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# Radiofrequency Dacryocystorhinostomy

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Surgical specialists worldwide are rapidly acquiring expertise in radiosurgery or radiofrequency surgery. Many praise its superior results over conventional scalpel surgery. It is particularly gaining ground in the field of ophthalmic oculoplastic and orbital surgery. The authors, for instance, have used radiosurgery in repair of upper lid retraction in thyroid eye disease, transconjunctival blepharoplasty, ptosis repair, endoscopic forehead lift, biopsy excisions, and orbital surgeries including procedures involving optic nerve gliomas, among others.[1] In this chapter, emphasis is given to the authors' evolving approaches to radiofrequency-assisted dacryocystorhinostomy (DCR) surgery.

## History

Ancient Egyptians evidently used heated metal instruments for surgical tissue destruction and hemostasis. Over recent centuries, electrosurgery emerged as a method to cut and coagulate tissues. The electrically heated, traditional platinum electrode wire produced residual tissue destruction, third-degree burns, prolonged healing, and poor cosmetic results. Low-frequency alternating current also caused muscle contractions in humans (the Faraday effect). In the late 1800s, Jacques d'Arsonval used high-frequency (>10,000 Hz) currents and a solenoid coil to heat tissues while avoiding the muscle spasms. In the 1920s, surgeon George Wyeth first used incisional electrosurgery, whereas William Bovie, a Harvard physicist, designed a machine for simultaneous cutting and coagulation of tissues. Today, the Bovie cautery or diathermy machine exists in practically every operating theater. Modern electrosurgical or diathermy machines have "step up" transformers to generate voltages higher than household, commercial current, and electric oscillating circuits to increase electric circuit oscillations.

In standard diathermy, a high-frequency electric current is passed through the patient. A "passive" electrode (large plate) is moistened and strapped to the patient's leg or back, and an "active" electrode is used to touch tissues. The electrical "density" of tissues determines the heating effect: current spread over a large surface area generates minimum heat, but current concentrated at a small point produces enough heat to cut, coagulate, or destroy tissue. Dr. Irving Ellman, in 1975, patented a lightweight, solid-state radiosurgery instrument to filter fully rectified waves. Its handpiece transmitted a pure frequency signal of 3,800,000 cycles per second. Maness et al. confirmed that a filtered wave produces less tissue alterations and that the optimum frequency for cutting soft tissues was 3.8 million cycles per second (MHz) and this frequency is still used in modern radio-units.

## Definition of Radiosurgery

High-frequency (500 KHz and 4 MHz) radio waves are transmitted through soft tissue from a handpiece (thin wire tungsten "active" electrode) and focused through soft tissues by a passive electrode (insulated ground plate/antenna plate that does not need contact with the patient).[2] Water molecules in tissues exert a natural resistance to the passing radio signals, generating heat to volatize the cells. Sebben[3] described this sudden expansion of microbubbles of steam within the tissues; in effect, the passing electrode tip leaves a trail of cellular dehydration and destruction with virtually no hemostasis. This cutting effect (electrosection) exerts no manual pressure or crushing because soft tissues split apart with razor-sharp precision. Alternatively, a coagulating current produces molecular oscillations to induce heat buildup that coagulates and dehydrates tissue without volatilization. This electrocoagulation is important for surgical hemostasis.

## Comparison with Electrocautery, $CO_2$ Laser Surgery, and Incisional Surgery

Incisional surgery with the scalpel still remains the gold standard. It produces no thermal damage but does not provide hemostasis. Radiosurgery has been shown to be superior over electrocautery because it results in less lateral thermal damage to tissues. It also produces significantly less tissue damage than KTP, YAG, or pulse $CO_2$ laser surgeries. An added advantage is that the electrodes are also self-sterilizing. Sebben differentiated the two high-frequency modalities. In electrocautery, the filament resists an electric current passing through it and becomes red-hot. This heat (not the electric current) transfers from filament to the tissues. In electrosurgery (radiosurgery), electromagnetic radiation is passed to the patient and converted to heat because of the resistance offered by the tissue cells. Whereas electrocautery operates optimally within the frequency range of 0.5–1.5 MHz, radiosurgery obtains best results within 3.8–4.0 MHz. There is less trauma to cells, less fibrous scarring, and less postoperative discomfort because a radiofrequency of 4 MHz is very gentle on the tissues with the active electrode remaining cold.[2]

## Radiosurgery Waveforms

A transformer in all radiosurgery units changes the main voltage input to a high-voltage, high-frequency current. Further filtering and rectification produces any of the following waveforms. A microsmooth pure cut (fully filtered, fully rectified, 90% cut/10% coagulation) waveform is ideal for initial skin incisions, grafting, and biopsies where excess bleeding is not expected. This waveform gives the least tissue damage from lateral heat. A blended current (fully rectified 50% cut/ 50% coagulation) cut/coagulation waveform balances the minimal tissue injury of a pure cut with the hemostasis induced by coagulation as needed for subcutaneous dissections and lesion excisions (e.g., of verrucae, nevi, skin tags, papillomas, keloids, and keratoses) where slight bleeding is expected.

The authors, likewise, reserve this waveform for transconjunctival blepharoplasty. Direct/indirect, spot coagulation with minimal lateral heat spread requires a partially rectified (10% cut/90% coagulation) waveform to adequately control bleeding vessels up to 2 mm in diameter. The authors use this waveform in resection of orbicularis muscle and orbital fat in procedures such as blepharoplasty, ptosis repair, correction of lid retractions, and lesion excisions (e.g., telangiectasias and spider veins). This is also used in external, mini-incision, and endonasal DCR. Fulguration uses a spark gap current which generates significant lateral heat (similar to unipolar diathermy [Hyfrecator]) mainly used for electro-desiccation as in superficial hemostasis and destruction of small basal cell carcinomas or cysts. The bipolar waveform (1.7 MHz), which avoids tissue adherence to the forceps tip, is ideal for wet-field cautery, very precise hemostasis, and for control of individual bleeding vessels in microsurgery.

## Electrodes

There are different types of electrodes available for use with the radiosurgery units. The choice of electrode is dependent on type of surgery to be performed, anticipated bleeding, and desired cosmetic results. There are extra-fine empire electrodes (for thin skin incisions with very minimal scarring), fine-wire electrodes (for extremely fine excisions and incisions), round-loop electrodes (for excision of small lid neoplasms/biopsy specimens from bigger neoplasms), triangular- or oval-loop electrodes (for excision of pedunculated and raised skin lesions), and ball electrodes (for coagulation).

The authors use the endoscopic forehead lift electrode for endoscopic radiofrequency-assisted forehead (ERAF) lift. The Ellman-Javate DCR electrodes (Figure 20.1), however, are preferred for endonasal DCR, mini-incision DCR, and standard-external DCR.[4]

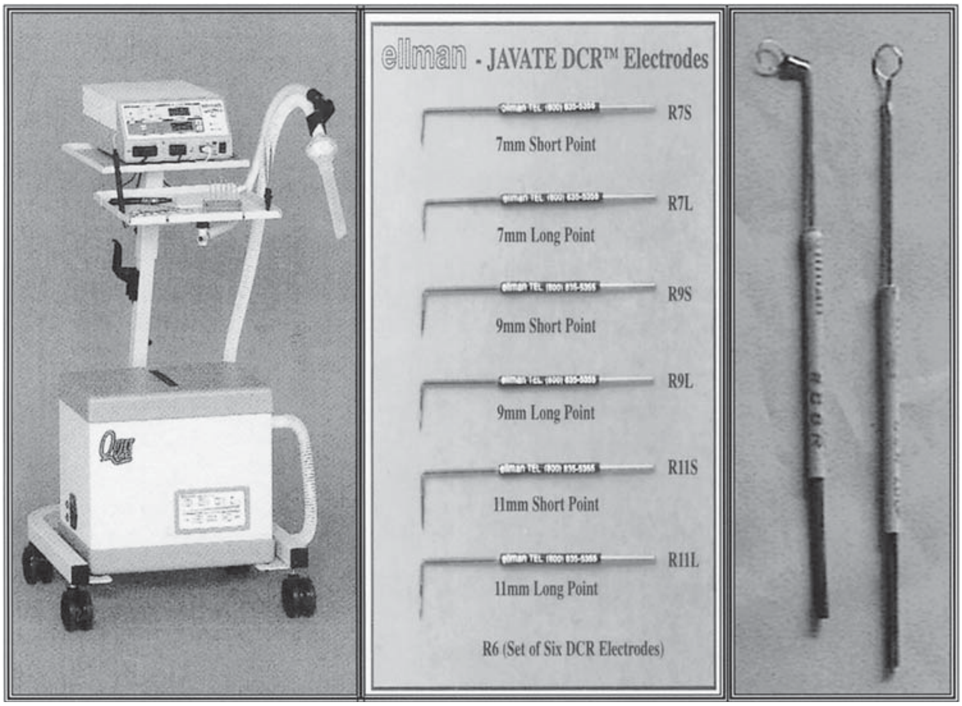


**FIGURE 20.1.** Ellman Dual Radiofrequency Surgitron Unit and Ellman-Javate DCR Electrodes.

## Radiosurgery in Dacryocystorhinostomy

The authors use an Ellman Surgitron Dual Frequency Unit (Ellman International, Hewlett, Long Island, NY) and all settings and waveforms refer to this machine. For more than 10 years, the initial techniques have undergone several modifications that have helped achieve surgical success.[5]

### External Dacryocystorhinostomy and Mini-Incision Dacryocystorhinostomy with the Radiofrequency Unit

In external DCR, the authors reserve radiosurgery for skin incisions, creation of lacrimal sacs and nasal mucosal flaps, and hemostasis. They recently introduced the mini-incision DCR[6] for better cosmetic results. The Ellman-Javate DCR electrode (attached to the Ellman Surgitron unit set in the cut mode) is used to make an 8- to 10-mm incision set about 7–8 mm below the lower lid margin (Figure 20.2A). It starts at a point slightly inferior to the medial canthal tendon, extending just into the anterior lacrimal crest, and continuing laterally in a horizontal direction following the periorbital relaxed skin tension lines. This offers less bowstringing and postoperative scarring in contrast to incisions positioned 3–4 mm beneath the lower lid margin which can cause ectropion from wound contracture or orbital fat prolapse when incisions are placed just above the orbital septum.[7] Radiofrequency also provides excellent hemostasis because individual bleeding points are

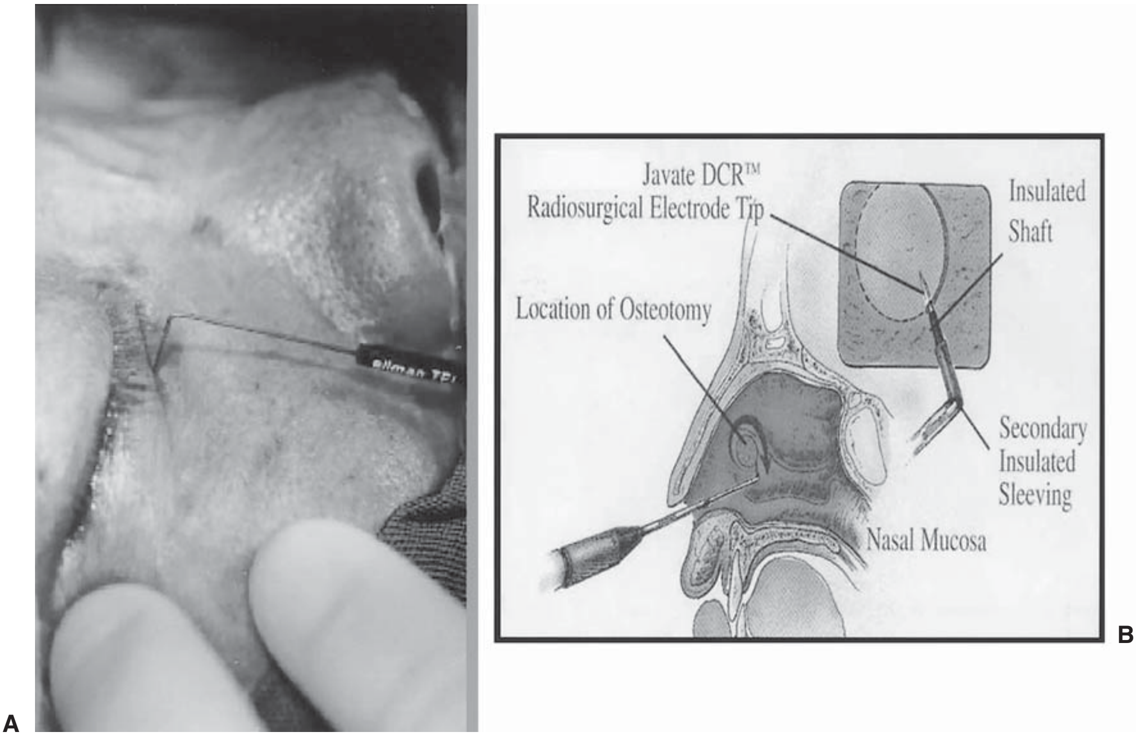


**FIGURE 20.2.** **(A)** Mini-incision DCR: (left) an 8- to 10-mm-long skin incision is place approximately 7–8 mm beneath the lower eyelid margin, using the Javate DCR electrodes attached to a radiosurgery unit. **(B)** ERA-DCR: (right) diagrammatic representation showing incision of the nasal mucosa with the Javate DCR electrodes.

controlled by the electrodes. Tissue anatomy is not obscured by hemorrhage, thereby providing better visualization and shortened operative time. Patients wearing spectacles also report greater comfort immediately after mini-incision DCR surgery. This is not only attributable to less postoperative pain and inflammation but also the spectacle nose pads usually do not rest on the resulting incision site. The rapid postoperative recovery allows an earlier return to normal daily activities and work.

Blunt scissors are then used to dissect down to the anterior lacrimal crest. Bleeders are coagulated to markedly decrease postoperative periorbital ecchymosis. The DCR electrode is then used to incise through the periosteum overlying the anterior lacrimal crest. After the osteotomy is created, the nasal mucosal flaps are made using the electrode set in coagulation mode. The remainder of the procedure is generally similar to the gold standard external techniques.

### Endoscopic Radiofrequency-Assisted Dacryocystorhinostomy

A patient undergoing endoscopic radiofrequency-assisted (ERA)-DCR is placed in a supine position with the head slightly elevated to decrease venous pressure at the operative site. Although local anesthesia is an option, general endotracheal anesthesia is preferred because of the copious volume of irrigation used to completely irrigate the mitomycin from the nasal passage. Nasal preparation includes packing with cotton soaked in 0.05% oxymetazoline hydrochloride along the lateral nasal wall to initiate mucosal decongestion. A 4-mm 0-degree rigid Karl Storz Hopkins endoscope (Karl Storz GmbH and Co., Tuttlingen, Germany) is used for visualization as submucosal injection of 2% lidocaine hydrochloride with epinephrine (1 : 100,000) is placed in the middle turbinate and the lateral nasal wall just anterior to the attachment of the turbinate. In some patients, the middle turbinate limits access to the lacrimal sac fossa. In such patients, the middle turbinate is infractured medially instead of removing its anterior portion. The entire procedure is performed with a videocamera attached to the endoscope. The assisting surgeon is able to observe the surgery on a video monitor.

A 20-G retinal light pipe lubricated with antibiotic ointment is inserted through the dilated superior canaliculus. To ensure that its tip reaches the most inferodependent portion of the lacrimal sac, a 0- or 30-degree rigid Karl Storz Hopkins endoscope is introduced into the nose to visualize the area anterior to the middle turbinate. The light from the endoscope is then kept at minimum setting to enhance the illumination visualized from the retinal light pipe. A diffuse glow indicates inadequate apposition of the light pipe to the lacrimal bone. A discrete area of light marks the intended area of rhinostomy along the lateral nasal wall. When the glow from the tip is adequately positioned at the posteroinferior wall of the sac (where the overlying bone is thinnest), the light pipe is held in place using sterile tape. The overlying mucosa is injected with the lidocaine-bupivacaine-epinephrine solution under endoscopic guidance. A 20-mm area of this nasal mucosa is incised using an assortment of electrode points of varying lengths (Ellman-Javate DCR electrodes) with the Ellman Surgitron Dual Frequency Unit set in coagulation mode at a power setting of 50–60 (Figure 20.2B). In the past, the authors used the straight electrode for this step. However, they have recently adapted the loop electrode for scraping the nasal mucosa with greater facility. The incised mucosa is then lifted off with a Freer periosteal elevator.

The initial puncture into the intended rhinostomy site is made with a curette and the ostium is further enlarged to a 10- to 15-mm diameter size using a Kerrison punch. This rhinostomy includes part of the frontal process of the maxilla (anterior lacrimal crest).

A retinal light pipe inserted into the lacrimal sac facilitates the demarcation of the posterior-inferior and anterior-inferior walls of the sac through visible indentations. These indentations ensure that incisions in these areas made with the Ellman-Javate DCR electrodes will create the ideal 5- to 10-mm openings. A lacrimal sac that is difficult to visualize (e.g., because of cicatrization) is dilated with Aquagel Lubricating Gel (Parker Laboratories, Inc., Fairfield, NJ) introduced through the canaliculus to help prevent injury to the common canaliculus during incision. Shorter DCR electrodes are used for normal-sized or enlarged lacrimal sacs, whereas the longer electrodes are necessary to reach cicatrized lacrimal sacs. Additional marginal sac tissue is removed with a Blakesley nasal forceps. The Ellman-Javate DCR electrodes and the Blakesley nasal forceps, when used under endoscopic visualization, permit the direct biopsy of the lacrimal sac, not possible in cases performed with laser DCR.

Once the nasal mucosa, rhinostomy, and lacrimal sac openings are judged adequate in size, cotton balls soaked in a 0.5 mg/mL solution of mitomycin C are applied for 3 minutes over the surrounding mucosa with the purpose of inhibiting fibroblastic proliferation. Residual mitomycin is then copiously irrigated from the operative site and nasal cavity with sterile normal saline.[4,8] Bicanalicular intubation of the nasolacrimal fistula is completed using a BD Visitec (Franklin Lakes, NJ) modified 5013 lacrimal intubation set with a retriever device to bring the tubes out through the external nares. A Griffiths nasal catheter (Griffiths Nasal Catheter 5206), with the probes of the canalicular tubes passed through it, is pushed superiorly through the nostril to straddle the bony opening using alligator forceps.[9] This is a nasolacrimal catheter designed for temporary retention in the lacrimal fossa to ensure the patency of the intranasal ostium (Figure 20.3). The canalicular tubes are tied into two square knots, further secured by a 5–0 silk suture, and cut to an appropriate length within the nose. Patency of the fistula is then confirmed endoscopically through visualization of lacrimal irrigation around the silicone stents in the nose. Oxidized, regenerated cellulose is placed at the tip of the middle turbinate with a bayonet forceps to control operative and postoperative hemorrhage. The material absorbs spontaneously. Table 20.1 details the different instruments that the authors use for a usual case of ERA-DCR.

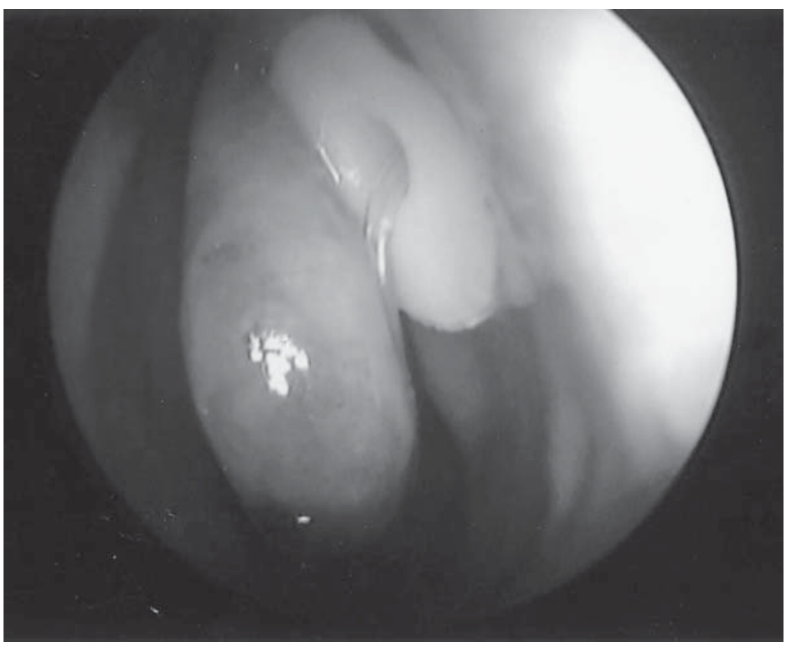

**FIGURE 20.3.** Endoscopic photograph showing bicanalicular silicone tubes emerging from the central lumen of the Griffiths nasal catheter.

**TABLE 20.1. Instruments used in ERA-DCR.**

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| 1. Headlight | 11. Retinal light pipe |
| 2. Bayonet forceps | 12. Ellman-Javate DCR electrodes (Ellman International, Hewlett, Long Island, NY) |
| 3. Nasal speculum | 13. Suction machine (Vapor-Vac Ellman International, Inc) with tip |
| 4. Cotton balls | 14. Bone curette |
| 5. Oxymetazoline hydrochloride 0.05% solution | 15. Kerrison punch |
| 6. Spinal anesthesia needle | 16. Becton-Dickinson Visitec Lacrimal intubation set with retrieval device |
| 7. Lidocaine 2% with epinephrine (1:100,000) solution; lidocaine 4% solution; bupivacaine 0.75% solution | 17. Mitomycin C solution (2 mg/mL) |
| 8. Karl Storz Hopkins 0- and 30-degree Rigid Endoscopes (Karl Storz GmbH and Co., Tuttlingen, Germany) | 18. Corneal eyeshields |
| 9. Karl Storz Blakesley nasal forceps | 19. Becton-Dickinson Griffiths nasal catheter no. 5206 |
| 10. Aquagel (lubricating gel; Parker Laboratories, Inc., Fairfield, NJ) | 20. Collagen absorbable hemostat |
| | 21. Suction tip |

## Postoperative Care

Postoperative regimen after external DCR, mini-incision DCR, and ERA-DCR includes a broad-spectrum oral antibiotic, antibiotic ophthalmic solution (Ofloxacin; Santen Pharmaceutical Co. Ltd., Osaka, Japan) applied topically four times daily, and nasal saline irrigation three times daily.

The postoperative care of patients after external DCR procedures is simpler, consisting of three to four follow-up visits where skin sutures and silicone tubes are removed at appropriate times. In contrast, endonasal DCR needs more frequent postoperative visits at intervals of 1–2 weeks. Lacrimal saline irrigation and meticulous endoscopic-guided removal of nasal debris and mucus at the rhinostomy site are performed when indicated. Steroid nasal spray (Fluticasone propionate Nasal Spray; Glaxo Smith Kline, Philippines) is used during the first postoperative week. The Griffiths nasal catheter is removed 2–3 months after surgery, whereas the silicone tubes are removed 3–6 months after surgery (Figure 20.4). Postoperative ostium patency is assessed by lacrimal irrigation and by endoscopic documentation of fluorescein dye flowing from the tear meniscus into the nose through the surgical ostium (Figure 20.5). Surgical success is further based on the relief of preoperative signs and symptoms of nasolacrimal obstruction.

The primary advantages of endoscopic lacrimal surgery (ERA-DCR) are elimination of external scarring and limited injury to the nasolacrimal fistula. Other advantages include less surgical trauma and bleeding, minimal operative and postoperative morbidity, rapid recovery, and patients' earlier return to work or school. ERA-DCR, likewise, allows the identification and correction of any intranasal pathology that may cause DCR failure, lacrimal sac biopsy under direct visualization, and success rates approaching 98%[10] for long-term patency of the intranasal ostium.

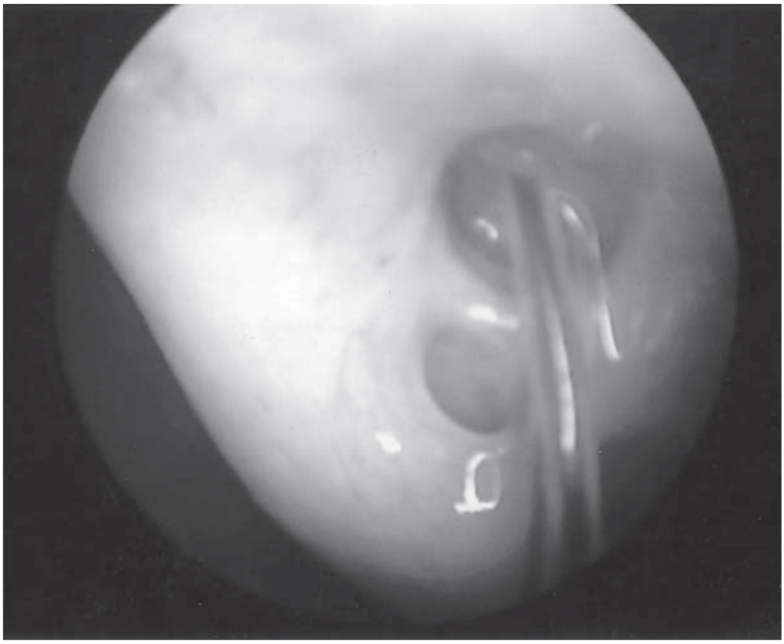

**FIGURE 20.4.** Endoscopic photograph showing large, healed, intranasal ostium 2 months after removal of the Griffiths nasal catheter and with bicanalicular silicone tubes still in place.

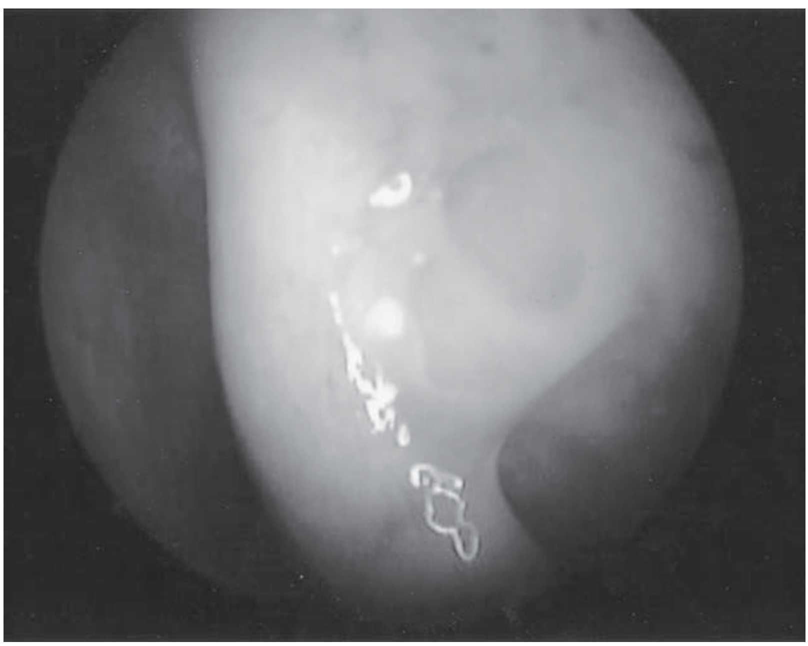

**FIGURE 20.5.** Endoscopic photograph taken 1 year postoperatively showing fluorescein dye flowing through the surgical ostium after lacrimal irrigation.

## Postoperative Complications

Any DCR procedure may present with possible complications. Epistaxis or infections in the nose or orbit are possible with the latter and may require antibiotics. Adhesions between the intranasal ostium, the middle turbinate, and the nasal septum may be avoided by meticulous surgery and regular cleaning of the intranasal cavity at the site of the ostium created during endonasal DCR. Placement of the Griffiths nasal catheter, likewise, may lessen the incidence of these adhesions. Although ERA-DCR with the Griffiths nasal catheter may be complicated by granulation tissue formation between the nasal mucosa and the edge of the distal flange of the button, this is not necessarily associated with ostium occlusion. Cheese-wiring of the canaliculi may occur if the stenting is too tight, necessitating stent loosening or removal. If the stent is too loose, however, prolapse of the stent onto the eye may occur; this may be avoided by tightening the stent. Sump syndrome may occur if the rhinostomy is too small in size and high up in the lacrimal sac, causing tears and mucus to accumulate in the sac and to discharge onto the eye. Pyogenic granulomas may form at the puncta or the rhinostomy site if the tubing is left in place too long. This necessitates tube removal. Persistent watering or epiphora may indicate scarring of the rhinostomy and reoperation may be necessary.

## Precautions in the Use of Radiofrequency Units

The radiosurgical instrument should never be used in the presence of flammable or explosive liquids or gases. It is contraindicated in patients with pacemakers, unless prior clearance is given by their primary physicians or cardiologists and steps are taken to ensure that the pacemaker is shielded from the high-frequency interference. Whenever the electrode is changed, always remember to deactivate the handpiece by releasing pressure on the foot pedal to avoid injury to the surgeon, the patient, and other personnel.

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