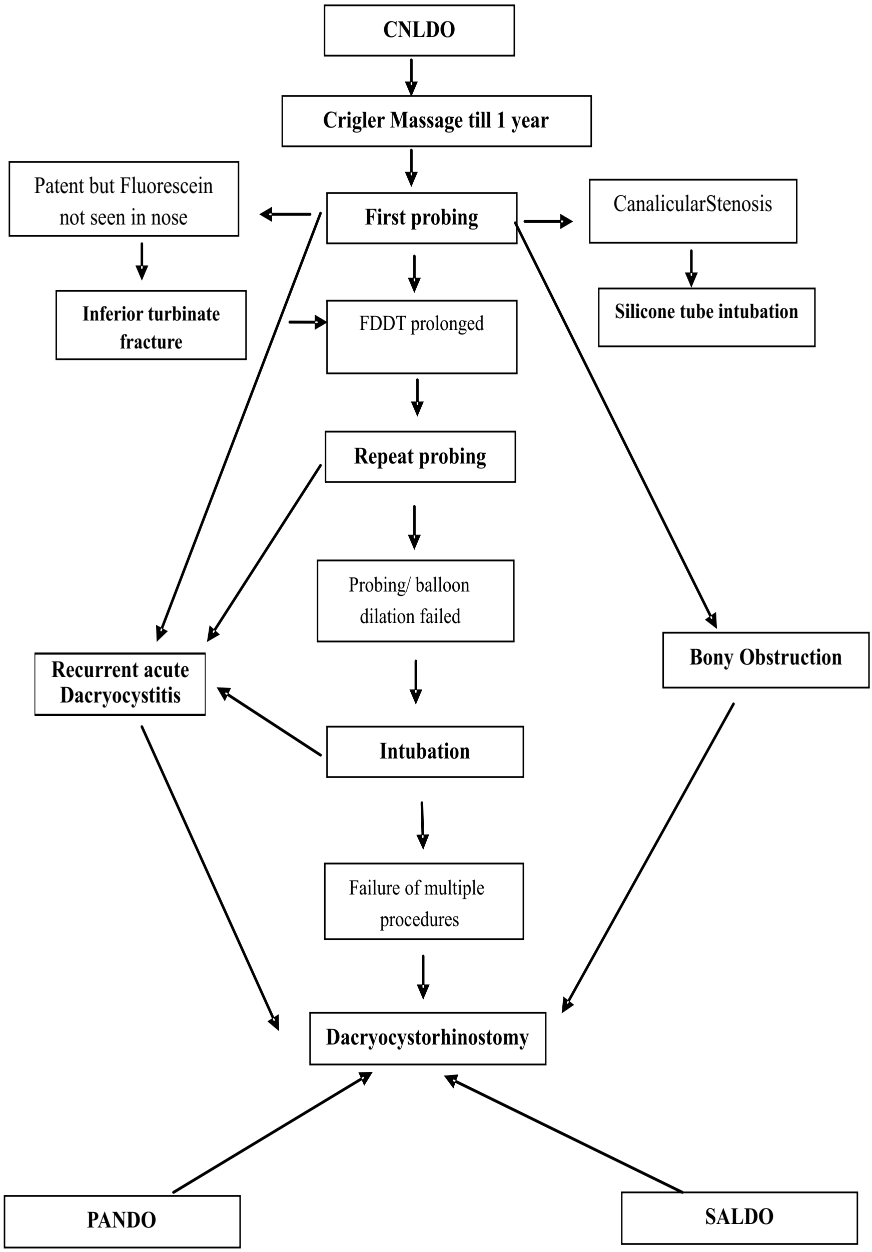
Table 1. Management protocol for pediatric nasolacrimal duct obstruction



Management of Failed DCR

Dr Vikas Menon
Dr Santosh G Honavar

Introduction

Epiphora after Dacryocystorhinostomy (DCR) is a distressing situation for both patient and the surgeon. Failure rate for external DCR has been reported to be 5%–10% or less and 20%–40% for endonasal DCR.[1] Some other reports quote a lesser failure rate with endonasal DCR.[2]

Etiology

Patients who have undergone a successful DCR may have epiphora due to a number of causes, some of which may be unrelated to Nasolacrimal duct obstruction (NLDO). Common causes are eyelid and punctalmalpositions, punctal occlusion, reflex watering due to ocular surface disorders orcanalicularinfection (canaliculitis). A DCR may also fail because of an inadequate or misplaced osteotomy, misdirected tear drainage (fistula) into the ethmoid sinus, incomplete opening of the lacrimal sac at the time of surgery ("sump syndrome"), trauma to middle turbinate or nasal septum which may lead to formation of adhesions in the nasal cavity, fibrosis across the fistula or canalicular obstruction, especially at the level of common canaliculus. At times, it can be a combination of above factors that leads to failure of surgery.

Some medical conditions like Lymphoma, sarcoidosis, and vasculitides, such as Wegener's granulomatosis, may increase the likelihood of failure after DCR. Any surgery in these patients should preferably be done when the disease is inactive.[3]

Assessment

A good clinical examination should focus on excluding common causes of epiphora like ectropion, punctal stenosis or ocular surface disorders. A modified Jones dye test can be done by instilling fluorescein in the inferior fornix and observing the presence of dye in the nose endoscopically.

A careful irrigation of lacrimal passages (Syringing) and gentle probing is a simple test which can ascertain the level of obstruction in lacrimal drainage pathway clinically. Regurgitation of fluid through the same punctum with a soft stop on probing signifies a canalicular obstruction. Regurgitation of fluid through the opposite punctum with a soft stop on probing at the level of distal end of canaliculus indicates common canalicular block. Regurgitation of fluid, mucopurulent or clear through the opposite punctum with a hard stop caused by probe entering lacrimal sac and hitting the lacrimal bone along medial wall of lacrimal sac represents a nasolacrimal duct block. In cases of cicatricial closure of the osteum, the probe will cross the canaliculus until it encounters a firm or hard obstruction as it enters the osteum.

Nasal Endoscopy is an extremely useful office procedure which can be used by the surgeon to directly visualise the status of osteum through the nose. It also helps to diagnose other nasal pathologies like deviated septum, polyp or an impinging middle turbinate which may have a role to play in failure of primary DCR.[4]

Ancillary investigations like Dacryocystography (DCG) may be used to further define the level of obstruction. DCG is also useful in cases of "Sump Syndrome" where the dye pools in a part of lacrimal sac left unopened during primary surgery.[5] Dacryoscintigraphy is a technetium scan that provides information on physiologic tear drainage as the radioactive tracer is sucked into the lacrimal drainage system via the lacrimal pump rather than being pushed into the canaliculi with a syringe. It is useful in cases of functional obstruction.

Management

Adequately assessing the cause of epiphora and addressing it, like performing a lid tightening procedure or inversion of the punctum may be all that is required in patients with eyelid malpositions to relieve their symptoms. Punctal stenosis would need a snip procedure or simple punctal dilatation with stenting. Canalicular blocks would require interventions like canalicular trephination or conjunctivodacryocystorhinostomy.Once it has been established that there is an anatomic obstruction of the osteum and a revision DCR is indeed necessary, a nasal endoscopy is performed in the office. If any nasal pathology is detected, it must be rectified before or during the revision surgery itself.

Balloon dilatation of the stenotic osteum under endoscopic visualisation is one of the ways to treat narrowed osteum. Protocols regarding the pressure required and optimum duration vary. Balloon dilatation can then be followed by intubation of the lacrimal passages.[6]

If the osteum is completely obliterated or severely stenosed, then a new opening needs to be created. This may be accomplished through external route or the endoscopic route. For the external approach, nasal packing is done with a ribbon gauze soaked in 4% Xylocaine and Adrenaline solution. If the first surgery was an external one, then the skin incision is made over the site of previous scar to avoid creating multiple scars. Orbicularis fibres are separated by blunt dissection till anterior lacrimal crest is exposed. Periosteum is then incised and an attempt is made to create a subperiosteal plane if the osteotomy created in the previous surgery is small. However, scarring from previous surgery may make identification of different tissue planes difficult. Care should be taken to preserve any residual sac and nasal mucosal tissues. If an anastomosis is identified, it can be divided carefully into medial and lateral halves. This would allow visualisation of deeper structures. A bowman's probe can be placed into the lacrimal sac to help demonstrate site of previous fistula and osteotomy. The probe also serves to avoid inadvertent damage to common canaliculus. If scar tissue is seen to be filling the osteotomy then it must be excised gradually. The osteotomy is then inspected for adequacy. If it is small in size or not in proper position, then the opening can be enlarged using a Kerrisonrongeur. The opening of common canaliculus should be clearly seen and any bone or soft tissue in its vicinity removed. If the osteum is significantly obstructed by middle turbinate, then a part of it may have to be removed after infiltrating it with local anaesthetic solution.

Bleeding can be a problem in repeat surgeries and the surgeon may need to use epinephrine soaked sponges, or hemostatic agents like Gelfoam® (Pharmacia & Upjohn, Kalamazoo, MI) or Avitene® (C.R. Bard, Inc., Murray Hill, NJ). Injury to anterior ethmoidal vessels may cause vigorous bleeding, and this would require identifying the source and cauterising the bleeder. Otherwise, as far as possible, excessive cautery use should be avoided in order to avoid complications like scarring in the osteum or delayed wound healing.

Once the osteum is cleared and enlarged to adequate size, Mitomycin C (MMC) is applied in the osteum with the help of a sponge to reduce subsequent fibrosis. The protocol for application of MMC varies[7], the authors use a concentration of 0.04% for 3 minutes. A bicanalicular silicone intubation tube,if planned is then introduced in the osteum from upper and lower canaliculi and its free ends are tied in the nasal cavity. Use of intubation tubes is controversial as these have been reported to be associated with increased incidence of granuloma, infection, slit punctum and stent prolapse. Some authors have reported increased failure rate in

Figure: 1

Figure: 2

Figure: 3

Figure: 4

Fig 1. *Osteotomy needs to be of adequate size and positioned in a way that it does not pose any obstruction to common canalicular opening.*
Fig 2. *Ensuring free passage of Bowman's probe beyond common canaliculus after removal of all obstructing scar tissue.*
Fig 3. *Taut anastomosis between sac-nasal mucosa.*
Fig 4. *Delayed wound healing following excessive use of cautery*

DCR performed with intubation. Hence, use of stents should be with caution and preferably restricted to cases with concurrent canalicular obstruction, fibrosed sac or when the sac-nasal mucosal flap anastomosis is inadequate.[8,9]

Anterior flaps of any remaining nasal mucosa and lacrimal sac are then sutured to each other in a way that the anastomosis remains taut. In case no intact nasal mucosa can be seen, periosteum from anterior lacrimal crest can be used to create a flap with the sac mucosa. Cutaneous incision is then closed in layers.

Postoperative care includes oral and topical antibiotics, vasoconstrictor nasal drops and a steroid nasal spray, which may help reduce cicatricial response to surgery.

Endoscopic-assisted approaches to failed DCR allow the surgeon to directly visualize intranasal anatomy as it relates to the previously formed surgical ostium. This approach has obvious advantage in cases that require concurrent correction of any co existing nasal pathology.

Conclusion

To treat epiphora after DCR surgery, it is extremely important to identify and understand possible etiologic factors contributing to the failure of primary surgery so that they can be properly managed. Nasal endoscopy is a useful tool to look at the nasal aspect of osteum before any surgery is undertaken. An occluded osteum can be managed by both endoscopic and external approaches. Adjuncts like Mitomycin C and silicone intubation can be useful to improve the outcome in repeat surgeries. Success can be assured once the etiology is systematically evaluated and addressed.

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Modified Implant Dacryocystorhinostomy

Dr. MD Pawar

Introduction

Lacrimal excretory dysfunctions that are not amenable to minor therapeutic attempts are often cured by dacryocystorhinostomy operation. This operation according to the site of obstruction in nasolacrimal passage and the status of lacrimal sac.The success rate was reported to be 90% with the failure rate 10% resulting from infection, granulation tissue formation and inadequate closure of anastomosis ostium in conventional DCR.

Though the conventional DCR is most commonly performed surgery, it has its own disadvantages as follows.

1. It is the time consuming time procedure.
2. Nasal packing is necessary to prevent the operative and post-operative bleeding.
3. Require large size of ostium of 12-14 mm in diameter.
4. Bleeding and tissue handling is more.
5. This procedure is contra-indicated in children and old patients, because below the age of 3 yrs the bones are thin, fragile and in developing stage. In old age this was described by Toti in 1904 which later on improved by various authors mucous membrane atrophic due to the senile changes.
6. Hospitalization is necessary.

To overcome all these difficulties various methods are introduced by various authors:

- Implant DCR
- Endonasal DCR
- Laser DCR
- Conjunctivo DCR
- Canaliculo DCR
- BallonDacryoplasty

Implant Dacrycystorhinostomy (Implant DCR)

Implant DCR was introduced by the author in 1985. The main aim of Implant DCR is to obtain and maintain a patent passage in between the lacrimal sac and middle meatus of the nose. In 1985, intracystic implants were prepared from silicone from the Denver's Hydrocepalic shunts. In 1987, intracystic silicone implants having 2mm inner diameter, 2.5 mm outer diameter and collar of 5 mm with the length of 12 to 15 mm were introduced. In1995, the implant was again modified to have a length of 15 mm for the newly fashioned ostium and 19 mm for the nasolacrimal duct. The collar of the implant was 2mm thick, 5mm width vertically, and 8mm width horizontally) with an inner and outer diameter of 2.5 mm and 3mm respectively. The silicone implant had multiple holes at the proximal and distal end of the implant to facilitate better drainage.

Expulsion of the intracystic implant through the nasal cavity was noted in 10% cases post operatively. To overcome this postoperative complication, the implant was further modified in 2007 to have a collar with haptics. The modified Pawarintracystic implant is made up of silicone providing maximum tissue compatibility. The length of the implant is varies - 13mm, 15mm, and 17mm. The diameter of the collar is 2X5X8 mm with a 3 mm haptic on either side as shown in the Fig1. Outer diameter of the implant is 3.5 mm and the inner diameter 3.0 mm. The diameter of additional drainage holes at the proximal and the distal end is 1.0 mm.The length of each haptic is 3mm and the width of the collar is 5mm vertically so that total vertical diameter of the collar is 11mm. The thickness of the haptic is 0.5mm, same as the thickness of the wall of the implant. The haptics are stiff but flexible so that there is minimal risk for the expulsion of the implant.

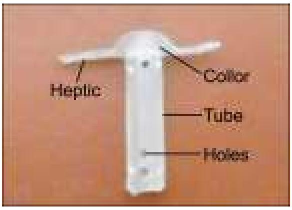

***Fig 1.** Intracystic implant*

Surgical Procedure

Implant DCR is being carried out since 1985, with the necessary modification time to time. Congenital or acquired dacryocystitis constituted 77% of patients, followed by mucocele or pyocelein 10%, lacrimal fistula in 8% and failed conventional external DCR in 5%.

Surgery is performed underlocal anesthesia in adults and general anesthesia in children. Local anesthesia comprises of surface anesthesia of the conjunctiva by instilling 4% xylocaine or Paracaine 1% eye drops 2-3

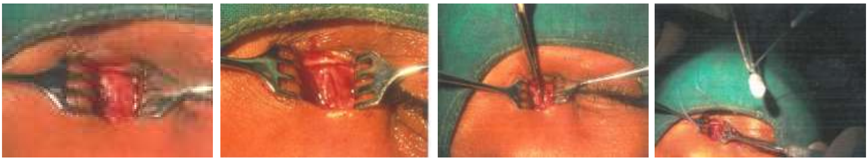

Figure: 2a *Figure: 2b* *Figure: 2c* *Figure: 2d*

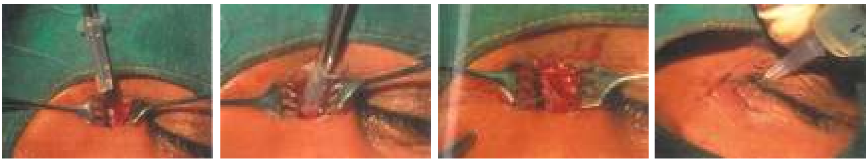

Figure: 2e *Figure: 2f* *Figure: 2g* *Figure: 2h*

Fig 2. *Dissection of the lacrimal sac (2a), 3.5 mm incision over the anterolateral wall of the lacrimal sac (2b), Making of the bony osteum with a mastoid gouge (2c), Application of mitomycin-C 0.04% to the edges of the osteum (2d), Needle is passed through the proximal hole of the implant and then through the anterolateral wall of the sac (2e), Implant is inserted into the lacrimal sac and the newly formed osteum (2f), Closure of the lacrimal sac (2g), and Closure of the wound with subcuticular sutures and syringing (2h)*

times. Infiltration anesthesia is provided by the Stallard technique by injecting 2% xylocaine with adrenaline 1:10,000 solution as follows:

- Skin over the anterior lacrimal crest is infiltrated along the line of the incision, and the needle is then directed posteriorly downwards and medially to infiltrate the entrance of the NLD.
- Blocking of the nasocilliary nerve around the anterior ethmoid foramen: Needle enters the orbit a little below the trochea and is passed backwards along the junction of roof and medial wall for 3 cm. Care is to be taken to avoid injury to angular vein. About 1ml xylocaine with adrenaline is injected before the needle is withdrawn and redirected medially for injection along the orbital margin and around the fundus of the sac.
- Superior alveolar nerve is blocked as it leaves the infraorbital margin to enter an osseous canal proximal to the infraorbital foramen about 7-9 cm below the inferior orbital margin.

Straight or curved incision 3 mm medial and about 5mm in length along the anterior lacrimal crest is taken on the skin and deepened up to the bone to expose the lacrimal sac. Lacrimal sac gets exposed with the blunt dissector separating the fibers of orbicularis muscle and cutting the lacrimal fascia. Anterolateral incision of 3.5 mm length is made on the anterior surface of the lacrimal sac. The cavity of the sac is irrigated with saline containing betadine and adrenaline in strength of 1:10,000.Mastoid gouge of 3mm diameter is passed obliquely downward through the anterolateral opening of the sac to perforate the posteromedial wall of the lacrimal sac along with the lacrimal bone and nasal mucous membrane. The mastoid gouge is passed into the NLD when it is planned to keep the implant at that site.A sterile cotton bud containing Mitomycin C 0.04% is kept for 3 minutes in the newly fashioned ostium and then the area is irrigated with normal saline.

A sterile intracystic implant is mounted on mastoid gouge of 3mm diameter, which acts as an introducer. The implant is introduced through the anterolateral opening of the sac into the nasal cavity negotiating the posteromedial wall of the lacrimal sac and the newly fashioned ostium. The implant is placed in such way that the wider collar of the implant lies in the cavity of the sac and the distal portion of the sac open either into the middle meatus or the inferior meatus of the nasal cavity. The intracystic implant without haptic is anchored to the wall of sac with nonabsorbable suture materal such as 6-0 Prolene. This step is not required for the implant with haptics. Saline is irrigated the cavity of the sac and through the proximal opening of the introduced implant to check the patency. The anterolateral opening of the sac is closed with a couple of interrupted with 6-0 absorbable or non-absorbable sutures material. The other wound layers are closed one after another. Skin is closed by subcuticular sutures. Pad and bandage is given after applying the antibiotics drops and ointment at the operative site and in the eye. The patient can discharge on OPD basis as there is no need of admission.

Post-operative Care

- Systemic oral antibiotics and anti-inflammatory drugs for 3 days.
- Local antibiotic drops 3-4 times for 4 weeks
- Decongestive nasal drops 2-3 times a day in the nostril of operated site
- Remove the non-absorbable skin stitches after 7 days.
- Instruction is given to the patient not to blow the nose or sneeze for 6-8 weeks
- Patient is asked to review weekly for 1 month and then once in a month for 3 months and then every 3 months for 1 year. Syringing is performed at each visit.
- Modified syringing:This is indicated to clear the mucoid plug formation as a late complication of Implant DCR. A straight blunt canula is attached to the 5 ml syringe containing saline + Betadine is introduced into the canaliculus and further into the cavity of the sac toward the introduced implant and then irrigated forcefully. This procedure is performed under the local anaesthesia.

Complications of Implant DCR

In comparison to the other types of DCRs, Implant DCR is simple, quick, less complicated and more effective. The success rate of Implant DCR is 100% on the operation table, but at the end of 6 months post-operatively it is reduced to 85%. However, after due and timely identification and successful management of post-operative complications, the success rate is 100% at the end of 1 year.

Following are the common causes for failure of Implant DCR and possible remedial measures:

	Causes of failure	**Frequency**
1	Expulsion of the Implant	6.6%
2	Displacement or misplacement of the Implant	20%
3	Infection	70%
4	Blockage of the Implant	6%
5	Non-perforation of nasal mucous membrane	35.5%

Expulsion of the Implant: Factors predisposing to expulsion of the implant are forceful sneezing or blowing of the nose and bigger-sized ostium. Use of a modified intracystic implant with haptics minimizes the risk of expulsion. Preventive measure is to close the nostril of operated side while sneezing and nasal decongestant drops to 3-4 times per day for 3 weeks. A repeat Implant DCR can be performed if the implant is expulsed. If the large osteum is the cause for implant expulsion, then a conventional flap DCR may be opted for.

Displacement of the Implant: Implant displacement can be of following types: 1. implant in between the lacrimal sac and fascia, 2. collar in between the lacrimal sac and fascia, 3. implant is folded in the lacrimal sac**,** 4. head of the implant protruding through the surgical wound.Remedial measure is repeat Implant DCR or convention flap DCR.

Infection: Factors predisposing to infection are: 1. improper closing the surgical wound. 2. Blockage of the implant by mucus or blood. If the infection if not treated promptly with systemic antibiotics, it may progress to an abscess and consequent lacrimal fistula.

Blockage of the Implant by mucous or blood:Suboptimal pumping action of the sac due to disruption of the medial palpebral ligament or inherent atonicity because of a longstanding mucocele can lead to blockage of the implant. Mucomist (Acetyl cystine) 4-5 times a day helps to dissolve the mucous along with topical antibiotic eye drops, nasal decongestants and lacrimal massage. Modified syringing with normal saline mixed with Betadine also helps relieve the block. These measures are 100% effective.

Non-perforation of the nasal mucous membrane: This would be a definite cause for failure. Endoscopy-assisted perforation of the nasal mucous membrane through the nasal cavity is the remedy.

Comparison of modified Implant DCR with Endonasal and Conventional DCR

No.		Implant DCR	Endonasal DCR	Conventional External DCR
1.	Anesthesia	Local	General	Local or general
2.	Nasal packing	Not required	Required	Required
3.	Skin incision scar	Present	Absent	Longer and prominent
4.	Acute dacryocystitis	Not indicated	Indicated	Not indicated
5.	Tissue handling	Minimal	Moderate	Extensive
6.	Bleeding	Minimal	Moderate	Extensive
7.	Implant left in situ	Permanently	No implant	No implant
8.	Closing of the surgical wound	Required	Not required	Required
9.	Endoscopy + Monitor	Not required	Required	Not required
10.	Ostium + Flaps	3mm No flaps	10-12 mm No Flaps or flaps	10-12mm, Flaps
11.	Hospital admission	Not required	Not required	Not required
13.	Operative time	20-30 minutes	45 - 60 minutes	60 - 90 minutes
14.	Lacrimal fistula and failed cases of EDCR and CDCR	Can be managed	Not managed	Not managed
15.	Children and very old patients	Indicated	Indicated	Not indicated
16.	Success rate	100%	90-95%	90-95%

Conclusion

Lacrimal excretory system dysfunction that are not amenable to minor therapeutic attempts are often cured by dacryocystorhinostomy. The success rate of external dacryocystorhinostomy conventionally was around 90%, with failure due to inadequate closure of the anastomosis, infection, and granulation tissue at the osteum. To overcome such operative and post-operative difficulties various modifications of were introduced. The author introduced 'Implant DCR' in 1985. Initial the success rate varied from 70 to 90% with the operative and post-operative complications such as blockage of implant, displacement of the implant, infection etc. The implant was modified with a collar of 2 X 5 X 8 mm with the inner and outer diameter of 3mm and 3.5mm respectively, and further with haptics. Surgical modification included anchoring of the implant to the wall of the lacrimal sac and use of Mitomycin C around the ostium. This apart, identification of early signs of failure and appropriate measures to address the specific cause yielded 100% success. Implant DCR is thus a safe, simple, quick and effective surgery.

Role of Adjunctive Use of Mitomycin C in Dacryocystorhinostomy

Dr. Gagan Dudeja

Dacryocystorhinostomy (DCR) is currently considered to be the gold standard for treatment of nasolacrimal duct obstruction. The two most popular surgical approaches for DCR are external and endonasal approach. The reported success rate for DCR ranges from 4% to 23 %.The most common cause of failure of DCR surgery is scarring and subsequent cicatricial closure of osteotomy.

This provides the rationale for trying to modulate healing process at the osteotomy site to prevent scarring and subsequent fibrosis to increase the surgical success rate. Mitomycin C (MMC) is one of the adjuvant that can be used for this purpose.

Mitomycin C is an antineoplastic antibiotic, which was first isolated in form of purple crystals from the culture filtrate of Streptomyces caespitosus by Wakaki et al. in 1958. . Mitomycin C contains an azauridine group and a quinone group in it's structure, as well as a mitosane ring, and each of these participate in the alkylation reactions with DNA. It inhibits fibroblast proliferation by inhibition of DNA replication in the S stage and synthesis of DNA dependent RNA.Being an antimetabolite drug, Mitomycin C has systemic toxic effects such as myelosuppression, nausea, vomiting, diarrhea, stomatitis, rash, fever, and malaise. The more serious effects include hemolytic uremic syndrome, neurological abnormalities, interstitial pneumonia, and glomerular damage. These adverse effects are seen with systemic use and are dose dependent.

Use of Mitomycin C as an adjunct to Glaucoma filtration surgery and pterygium excision for inhibiting wound healing and reducing scarring is well established. Kao et al, Ugurbas et al & Zilelioğlu et al were the early groups to report use of MMC in dacryocystorhinostomy. There is currently no consensus on dose and duration of application of MMC in DCR Surgery. In the published literature, MMC concentration range 0.2 mg/ml to 1 mg/ml has been used for duration of 2 min to 48 hours. Ali et al have demonstrated in vitro MMC concentration of 0.2 mg/ml for 3 min to be effective in reducing fibroblast proliferation without causing significant apoptosis.

As a surgeon, a concentration of 0.2mg/ml for 3 minutes should be a good safe starting point for use of MMC till further evidence is available. Etiologies associated with increased risk of DCR failure i.e. Pediatric DCR, traumatic NLD obstruction & revision DCR surgery can benefit from adjuvant use of MMC.In order to prepare MMC concentration of 0.2mg/ml, commercially available 2 mg vial is reconstituted in 10 ml of normal saline. A cottonoid or weck-cel sponge can be soaked in the prepared solution and kept at the osteotomy site for 3 min. Utmost care should be taken to avoid direct contact of Mitomycin C with the skin edges of the wound, as this may result in impaired wound healing and possible postoperative wound dehiscence.

Qian et al in their meta-analysis of 14 randomized control trials (RCT) have reported significantly increased rate of patency on irrigation in both endonasal and external DCR group. Cheng et al in their meta-analysis of 11 randomized control trials (RCT) on use of MMC in endoscopic endonasal DCR have reported that adjunctive intraoperative MMC application in endonasal DCR surgery had a significantly higher success rate than endonasal DCR without MMC. Qian et al found delayed skin incision healing due to use of MMC in external DCR in 3 RCTs. 2 studies reported cases that had wound disruption during skin suture removal and another study reported delayed wound healing.Cheng et al found no reported complications with use of MMC in endonasal DCR in their analysis.

Conclusion: Application of MMC 0.2mg/ml for 3 min at the osteotomy can increase the surgical success rate for endonasal and external DCR. Intraoperative use of MMC should be considered in those etiologies of nasolacrimal duct obstruction, which have a higher risk of surgical failure.

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