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# CT of the Inferomedial Orbit and the Lacrimal Drainage Apparatus: Normal and Pathologic Anatomy

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**The normal and pathologic CT anatomy of the lacrimal drainage apparatus was examined during study of the orbits, nasal cavity, and paranasal sinuses in 100 patients with a variety of clinical complaints related to the inferomedial orbit. The bony lacrimal fossa, the nasolacrimal canal, and the fluid- or air-filled lacrimal sac and nasolacrimal duct were readily recognized in all cases. The lacrimal fossa and sac are found at the inferomedial orbit and are preseptal structures. Cystic expansion of the lacrimal sac (dacryocystitis) may mimic orbital abscess clinically; however, the radiographic recognition of a cystic, peripherally enhancing mass centered at the lacrimal fossa should exclude postseptal abscess and permit more conservative therapy. Obstruction or invasion of the drainage apparatus by tumor, infection, or posttraumatic scarring is readily depicted by CT. Sagittal/coronal images reformatted from thin transverse axial sections are often useful in defining the origin of an inferomedial orbital mass and its relation to the lacrimal sac when clinical studies and axial CT findings are equivocal.**

Computed tomography (CT) is the most effective technique for defining the extent and nature of diseases of the nasal cavity, paranasal sinuses, and orbit. The relatively simple clinical techniques for the diagnosis of diseases affecting the lacrimal drainage apparatus obviate sectional imaging in most cases of lacrimal sac obstruction. This is in all probability why many radioanatomic and pathologic descriptions of the orbit, nose, and facial skeleton skim over or ignore the anatomy of the inferomedial orbit [1–5]. The literature concerning the clinically important differentiation of preseptal (periorbital) and postseptal (orbital) infection ignores the lacrimal sac, despite its intimate relation with the medial orbital septum [6–8].

In examining a series of 100 CT scans of the orbit and facial structures, it became apparent that the normal sac, either tear- or air-filled, was an important anatomic marker for localizing medial orbital disease, and that the sac and nasolacrimal duct proper were often directly involved in such cases. Toward the goal of using this anatomy in improving our diagnostic accuracy, normal scans were correlated with known anatomic works, and this knowledge was applied to all scans with abnormal findings encompassing the medial orbit.

## Materials and Methods

One hundred patients examined with CT underwent chart review for pertinent clinical history and physical findings relating to the inferomedial orbit and lacrimal drainage apparatus. All patients had thin-section (2-mm) CT sections obtained in the transverse axial plane through the orbits and nasal/paranasal structures; when appropriate, data were subjected to coronal reformatting of axial images to better localize the lacrimal fossa and the nasolacrimal canal (NLC). A Siemens Somatom 2 scanner was used, with exposures at 10 sec and 460 mAs. Patients with no symptoms or signs related to the lacrimal apparatus and no abnormality at that site on CT were grouped as normals for the purposes of our anatomic demonstration.

In abnormal cases, an intensive effort was made to correlate clinically observed anatomic alterations with demonstrated CT findings. Operative and biopsy results confirmed all findings

Superior Canaliculus

Posterior Lacrimal Crest

Anterior Lacrimal Crest

Lacrimal Sac

Orbicularis Oculi

Medial Canthal Ligament

Common Canaliculus

Lacrimal Punctae

Inferior Canaliculus

Nasolacrimal Duct

Lateral Canthal Ligament
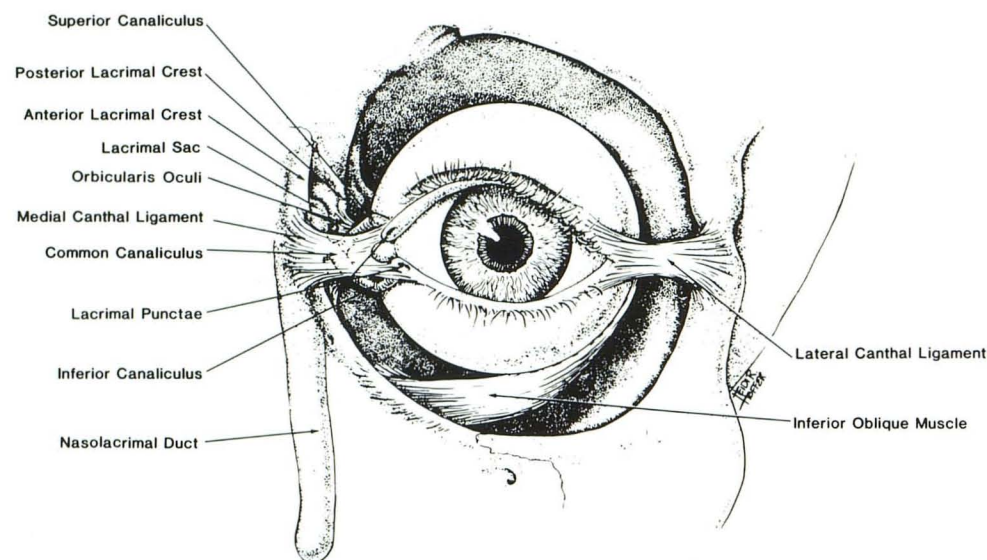
Inferior Oblique Muscle

Fig. 1.—Left eye: septal relations of anteromedial orbit. Lacrimal sac lies within lacrimal fossa, between anterior and posterior lacrimal crests, and is invested by superficial and deep parts of orbicularis oculi muscle. Medial canthal ligament lies anterior to anterior crest, and true orbital septum (not shown) is composed of orbital periosteum and lies posterior to posterior crest. Lacrimal sac is therefore preseptal in location.
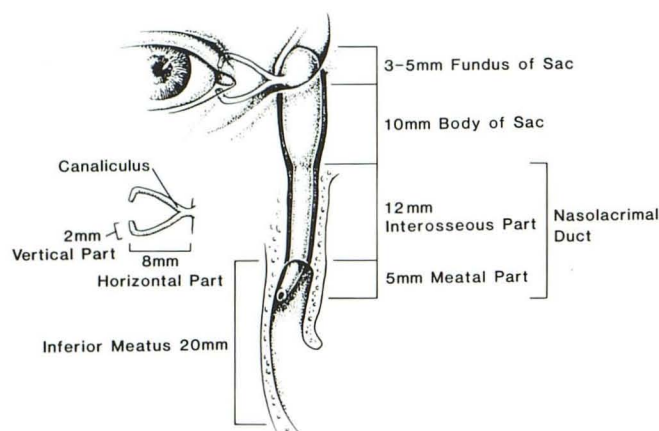
3–5mm Fundus of Sac

10mm Body of Sac

Canaliculus

2mm
Vertical Part    8mm
Horizontal Part

12mm Interosseous Part

Nasolacrimal Duct

5mm Meatal Part

Inferior Meatus 20mm

Fig. 2.—Right eye: dimensions of the lacrimal drainage apparatus. (Modified from [12].)

Frontal

Nasal

Posterior Lacrimal Crest

Anterior Lacrimal Crest

Lacrimal Groove
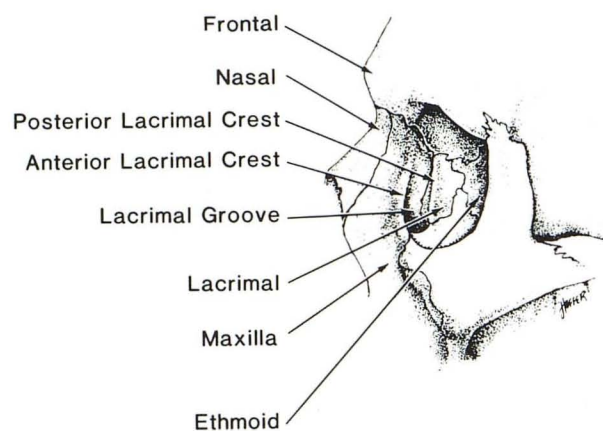
Lacrimal

Maxilla

Ethmoid

Fig. 3.—View of anteromedial orbit. Note origin of anterior lacrimal crest from frontal process of maxilla, and posterior lacrimal crest from lacrimal bone.

in patients included in the study with tumor or localized fluid collections.

## Anatomy

Tears are produced by the secretory part of the lacrimal system, which includes the lacrimal gland proper, the accessory glands of Krause and Wolfring, the glands of Zeis, and the Meibomian glands. Once produced, tears track medially along the eyelid margins to collect at the lacrimal lake at the inner canthus [9–11]. Muscular contraction, blinking, and capillary action cause tears to flow through the lacrimal puncta in each lid margin, and then in a descending course through the lacrimal canaliculi, lacrimal sac, and nasolacrimal duct (the lacrimal drainage apparatus) to the inferior nasal meatus below the inferior turbinate (figs. 1 and 2).

Embryologically, the drainage structures form as a solid cord of epithelial cells. Canalization begins at the most supe-

rior end and proceeds inferiorly, resulting in a tubular collecting system that remains closed at its lowest extremity by a thin membrane (Hasner's valve) until shortly after birth [13].

The orifices of the inferior and superior puncta within the lid margins mark the beginning of the lacrimal canaliculi. Each canaliculus enters the lacrimal fascia and joins the other to form the common canaliculus (sinus of Maier) (fig. 1). This common channel then joins the more medial lacrimal sac. The puncta and canaliculi are incorporated within the soft-tissue image of the lids and cannot be separately defined by CT examination.

The lacrimal sac is a membranous tissue situated within the lacrimal fossa, a depression in the inferomedial orbital wall, located between the anterior lacrimal crest (ALC) of the frontal process of the maxilla and the posterior lacrimal crest (PLC), a linear ridge of the lacrimal bone (figs. 1 and 3). The ALC is a key surgical landmark during orbital and ethmoid sinus surgery [14]. The lacrimal sac has a bulbous superior

end (fundus) and a tapering body that is continuous inferiorly with the nasolacrimal duct (NLD). The lacrimal sac is enclosed by a lacrimal fascia, which is actually part of the orbital periosteum (periorbita). At the PLC, the orbital periosteum divides into two layers to invest the lacrimal sac. Inferiorly, the NLD is also invested by this fascial layer, and it becomes continuous with the periosteum adjacent to the inferior nasal meatus. A rich venous plexus lies between the lacrimal sac/
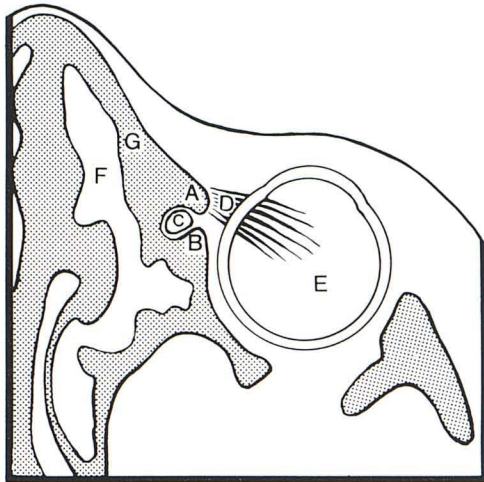


Fig. 4.—Cross-sectional (axial) relations. A = anterior lacrimal crest; B = posterior lacrimal crest; C = lacrimal sac; D = inferior oblique muscle; E = globe; F = nasal cavity; G = frontal process of maxilla.

duct and the lacrimal fascia. Surrounding the lacrimal fascia is a muscular envelope composed of the deep and superficial heads of the orbicularis oculi muscle. The superficial head forms part of the medial canthal tendon, attaching to the ALC, and the deep head attaches to the PLC (fig. 1). Just posterior to the PLC are the attachments of the medial orbital septum and the check ligament of the medial rectus muscle [15]. Therefore, the lacrimal fossa and lacrimal sac are preseptal structures. The sac below the medial palpebral ligament is not covered by muscle, and hence this represents a site of potential weakness, offering little resistance to intraorbital spread of infection. Images in the axial plane nicely demonstrate the anatomic relations at the lacrimal fossa (figs. 4 and 5).

The NLD represents the inferior continuation of the lacrimal sac, and is partly separated from the sac by valvelike folds of mucosa (valves of Krause). The NLD has two parts: intraosseous and membranous. The intraosseous part lies within the bony NLC, a groove in the maxilla that slopes backward as it passes downward (fig. 3). The soft duct occupies only a small part of the NLC, as it is usually collapsed. The membranous or meatal part is 5 mm long and runs beneath the nasal mucosa, before ending beneath the inferior nasal turbinate as a slitlike opening (fig. 2). CT not uncommonly demonstrates air within one or both normal NLDs (fig. 6). Direct coronal CT scans or coronal CT reformations of axial images are especially useful in demonstrating the entire course of NLC (fig. 7).

It is important to understand the anatomic relations of the *medial orbital septum* in regard to the lacrimal sac, before
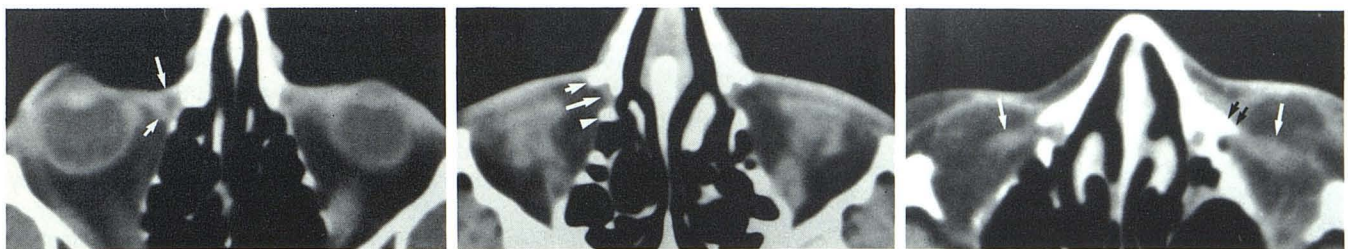


**A**                    **B**                    **C**

Fig. 5.—CT anatomy of lacrimal fossa. **A,** Axial section through lacrimal fossa. Anterior (*large arrow*) and posterior (*small arrow*) slips of orbicularis oculi muscle invest lacrimal sac. **B,** Lacrimal sac appears as soft-tissue density (*large arrow*) between anterior (*small arrow*) and posterior (*arrowhead*) lacrimal crests. **C,** Low axial section defines inferior oblique muscle (slightly thickened in this case) coursing from undersurface of globe (*white arrows*) anteromedially to its insertion at base of anterior lacrimal crest (*black arrows*).

Fig. 6.—Normal variation in aeration of lacrimal sac and nasolacrimal duct. **A,** Axial section through lacrimal fossa. Note anterior lacrimal crests (*white arrows*), fluid (tear)-filled right sac (*black arrow*), and air-filled left sac (*arrowhead*). As sac is anterior to orbital septum (see Anatomy), air is not truly intraorbital. **B,** Coronal reconstruction from axial images shows normal asymmetry of aeration of fluid-filled right (*small arrow*) and air-filled left (*large arrows*) lacrimal sac and nasolacrimal duct.
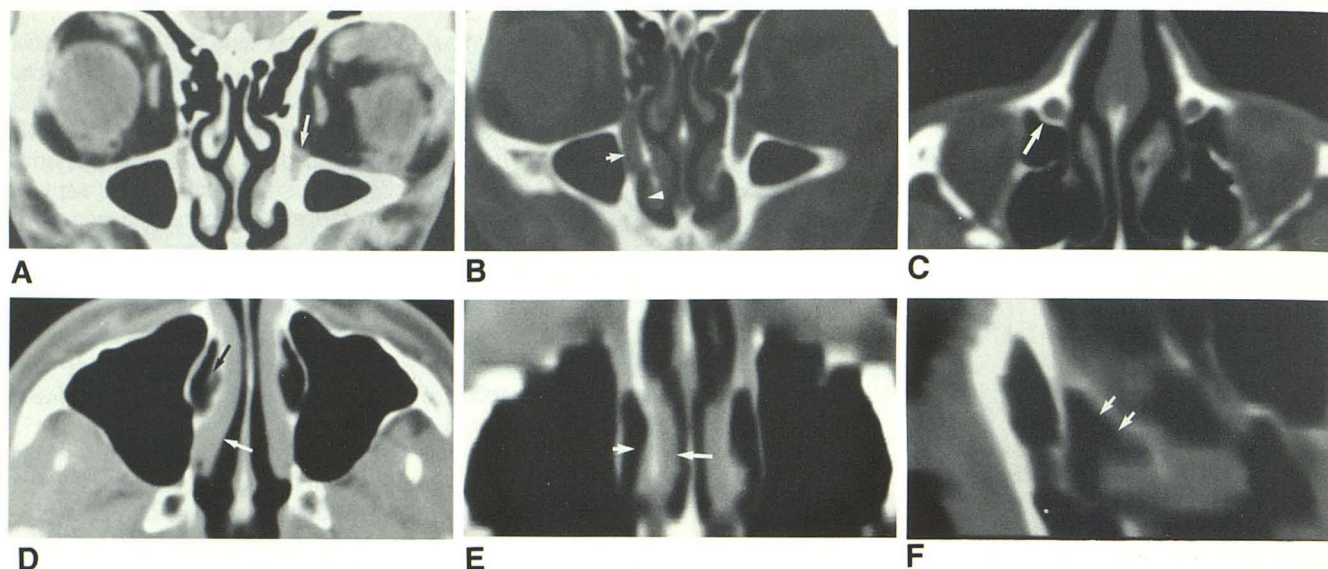


**A**                    **B**
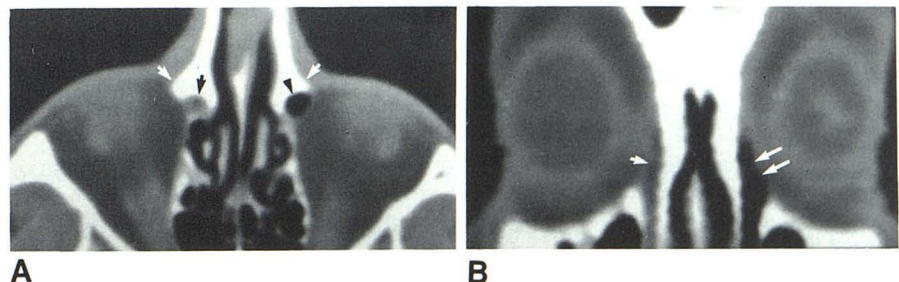
Fig. 7.—Direct and reformatted studies of nasolacrimal canal. **A** and **B**, Normal direct coronal scans through nasolacrimal canal. Note lacrimal sac (*large arrow*) as soft-tissue structure forming border with orbital fat. Wide-window image (**B**) better demonstrates bony nasolacrimal canal (*small arrow*) and its terminus at inferior meatus (*arrowhead*). **C**, Axial section below lacrimal fossa shows complete bony encircling of nasolacrimal canal (*arrow*). **D**, Lower axial section, at level of terminus of nasolacrimal canal within inferior nasal meatus. Terminus is funnel-shaped (*black arrow*) and lies lateral to inferior nasal turbinate (*white arrow*). **E**, Coronal reconstruction from axial images through vertical length of nasolacrimal canal. Note termination within air-filled inferior meatus (*small arrow*) lateral to inferior turbinate (*large arrow*). **F**, Sagittal reconstruction from axial images through inferior meatus (*arrows*), terminus of nasolacrimal canal, and duct (see fig. 2).

discussion of disease processes involving this region. The orbital septum attaches to the orbital margin at a thickening called the arcus marginale, which is formed where the periorbita joins with the periosteum. The attachment of the septum roughly follows the orbital margin, but is located more posteriorly along the medial aspect. Superomedially, the orbital septum leaves its bony attachment at the supraorbital margin, and as it descends inferiorly becomes attached to bone behind the upper aspect of the PLC. It then extends downward on the lacrimal bone behind Horner's muscle (lacrimal part of orbicularis oculi) and thus behind the lacrimal sac and the medial palpebral ligament. Passing more inferiorly, it leaves its bony attachment again and crosses the fascia covering the lacrimal sac and reaches another bone attachment at the ALC. Therefore, the lacrimal sac is, as previously noted, a preseptal structure.

## Results

Of the 100 patients examined with CT, 67 had no abnormality referable to the inferomedial orbit or adjacent nasal cavity and were considered normal for the purposes of the following anatomic description. The NLC and the lacrimal fossa are well shown in transverse axial CT sections obtained in a plane parallel to the hard palate. These structures are remarkably symmetric in size and appearance, although the normal NLD and the lacrimal sac are often asymmetrically aerated. The normal sac is not more than 2 mm in diameter, unless distended with air.

## Inflammatory Disease

Ten of the 33 patients with clinical signs referable to the inferomedial orbit were studied for possible complications of preseptal periorbital cellulitis. CT was effective in localizing the inflammatory process to the correct orbital compartment (pre- or postseptal) in all 10 cases. In five patients, CT revealed preseptal soft-tissue thickening only (fig. 8). Periorbital cellulitis was therefore diagnosed, and all of these patients responded to nonoperative therapy (antibiotics).

Medial orbital fluid collections (septal and postseptal) were present in the other five patients. One patient examined by pre- and postcontrast CT had a superficial lower lid abscess shown to be contiguous with a second cystic fluid collection centered at the lacrimal fossa (fig. 9). The location of the medial collection suggested lacrimal sac origin, and an abscessed sac was found clinically. In two of the five patients, medial subperiosteal (extraconal, orbital) abscesses were found, each associated with ethmoid sinusitis and each responding only to surgical abscess drainage (fig. 10). In the last two patients, CT findings characteristic of lacrimal sac dilatation (a cystic mass centered at the lacrimal fossa) were seen. This pattern allowed us to differentiate dacryocystitis (septal process) from an orbital (postseptal) abscess. Contrast-enhanced CT was essential for the correct diagnosis in one case (fig. 11A).

## Mucocele of the Ethmoid Sinus

Anteriorly placed mucoceles were found in three patients presenting with painless medial canthal masses. In one pa-
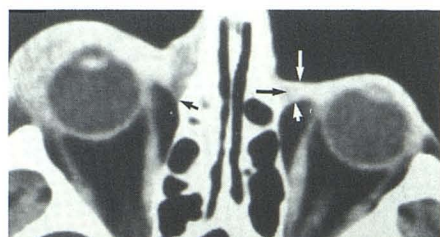
Fig. 8.—Preseptal cellulitis: 31-year-old man with lid swelling and conjunctival chemosis 6 months after frontal craniotomy for cerebrospinal fluid rhinorrhea. Note superficial soft-tissue swelling confined posteriorly by orbital septum (periorbita) attached behind posterior lacrimal crest (*small black arrow*). On normal side, medial soft tissue contains medial canthal ligament most anteriorly (*large white arrow*), split orbicularis oculi muscle, which invests lacrimal sac (*large black arrow*), and medial orbital septum (*small white arrow*) posteriorly. Cellulitis responded to antibiotic therapy.
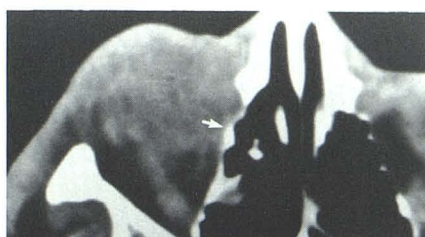
Fig. 9.—Preseptal lid abscess and related lacrimal sac abscess—value of infusion CT: 32-year-old man with long history of sinusitis, with acute pain and swelling of right eye, later associated with fever, chills, and tender mass at medial canthus. Lids were swollen shut, and clinical suspicion of exophthalmos prompted CT examination to exclude postseptal orbital cellulitis. **A**, Noncontrast scan. Homogeneous mass involves lower lid and inferomedial orbit. Note apparent extension of process within orbit proper, behind plane of posterior lacrimal crest (*arrow*). **B**, Contrast-enhanced scan. Peripheral enhancement of lid abscess (*arrowheads*), and second posteromedial cystic mass centered at lacrimal fossa (*arrow*), which represented dilated abscessed lacrimal sac. Lid abscess drainage was effective in delivering pus containing *Staphylococcus aureus*. No orbital surgery was required.



Fig. 10.—Postseptal (orbital) abscess in 10-year-old girl displaces lacrimal sac anteriorly. Patient had 3-day history of fever and chills, and periorbital swelling for 24 hr. Axial contrast-enhanced scans show medial subperiosteal orbital abscess bordered laterally by enhancing muscle and membrane (**A**, *white arrows*). Collection is centered behind lacrimal fossa (*black arrow*), and lacrimal sac is pushed forward (*arrowhead*). Underlying ethmoid opacification ($\beta$ = hemolytic streptococcus sinusitis) is seen well on wide-window image (**B**, *arrows*).
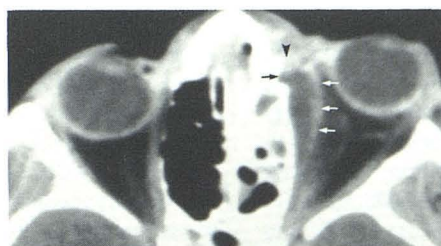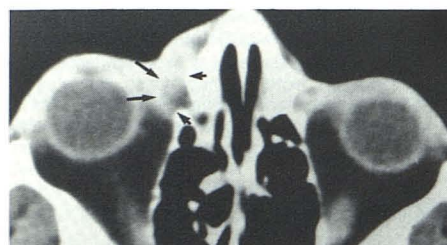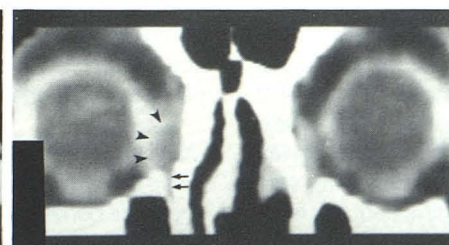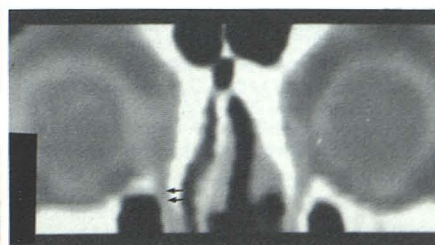


Fig. 11.—Chronic and acute dacryocystitis in two patients. **A**, Axial enhanced scan in 38-year-old woman with periorbital inflammation, tearing, and swelling of left eye for 2 weeks. Mucopurulent discharge could be seen at medial canthus. Dilated lacrimal sac is outlined by investing enhancing tissues (*large arrows*), confined by anterior and posterior lacrimal crests (*small arrows*). Complete resolution of edema and sac swelling followed oral antibiotic therapy.

**B** and **C**, Coronal reformations of axial scans through lacrimal sac in 78-year-old woman with chronic dacryocystitis. Ovoid mass (*arrowheads*) is centered at opening into nasolacrimal canal (*arrows*). Lacrimal probing and irrigation revealed nasolacrimal duct obstruction. Chronic swelling persisted despite antibiotic therapy. Patient refused surgery.

tient, the slowly expanding mass caused smooth erosion of the lacrimal fossa, leading to extrinsic lacrimal sac and NLD obstruction (fig. 12). Erosion of the NLC resulted in a ductal fistula draining toward the nasal cavity. Differentiation of mucocele from lacrimal sac dilatation rested on the more extensive bone destruction not centered on the lacrimal fossa, characteristic of sinus mucocele.

## Primary and Secondary Neoplasia

Fifteen cases had a tumor mass variably related to the lacrimal drainage apparatus. A primary tumor of the lacrimal sac (fig. 13) was found to extrinsically compress the sac, but not invade it. Secondary tumors spreading to the inferomedial orbit from primary sites in the nose and paranasal sinuses
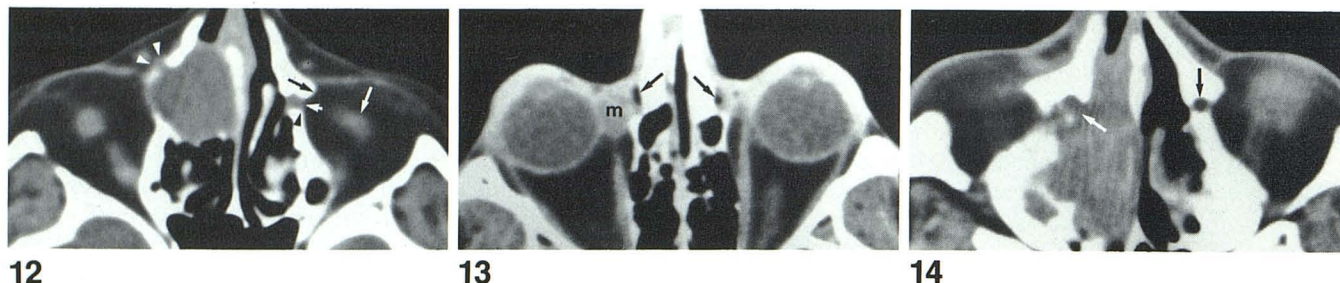
**12**   **13**   **14**

Fig. 12.—Right ethmoid mucocele with epiphora. Axial enhanced scan through nasal cavity and orbits. Normal anatomy on left: anterior lacrimal crest (*black arrow*); posterior lacrimal crest (*black arrowhead*); lacrimal sac (*small white arrow*); inferior oblique muscle (*large white arrow*). On right, expansile, homogeneous, nonenhancing mass (mucocele) erodes lacrimal fossa and presents at medial canthus (*white arrowheads*), bulging medially into nasal cavity. After operative removal of mucocele, methylene blue injected at lacrimal punctum leaked freely through upper duct into operative bed, indicating fistula, requiring surgical correction.

Fig. 13.—Extrinsic displacement of lacrimal sac by medial canthus mass in 26-year-old man with previously resected cutaneous melanoma. Pigmented

mass was noted at medial canthus. Air bilaterally fills lacrimal sacs (*arrows*); mass (m) displaces sac anteriorly on right. Clinically evident mass is extrinsic to sac, and is located anterior to posterior lacrimal crest (preseptal) and medial to insertion of medial rectus (extraconal). Surgery revealed yellow-blue fibroepithelial polyp arising from dome of lacrimal sac.

Fig. 14.—84-year-old man with nasal stuffiness and left orbital tearing (epiphora), with fullness at left medial canthus. Axial CT performed after nasal mass was discovered. Noncontrast scan through normal right lacrimal fossa (*black arrow*). Intranasal mass erodes medial left nasolacrimal canal (*white arrow*). Tumor (squamous cell carcinoma) responded dramatically to radiation therapy, with resolution of epiphora.



Fig. 15.—23-year-old man with right epiphora (chronic tearing) 1 year after severe midfacial trauma. Axial CT reveals extensive fractures of maxillae and nasal cavity. Patient also had sagittal fracture of hard palate. Intact nasolacrimal canal (NLC) on right (*large arrow*); severe left-sided medial maxillary disruption. Left NLC is comminuted and not recognizable (*small arrows*). Nasolacrimal duct was completely obstructed on left, and correction required dacryocystorhinostomy with acrylic and Silastic stenting.



Fig. 16.—Female infant with palpable medial orbital mass and epiphora: chronic dacryocystitis and mucocele of lacrimal sac, due to congenital obstruction of nasolacrimal duct and inferior nasal meatus (valvular atresia). Homogeneous soft-tissue mass at inferomedial orbit in expected location of lacrimal fossa. Note expanded fossa, with erosion accentuating posterior lacrimal crest (*arrows*). Mass represented dilated lacrimal sac, enlarged due to outlet (ductal) obstruction. (Case courtesy of Robert D. Zimmerman, M.D., New York Hospital, Cornell Medical Center, New York, NY.)

could be seen to invade the sac and destroy bone around the lacrimal fossa and the nasolacrimal canal. Such findings accurately predicted, in all cases, clinically observed epiphora due to ductal obstruction (fig. 14).

*Trauma*

Five patients were examined for severe central facial trauma. In two, despite multiple fractures, there was no fracture of the lacrimal fossa or the NLC. Neither of these patients developed epiphora. In the other three, fractures of the lacrimal crests and the NLC were observed. In two of these cases, associated sac and duct injury led to delayed

stricturing and the need for surgical restoration of ductal patency or lacrimal drainage via dacryorhinocystostomy (fig. 15).

## Discussion

The lacrimal sac, NLD, and inferior nasal meatus constitute the lower drainage pathway for tear fluid. The contour and position of each is easily recognized on transverse axial CT study. The lacrimal sac is a preseptal structure, lying anterior to the attachment of the medial orbital septum at the posterior lacrimal crest. The sac may contain air normally (fig. 6), and this air, by location, should not be confused with orbital

(postseptal) emphysema associated with fracture.

*Obstruction and inflammation* of the sac and the NLD may lead to dilatation of the sac (dacryocystitis), with or without associated preseptal periorbital cellulitis. Clinical testing, including probing of the sac and duct, is usually sufficient for diagnosing and treating most cases of obstruction [9]. However, cases do arise in which periorbital edema prevents adequate clinical examination, and CT is performed to clearly differentiate uncomplicated periorbital cellulitis (fig. 8) from orbital abscess (fig. 10), the latter requiring operative intervention [6–8]. While most cases of dacryocystitis are diagnosed clinically, orbital swelling may mask sac dilatation. CT performed in such cases will reveal an inferomedial orbital fluid collection that might superficially resemble orbital abscess. The exact localization of the collection is critical for proper therapy, as preseptal infection and acute dacryocystitis are usually best treated without surgical interference. Lacrimal sac dilatation (fig. 11) should be easily recognized as a cystic mass centered at the lacrimal fossa in all planes. Coronal image reformation is extremely useful for confirmation of sac dilatation, as the mass can be shown to lie just above the superior orifice of the NLC (figs. 11B and 11C).

An infantile form of lacrimal sac dilatation results from failure of perforation of the lower end of the NLD at Hasner's valve near the inferior nasal meatus. When mild, this form of obstruction clears spontaneously or responds to gentle sac massage within the first few days of life. If obstruction persists, ductal probing or surgical drainage (dacryocystorhinostomy) may be indicated to obtain patency. In untreated cases or with more severe forms of NLD atresia, chronic dacryocystitis and mucocele formation occur [13, 16]. Clinically, the resulting medial canthal mass may resemble lateral nasal meningocele, and radiographic study may be required for such differentiation [17]. A case of congenital NLD atresia with mucocele of the lacrimal sac is presented as figure 16. CT should replace the more invasive dacryocystogram for the differentiation of sac mucocele from meningocele, as CT can with certainty demonstrate normal sinuses and bone between the orbit and cranial cavity.

Medial postseptal (intraorbital) abscesses are often associated with ethmoid sinusitis. These fluid collections are never centered at the lacrimal fossa, as they are contained anteriorly by the insertion of the medial orbital septum just behind the PLC. The lacrimal sac and the investing orbicularis oculi muscle may be bowed anteriorly by such postseptal collections (fig. 10A). A medial orbital fluid collection with its maximal width centered behind the PLC is an orbital abscess.

It is also important to realize that localized preseptal (lid) abscesses may occur in association with periorbital cellulitis, and these collections may require surgical drainage. Contrast-enhanced CT is useful for demonstrating the abscess as a nonenhancing region surrounded by inflammatory tissue (fig. 9B). Such collections may not be appreciated on noncontrast studies.

*Primary tumors of the lacrimal sac* are rare [18], usually arising from the pseudostratified columnar epithelial lining of the sac. In a series of 184 cases reported by Radnot and Gall [19], 86 were epithelial tumors and two-thirds of these were malignant. The most common malignancy is transitional cell carcinoma. Tumor may mimic chronic dacryocystitis clinically, although the finding of blood within the sac fluid and a medial swelling centered above the canthal ligament suggest tumor. Despite this, tumors are often missed for months or years [20], as treatment for infection may transiently improve associated swelling. Polytomography and dacryocystography may suggest tumor by revealing lacrimal fossa erosion and luminal irregularity [18, 21]. The diagnosis of tumors arising from the dome of the sac often requires contrast material injection (dacryocystography) [21]. CT should easily differentiate such tumors from chronic dacryocystitis. Although no conclusions can be drawn from our limited series, the CT findings of sac enlargement are quite characteristic and should be easily distinguishable from the findings with a solid tumor. The tumor may be seen to displace the air-filled sac, as in our case of benign fibroepithelial polyp (fig. 13). Further study may show CT to be of use for the earlier diagnosis of lacrimal sac neoplasia.

CT is the procedure of choice for determining the full extent of *malignant tumors* involving the facial skeleton, orbit, and nasal cavity [3, 22, 23]. Masses appearing clinically superficial often have silent deep extensions, and CT is often of use for defining tumor extent and planning surgery. The presence of signs of lacrimal drainage obstruction in a patient with a nasal or paranasal sinus tumor (nasal fullness and epiphora) should prompt CT study, unless the clinical findings are characteristic of uncomplicated dacryocystitis. Knowledge of the CT anatomy of the lacrimal apparatus should allow the examiner to define tumor involvement and the point of obstruction (fig. 14).

*Traumatic lacerations* of the lacrimal canaliculi occur often with lid trauma. Such injuries rarely involve the more distal drainage apparatus, as the lacrimal sac is protected by the nasal pyramid and the ALC [24]. Blunt trauma resulting in orbitonasal fracture may result in transient epiphora due to acute ecchymosis and edema of the superficial tissues [20]. If tearing should persist after soft-tissue swelling has subsided, or if obstruction of the NLD is signalled by recurrent dacryocystitis, clinical assessment of the point of obstruction may be required to plan for ductal dilatation or surgical drainage (dacryocystorhinostomy).

Fractures of the bony structure of the lacrimal fossa and the nasolacrimal canal are associated with acute and delayed posttraumatic obstruction of the nasolacrimal apparatus [25, 26], often requiring surgical correction for chronic epiphora. Axial CT is well suited for definition of these fractures and the degree of fracture fragment rotation and displacement. Motor-vehicle accidents often cause severe blunt trauma of the midface and complex nasofrontal injuries. Comminution and telescoping of fragments place the nasolacrimal drainage apparatus at high risk, although the incidence of such associated injury is low [27]. The osseous part of the NLD is most vulnerable, as fractures often propagate through the structurally weak bony lacrimal canal [28, 29]. Of 96 patients with medial orbital fractures studied by Powell [20], 38 (40%) had obstructive nasolacrimal symptoms. In 30, symptoms cleared spontaneously. In six patients (15%), persistent symptoms

required surgical therapy.

CT can and should be used to accurately demonstrate the fractures most often associated with posttraumatic epiphora, but should not be used routinely to assess for ductal obstruction, as more routine clinical testing including the fluorescein dye test [30] is usually sufficient. However, undue closed manipulation of sharp displaced fracture fragments in the region of the nasolacrimal duct may lead to sac or duct laceration, followed by scarring. CT can detect such dangerous fragments (fig. 15) before manipulation, and such findings may thereby direct more appropriate open surgical therapy.

Chronic dacryocystitis in the adult may arise in the wake of trauma due to stricturing of the NLD. In 85% of cases, the obstruction is at the junction of the lacrimal sac and the NLD [31]. Dacryocystography may differentiate the classic high obstruction from lower obstructions occurring in the mid NLD, which usually follow fractures of the NLC. This localization may be of some importance in planning surgery (dacryocystorhinostomy) so that a lower, infected, ductal part does not remain after surgery [31]. It does not seem that CT can securely diagnose a point of obstruction, although the location of fracture fragments may suggest the location of the point of obstruction when CT is obtained for preoperative (open reduction) planning.

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