T H E S I S

CLINICAL RADIOLOGICAL INVESTIGATIONS

of the

LACRIMAL SYSTEMS

and the

MANDIBULAR JOINTS

PART I

THESIS SUBMITTED FOR THE DEGREE OF

DOCTOR OF MEDICINE, EDINBURGH UNIVERSITY

CLINICAL RADIOLOGICAL INVESTIGATIONS

of the

LACRIMAL SYSTEMS

and the

MANDIBULAR JOINTS

Procedures and Observations carried out by

WILLIAM CAMPBELL, M.B., Ch.B., Edin.,
D.M.R.D., R.C.P. & S. Eng.,
Hon. Major R.A.M.C.

Consultant Radiologist to the Plastic Surgery and Jaw Injuries Centre, East Grinstead, also to the Tunbridge Wells Group of Hospitals, Lecturer in Maxillo-facial Radiology for the Diploma in Medical Radio-Diagnosis and for the Fellowship of Dental Surgery of the Royal College of Physicians and Surgeons of England since 1952

C O N T E N T S

PART I

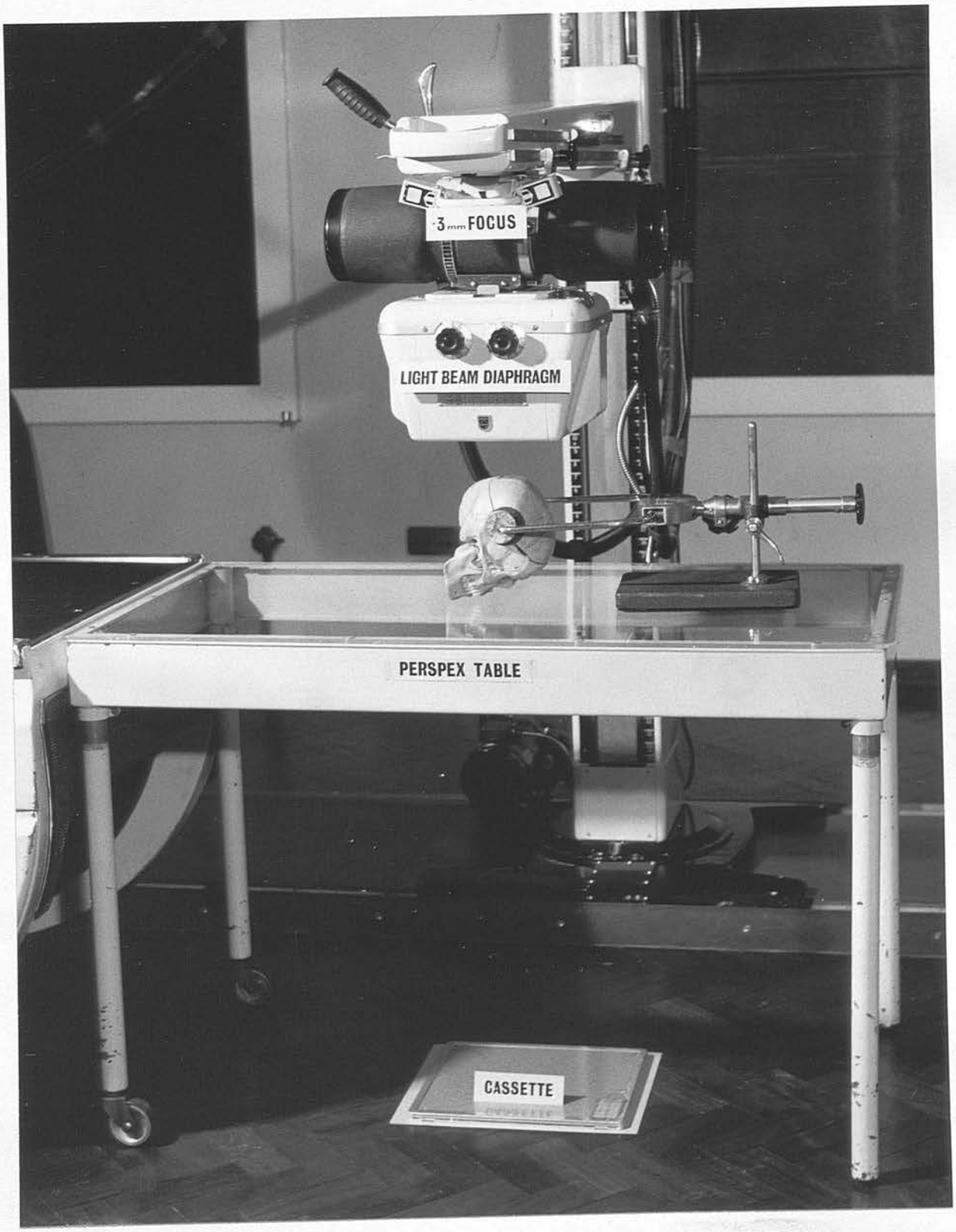
THE LACRIMAL SYSTEMS

PART I

THE LACRIMAL SYSTEMS

INTRODUCTION

My thesis on clinical radiological investigations of the lacrimal systems and mandibular joints is based on the experience gained in the last fifteen years as consultant radiologist to the Plastic Surgery and Jaw Injuries Centre of East Grinstead in Sussex. Injuries of the lacrimal systems and mandibular joints were associated with cases admitted to the centre, and as time went by disorders of these particular systems alone were referred in increasing numbers from far and wide for diagnosis and treatment. In both systems a substantial influencing factor upon the number of cases encouraged to the centre was the fact that satisfactory routine radiological methods of examination of these systems were established, and a clinical liason had grown up between myself as radiologist and the ophthalmic and dental surgeons.


·3 mm FOCUS
LIGHT BEAM DIAPHRAGM
PERSPEX TABLE
CASSETTE

THE LACRIMAL SYSTEMS

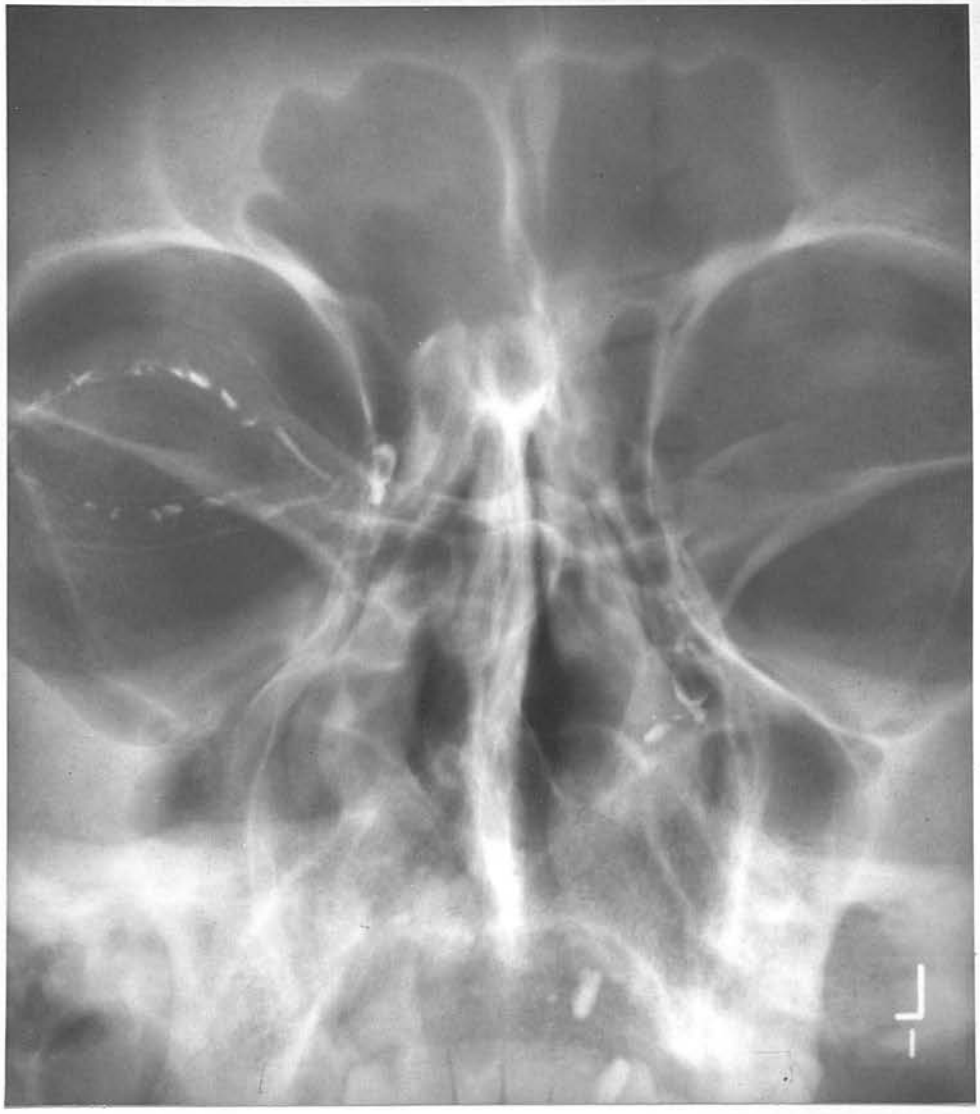
A complication of fractures of the facial bones is obstruction to the flow of tears from the eye into the nose. Consequently an ophthalmic surgeon, now Sir Benjamin Rycroft, was appointed in 1947 to make up the post-war establishment of the Plastic Surgery and Jaw Injuries Centre at East Grinstead. He was particularly interested in the treatment of epiphora and I was able to take an interest in this work. I found the available information on the radiology of epiphora at that time of very little value and the accepted methods of radiography not sufficiently accurate or informative. In the "British Authors Textbook of X-Ray Diagnosis" this subject is dismissed in half a page.

METHOD OF EXAMINATION

I attempted an enlargement technique in 1948 using a standard rotating anode tube and a long object film distance, but the results were very coarse. In 1950 Dr. G.J. Van der Plaats published his work on "X-ray Enlargement Technique" using a 0.3 mm focus tube. By 1954 I had obtained a micro-focus tube, and I converted a table into a device for rapid routine macro-dacryocystography. This has been in constant use since that time with highly successful results, of considerable value in the surgical treatment of epiphora.

The table is illustrated in the photograph and was made by substituting the wooden top of a supplementary table of a Philips Tomograph Unit by perspex ruled with cross-lines, so that the light beam diaphragm could be pre-centred. The table is four feet in length and of the same width as the radiographic

Case no. I. Hilda Walling.



Comparative pair to scale.

couch. Two of the legs at one end have wheels so that it can be manoeuvred rapidly into position against the end of the X-ray couch and remain positioned by virtue of the non-wheeled legs at the other end. The height of the table is such that the floor to the table distance gives an optimum magnification of $2\frac{1}{2}$ diameters. The floor is marked in line with the cross-lines of the table and of the light beam, so that cassettes can be rapidly placed in position. A sheet of 12 x 10 yellow paper sellotaped to the floor has proved the simplest method for placing the 12 x 10 cassettes and limiting the beam to that size.

To establish a routine technique for the procedure of dacryocystography, I took a lateral radiograph of the dried skull with a probe in the naso-lacrimal duct and rotated it to bring the plane of the lacrimal duct parallel with the table top, and measured the orbito-meatal angle as formed with the table top. This angle is 40° and for practical purposes is achieved when the nose and chin are firmly against the table top. In this position the petrous temporal bone is across the base of the antral cavity. A set square was cut to 40° for setting up the head. The head is placed so that the infra-orbital rim (that is approximately the middle of the naso-lacrimal duct) is over the transverse line inscribed on the perspex table top. The tube has previously been centred to these lines and to the film site below the table by virtue of the light beam. The factors used are 125 K.V. at 10 M.A. with time factors of 0.15 seconds for the P.A. and 0.3 seconds for the lateral using 80502A Kodak film.

Case no. II. May Rainbird.

Lateral of case no. II opposite to show penetration of superimposed ducts. (Actual size).

The sequence of events is to inject the lacrimal system of one eye with the patient supine. He is then turned over and a 40° O.M. projection made, followed by a lateral projection, and the process repeated for the other eye if indicated - the detail of this to be discussed later. This method has the advantage first of all, of a $2\frac{1}{2}$ times magnification of these small structures (illustrated by a comparative pair, page 8), secondly, of speed by using 125 K.V. and no grid. An excellent contrast is obtained from the filtration of the large air-gap. Thirdly, an important advantage is that the lateral projections are close-focus technique projections of an order to make clearly distinguishable one injected lacrimal duct from the other, although these are superimposed (page 13). Penetration of both filled ducts is effected by the high K.V. With this method no oblique projections are necessary to distinguish between the two sides.

Of a total of over three hundred dacryocystogram examinations, I have carried out two hundred using this method. The type of cases initially investigated in this centre were, in the first instance, those associated with the face injuries, but gradually cases of epiphora from every cause were referred for treatment and advice, so that it has been possible to build up a general radiological picture of the appearance of the lacrimal system in disease. These appearances all have a value in the assessment of the duct obstructed primarily because of trauma, in that the next stage is so often the varied appearance of an infected lacrimal system. It is impossible in the majority of cases to be able to assess

the aetiology of the obstruction from the radiograph.

SYSTEM OF PHYSICAL INVESTIGATION OF CASES OF EPIPHORA

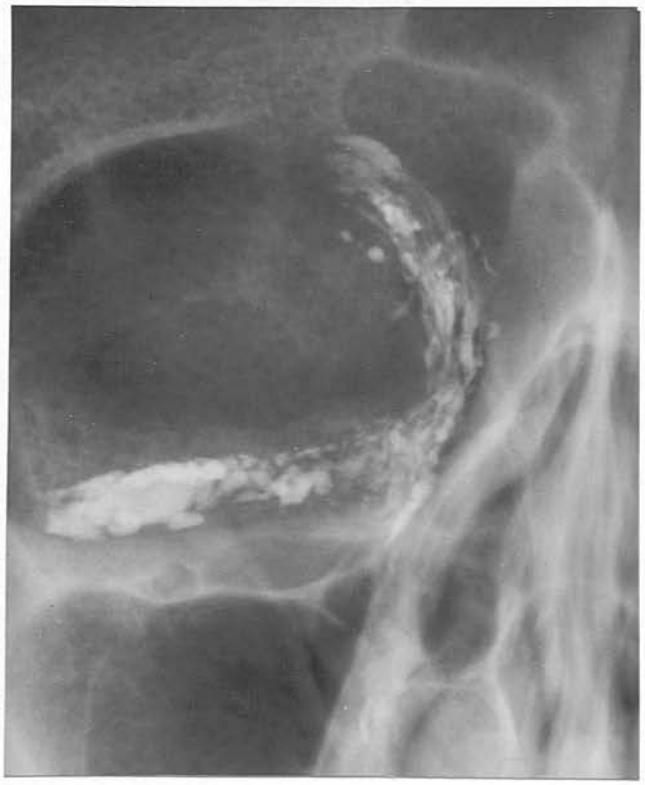
Epiphora is defined by Sir Stewart Duke-Elder, in contra-distinction to lacrimation or the excessive secretion of tears, as the imperfect drainage of tears through the lacrimal passages so that they fall over the lid-margin on to the cheek.

The treatment of epiphora is surgical. It is essential prior to planning treatment to determine the location and, if possible, the nature of the obstruction to the normal course of the tears from the eye to the nose.

A clinical assessment of the eyes determines if the puncta are normally placed. They take up fluid by capillarity by opposing the globe. Normally when the eye looks upwards the lower punctum should not be visible without slightly everting the lid. There is rarely any doubt about this but, should doubt exist, then installation of rose of bengal solution can decide the question because it selectively stains the posterior margin of the lower lid. If the punctum lies without the stained area an eversion is present.

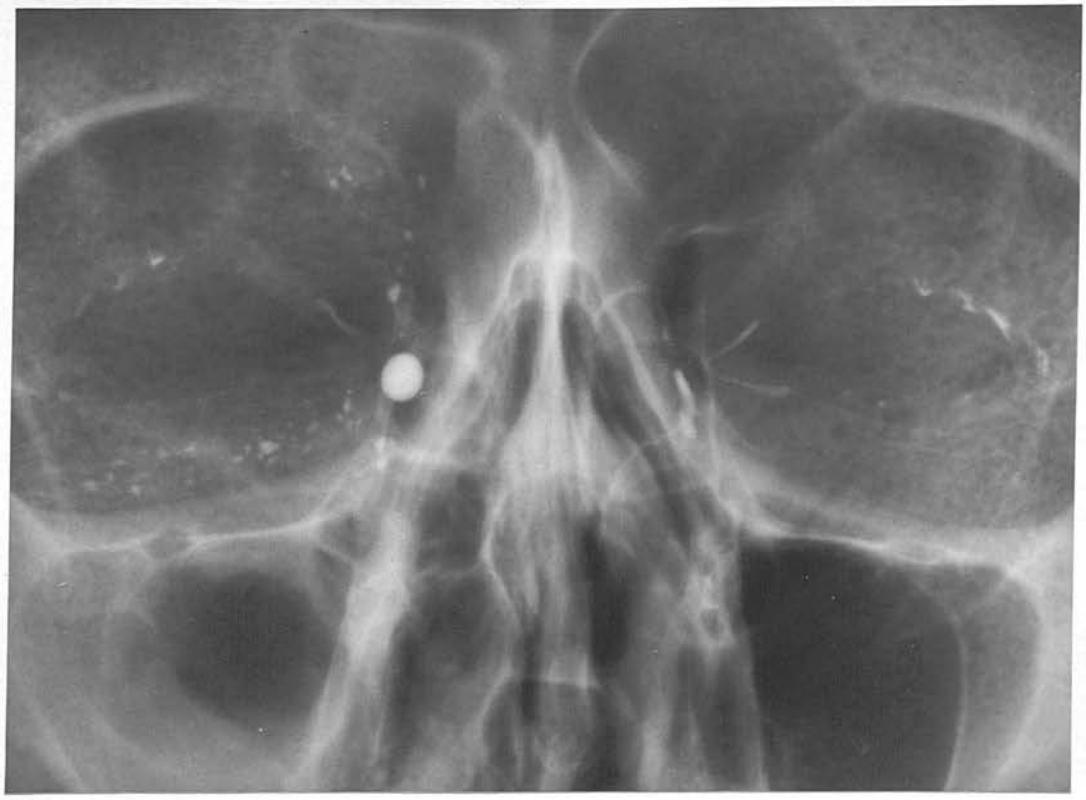
The appearance of the lids and their movements are observed. Pressure is applied by the finger over the area of the lacrimal sac to express any secretions retained within it, either out through the puncta or into the nose. The conjunctiva and cornea are carefully examined to exclude any injury, abrasion, foreign body or inflammation.

An assessment of the patency of the lacrimal passages is the next step. Of the three methods employed to do this, namely, the installation of a coloured fluid (fluorescein) into



Case no. III. Mrs. Hammerton.

False passage, with injection of periorbital tissues.



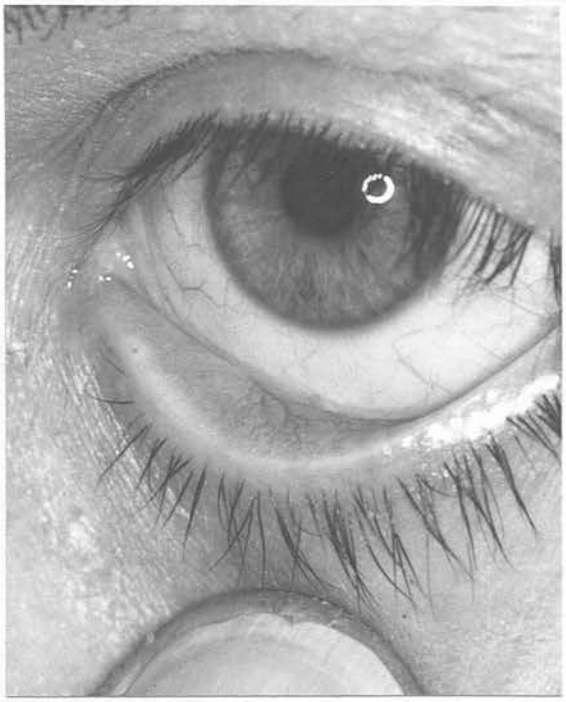
Three months later.

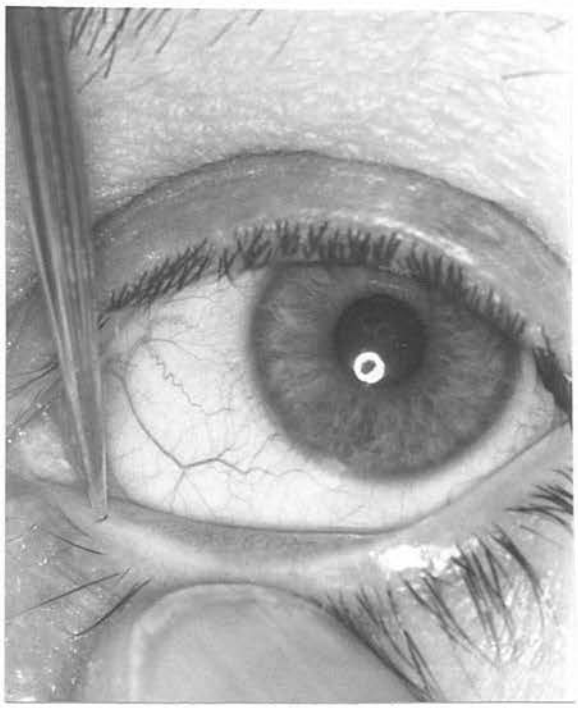
the conjunctival sac then to be detected in the nose, probing, and syringing, the latter is in my opinion the most useful when carried out with a radio-opaque fluid, and is the only method really necessary. Although invariably carried out, syringing with saline has nothing to commend it as a diagnostic measure, apart from the possibility of shifting a mucous plug and thereby freeing drainage without recourse to X-rays.

TECHNICAL PROCEDURE OF DACRYOCYSTOGRAPHY

The anatomy of the lacrimal passages is of importance in the technical procedure of dacryocystography, the most important practical point being that each canaliculus consists of a vertical and a horizontal portion. The vertical portions are approximately $2\frac{1}{2}$ mm long and the horizontal portion at right angles to the vertical being approximately 7 - 10 mm long. The lids must be everted to reveal the puncta. The importance of the technique of the injection of the opaque media is related to these anatomical facts in that a false passage may be created (page 20) or the punctum may be damaged.

The injection procedure for macro-dacryocystography is to place the patient supine with the head on pillows on the perspex table over the crossed lines, and firstly to apply pressure over the area of the lacrimal sac against the nasal bones. If the neck of the lacrimal sac is occluded it may be distended with fluid and this fluid will be expressed through the puncta, or even forced down into the nose. This is a necessary preliminary of the technique of injection of the opaque medium because if the sac is not emptied before the medium is injected a false impression of the size of the lacrimal sac may be given.





Fluid in the sac will also cause an oily medium to globulate(page27) and to give the false impression of a polycystic sac or one with a diverticulum. The fluid which flows back from the distended sac gives information of prognostic value, since it is either clear or thick from infection or purulent.

The eye to be injected is anaesthetised, using two or three drops of Ophthaime in the region of the lacrimal lake. The injection can be carried out without anaesthesia but the anaesthetic does make the procedure easier for both operator and patient, because the blinking from slight pain is less and the lacrimation is also less with anaesthesia than without.

The lower punctum is the most easily entered and this is displayed, as shown (page24) in photographs of the sequence of events of this procedure, by depressing the lower lid with the pad of the thumb on the cheek and everting the lower lid, at the same time directing the patient to look upwards and outwards. It is usually necessary now to dilate the punctum with a blunt Nettleship dilator. The dilator is, in the first instance, held vertically and introduced in this direction, it is then rotated through 90° whilst the canaliculus is maintained stretched in a lateral direction so that the punctum and canaliculus are in a straight line. If this is not done, the dilator and subsequently the lacrimal cannula may strike against a fold of mucosa and produce a false passage if pressure is continued. Such a case is illustrated and followed over a period of three months by which time the Neohydriol was almost completely absorbed, and the continuity of the canaliculus restored (page20).

The dilator is then substituted by a silver lacrimal cannula

Globulation in mucocele of lacrimal sac.

with a Luer lock fitting attached to a 1 c.c. syringe loaded with fluid Neohydriol. It is introduced in the vertical direction, rotated through 90° and slid along the canaliculus stretched into a straight line until the bony wall of the nose is felt through the medial wall of the lacrimal sac. The cannula is then withdrawn a few millimetres and the fluid is injected. If patency exists the patient very rapidly tastes the fluid and at this point radiography can commence. If the passages are occluded then regurgitation takes place through either the lower or upper punctum, or both. In either event it is worthwhile everting the upper lid, directing the patient to look downwards, and injecting the upper canaliculus. When regurgitation takes place again through the lower canaliculus it is also worthwhile occluding this to obtain good filling of the canaliculi, the sinus of Maier, the sac and possibly effecting a complete filling of the naso-lacrimal passages in cases of partial obstruction. The lower canaliculus is occluded with the point of the Nettleship dilator during injection through the upper punctum. Droplets of Neohydriol on the eye-lashes help to orientate the soft tissue, but the creases of the skin about the eye should be wiped as free as possible of the oil. The quality of the films with this technique is, however, so good that the eyelids themselves cast a shadow when they are open. If the eye-lashes are also free of oil the canaliculi are more readily seen in the lateral projection when they have retained the medium.

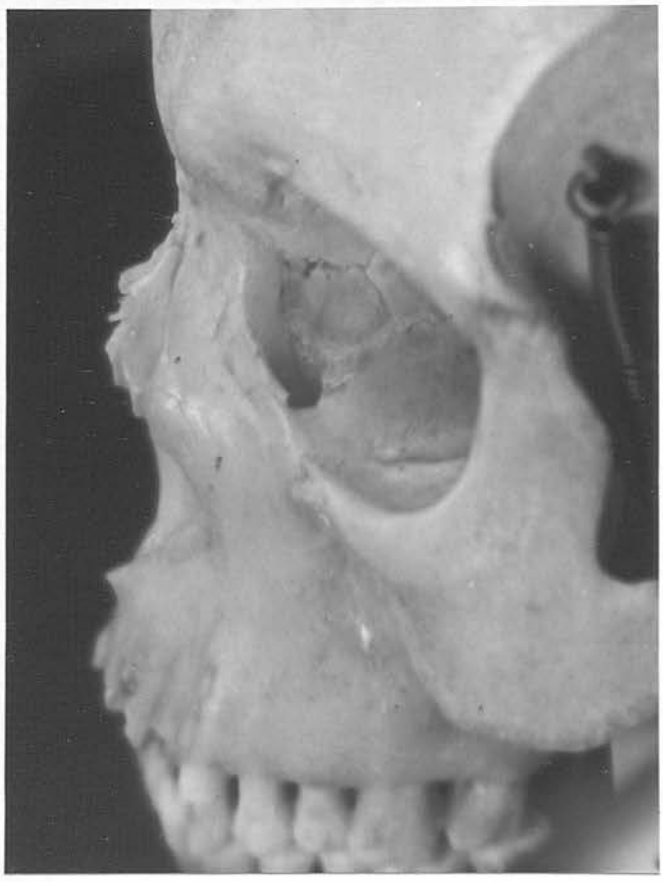
PRACTICAL INTERPRETATION FROM PROCEDURE

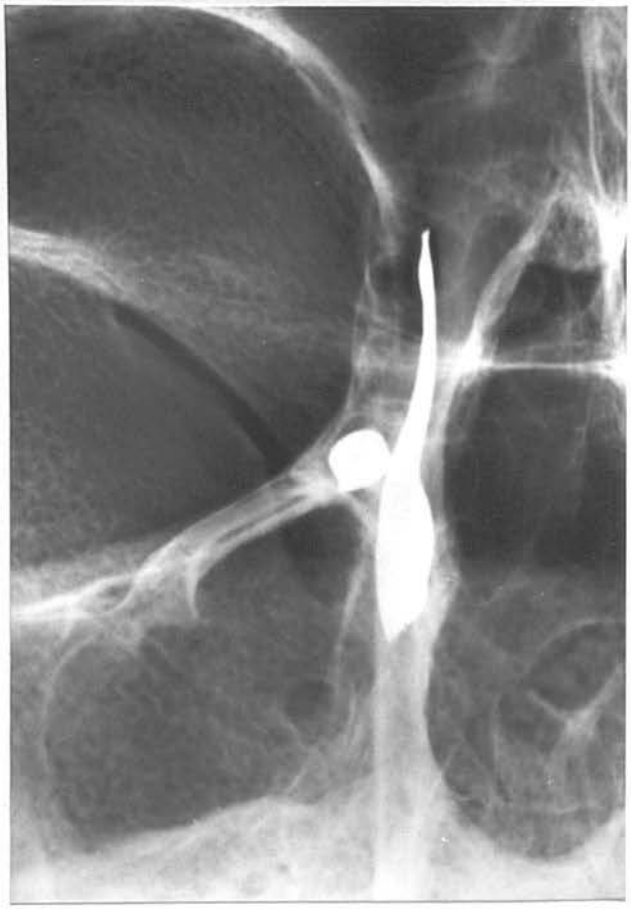
Useful information may be obtained from the practical procedure of injecting the opaque medium. The lacrimal cannula may detect the presence of a stricture as it is passed along the canaliculus, and then, as in the case illustrated (page 54) injection of the upper canaliculus should result in the retrograde filling of the medial part of the lower canaliculus and thence the radiographic demonstration of this stricture. A fistula of the canaliculus itself may exist when the punctum, although in apposition to the globe, is found to be too small from disuse to admit a lacrimal cannula. Careful search reveals the fistula which can be entered and the system injected.

Occasionally when a high ampullary obstruction exists in the system regurgitation takes place through both upper and lower canaliculi, and yet the medium is not retained a sufficient length of time for its radiographic demonstration. It is therefore of fundamental importance that the radiologist must carry out this examination himself, or be with the Ophthalmologist who is doing it, to be able to interpret the results of the examination correctly. A comparison can be drawn between this and the screening of the stomach, and the relationship of this procedure to the subsequent radiographs.

RADIOLOGICAL ANATOMY

The anatomy of the lacrimal system has features of importance and features which do not bear out the generally accepted theories of the causes of obstruction. The total length of the naso-lacrimal duct, together with the lacrimal sac, is a passage of approximately 3 cms, whilst the bony nasal canal is a passage of only 1 cm in

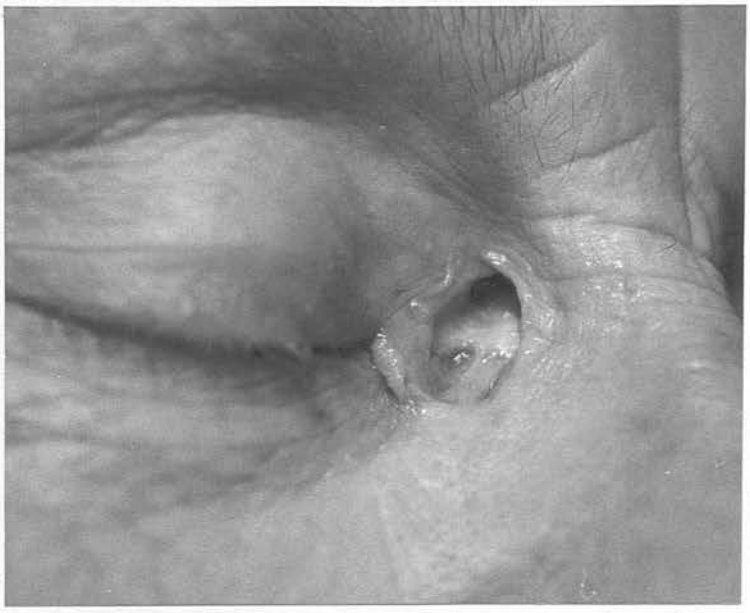




length. There is, therefore, more of the lacrimal passage-way within the orbit and not surrounded by bone than might be assumed to be the case from routine X-rays of the opaque medium filled duct. This is evident from the photograph illustrating the bony canal within the orbit on the dried skull, and the radiograph of the same skull in the described position for viewing the duct (page 34). In the radiograph of the dried skull the naso-lacrimal duct is exactly outlined by lead on its medial wall and the level of the rim of the foramen of the naso-lacrimal canal in the bone is indicated by a ring of lead. This demonstrates that in fact two-thirds of the lacrimal duct is within the orbit. Bearing the position of the foramen in mind when interpreting the level of obstruction of the passage-way, I found obstruction to be rare at this level. That is to say, the generally accepted conclusion (E.R. Veirs) that obstruction takes place at the level of the bony canal because of the limited room for swelling to take place in cases of infection is not entirely correct. Obstruction takes place at a higher level, that of the neck of the sac. My analysis of two hundred macro-dacryocystograms, laid out on page 85, shows that complete mid-level obstruction occurred in only 22% at the level of the bony rim of the canal. The remaining 77% occurred at the neck of the sac.

To attempt to determine the reason for this I carried out a post-mortem room dissection after injecting the lacrimal system with methylene blue in oil, to define it from the surrounding structures (page 38). I found that the fascia of the orbicularis which split to encase the lacrimal duct was tough,

Post-mortem dissection.

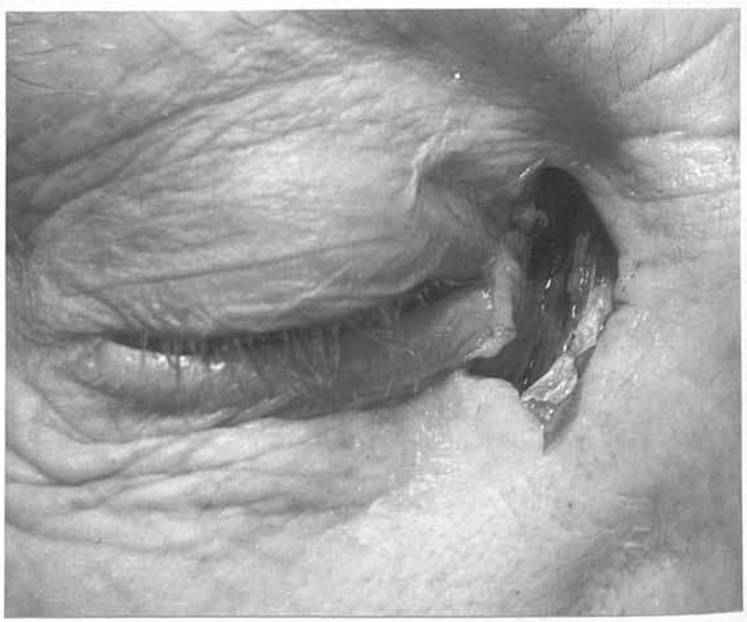


Medial palpebral ligament defined.

Split fascia defined to the constricting level. Lacrimal sac displayed.

Lacrimal sac & duct reflected. Lacrimal fossa perforated.

Lacrimal sac opened. Methylene blue reflecting the light.

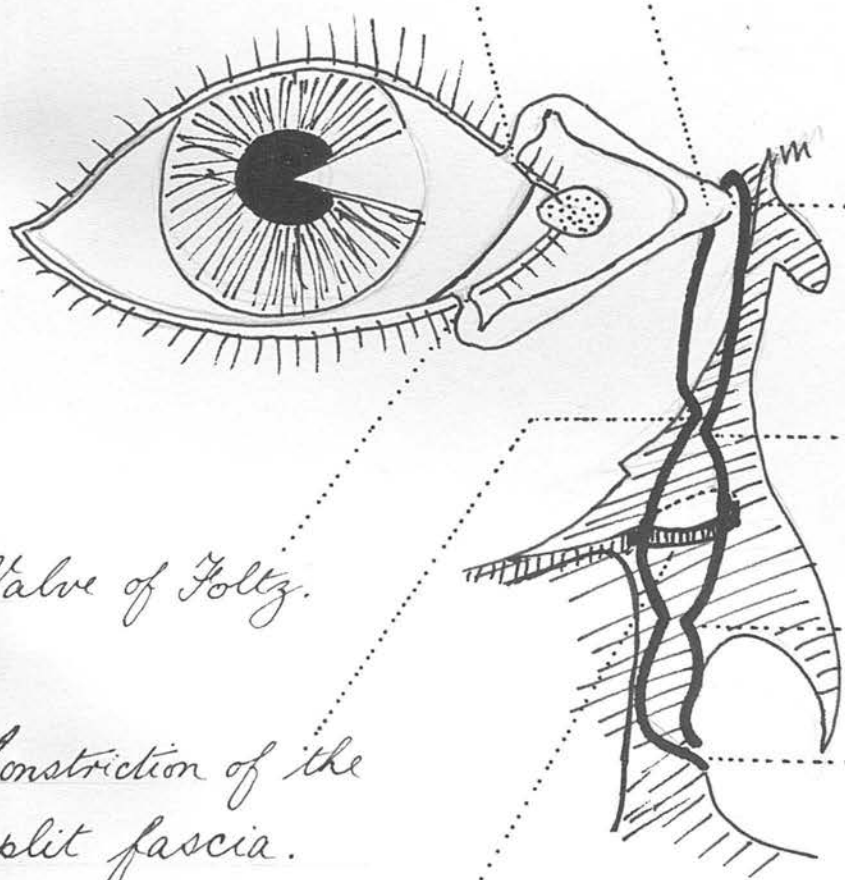


thick and tight about 0.5 cms above the lacrimal spine and approximately 0.7 cms above the bony rim of the canal. The indentation of this part of the fascia is evident in those dacryocystograms where the obstruction is incomplete and the duct is distended (page 69). Obstruction takes place at this level due to the limited space for swelling caused by the tautness of the fascia dividing here, as the duct tends to change its direction and incline slightly backwards. This is also the level of the mucosal fold called the valve of Krause, and this must also contribute to the occlusion when there is swelling of the tissues from infection.

The view is held by some (S.A. Fox) that the medial palpebral ligament prevents distension of the cupula of the lacrimal sac. My findings, by both dacryocystography and dissection, do not support this. This is clearly evident in the case illustrated on page 58 where the inner canthus of the eye is well marked by Neohydriol in relation to the distended sac. Also the point of entry of the ampulla of the canaliculi into the lacrimal sac is seen in the lateral projections (page 91) to be near the apex of the cupula. In the dissection, the medial palpebral ligament is demonstrated to be in line with the margin of the upper lid, that is in the plane of the upper canaliculus. Therefore only the very tip of the cupula is shielded by the ligament, so that it cannot prevent swelling of this part of the sac, which displaces beneath it. The sac is approximately 1.2 cms long and 0.3 cms in width, and is displayed in the dissection as a flattened tube which can be likened in radiology to the stomach, in that its walls are

× Level of constriction of neck of lacrimal sac by split fascia.

Diameter of bony rim of canal, + 4 mm.



Normal lacrimal passages.

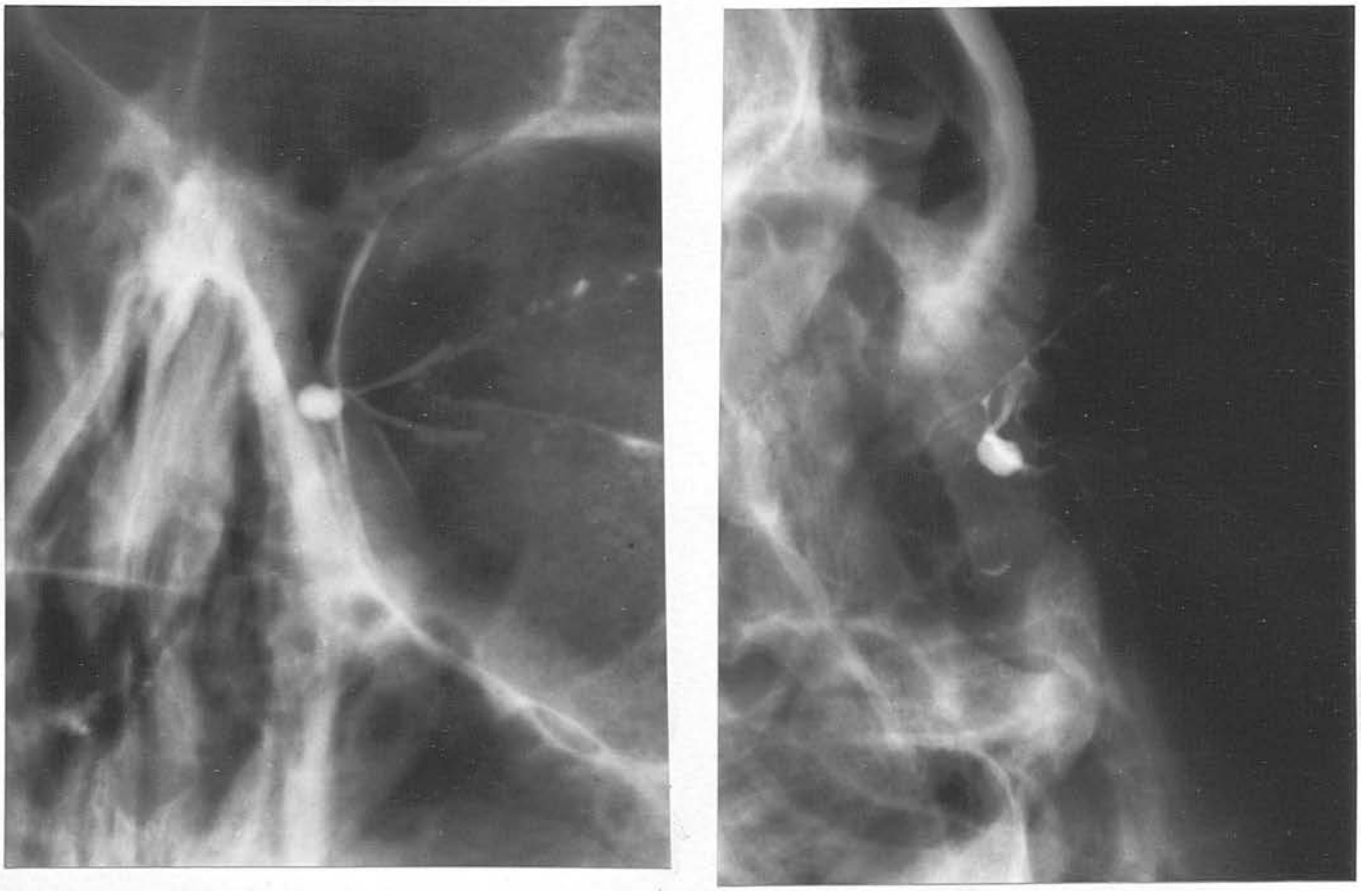
approximated until separated and distended with an opaque media or other substance. In the case of the lacrimal sac, it is capable of great distension as far as the tight band fascia described about its neck, because above this it is covered by only the thin portion of the split fascia of the orbicularis and by fibres of that muscle.

The bony rim of the lacrimal canal is surprisingly wide, and measures a little over 4 mm in diameter in the skull photograph (page 42). The anatomical tendency is, therefore, towards a duct or tube of increasing diameter from above downwards.

The lower opening is below the inferior turbinate and is further back in the anatomical specimen than would seem to be the case from the radiographs.

The size and shape of the sac and the remainder of the system, distended by slight pressure from a partial obstruction at the lower end of the duct, is illustrated by macro-dacryo-cystograms (page 49). This type of projection shows to advantage the indentations in the system which correspond to the named valves or mucosal folds. The neck of the lacrimal sac is marked by the valve of Krause. The valve of Taillefer produces an indentation at a variable position within the bony canal, but usually in the middle. The valve of Hasner is at the very termination of the duct.

The canaliculi fuse in the sinus of Maier. Some 1 - 3 mm long, this sinus, or ampulla, is situated on the antero-lateral aspect of the apex of the sac. It is visualised on the lateral radiograph with the canaliculi converging into it. It has never



Entry of canaliculi into the sinus of Maier, or ampulla, in a case of failed dacryocystorhinostomy.

Case no. I (continued). Mrs. Hilda Walling.

Partial low level obstruction at the valve of Hasner.

been described as a radiological quantity, probably because without the advantage of the macro-radiographic technique it is scarcely visible. At the entrance of the ampulla into the sac are the mucosal folds of the valve of Rosenmuller. The presence of these folds and the bulbous nature of the ampulla are the reasons for those cases of obstruction in which no filling of the sac can be achieved in dacryocystography.

The canaliculi themselves vary in width and on the macro-radiographs they are clearly widest in the lateral thirds of their horizontal portions. (page 48).

INTERPRETATION OF DACRYOCYSTOGRAMS

Classification of Obstructions

From a survey of my 200 macro-dacryocystograms of cases of epiphora I found that the common sites of obstruction fell broadly into high, middle and low level obstructions of the lacrimal passages.

(1) High Level Obstructions - these were in the canaliculi or in the ampulla.

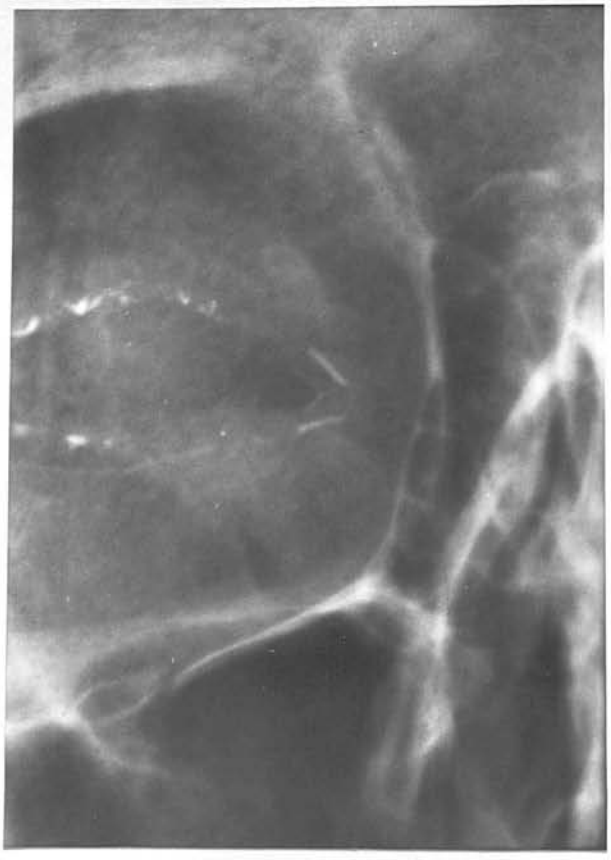
(2) Mid Level Obstructions - these were in the region from the neck of the sac to the lower third of the bony canal.

(3) Low Level Obstructions - these were at the lower end of the naso-lacrimal duct, that is at the valve of Hasner.

The relative frequency of the high, middle and low obstructions is -

22%	High
62.5%	Middle
15.5%	Low

Case no. IV Arthur Weston.



Ann Mellor.

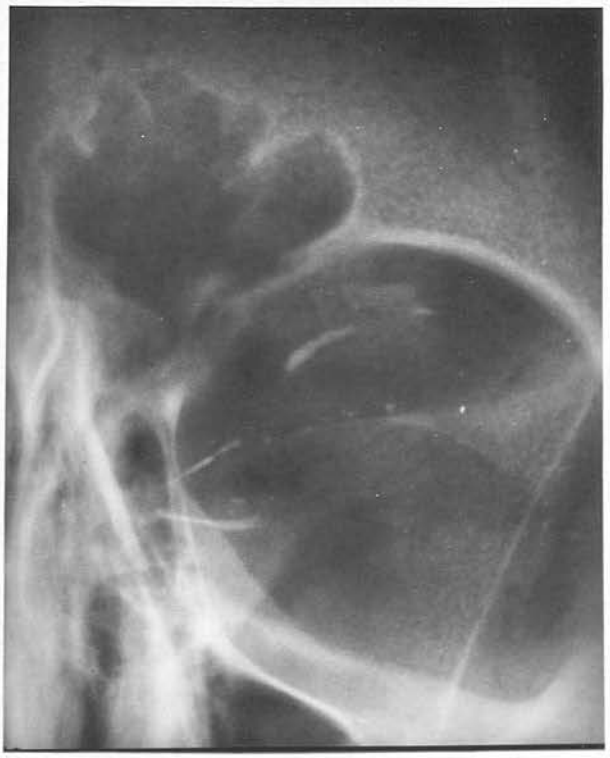
High Level Obstructions

The high obstruction in the canaliculus is usually traumatic in origin.

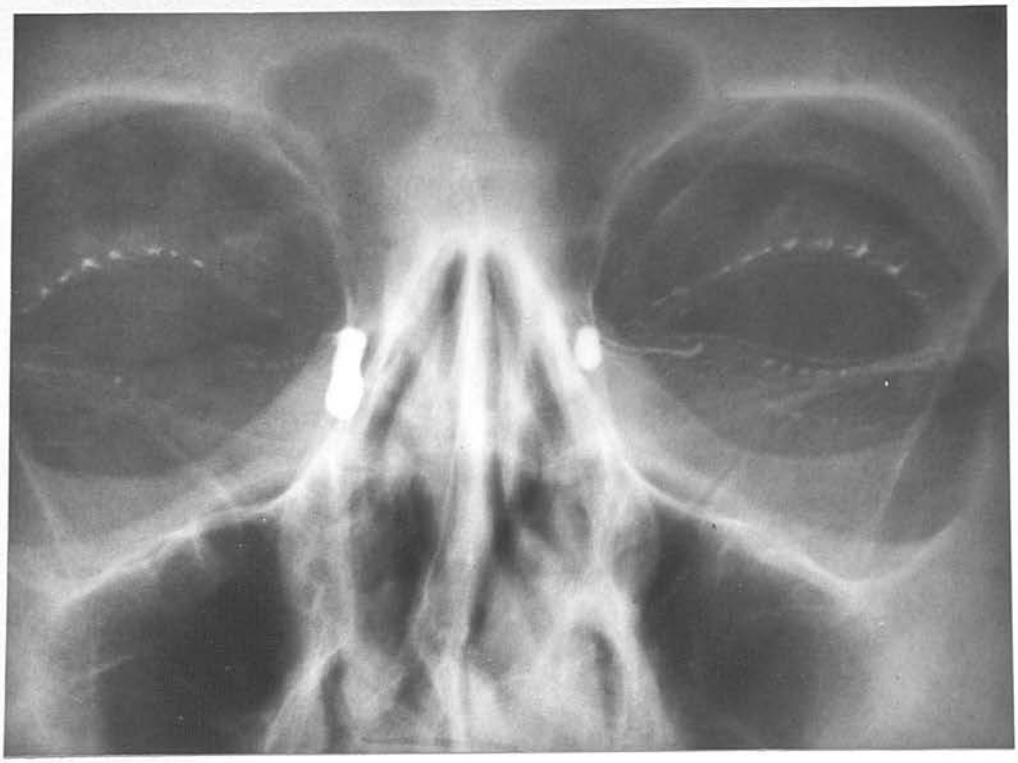
In the case of Arthur Weston (page54) he was complaining of epiphora from the left eye. He was investigated a year after a tree felling accident. He had been struck by the branch of a tree and suffered facial scarring and a fractured mandible. The lower left canaliculus had been divided and there was a block which could be felt by the lacrimal cannula. Filling of the remainder of this canaliculus was effected by injecting through the upper punctum; and this also demonstrated patency of the lacrimal duct into the nose. This dacryocystogram was the basis of the surgical plan, an upper left canthocystostomy, which was entirely successful. Six months later there was freedom from watering in spite of his continued outdoor occupation.

In the case of Ann Mellor (page54) she was involved in a motor car accident and thrown against the driving mirror which shattered and lacerated the right upper eyelid. When first examined because of epiphora the obstruction was complete in the ampulla. A dacryocystorhinostomy was carried out and a month later the eye was still watering. The dacryocystogram on page 54 was then obtained by injecting both canaliculi. This shows both to be occluded. At operation the medial ends of both canaliculi were found to be obliterated by fibrous tissues.

I found the commonest type of high obstruction to be in the ampullary entrance to the sac. In these cases the only complaint may be of epiphora of a year or more duration with no



Case no. V. Mrs. Margaret Mayer.

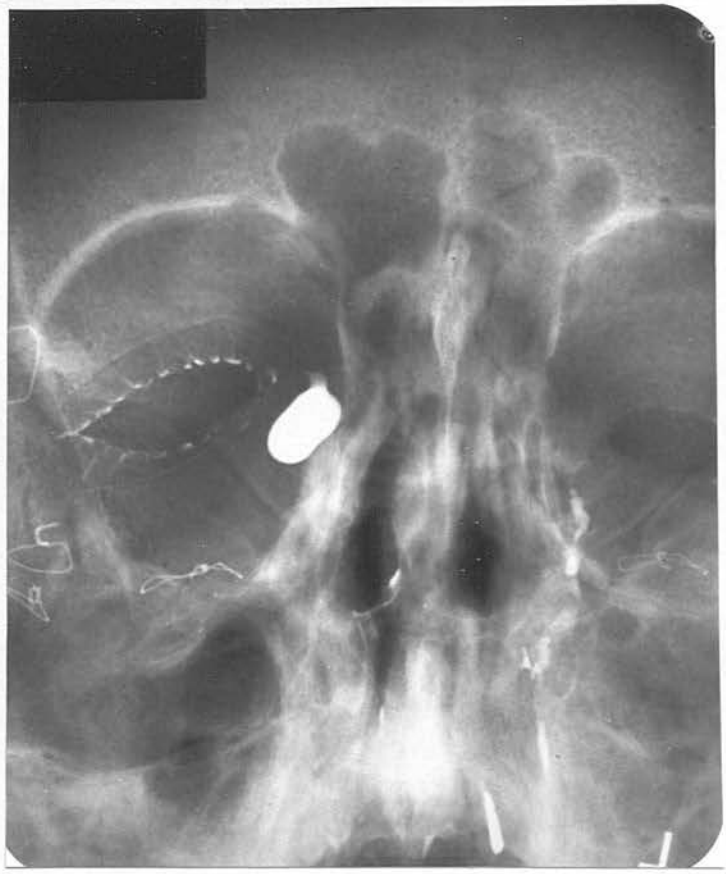


Case no. VI

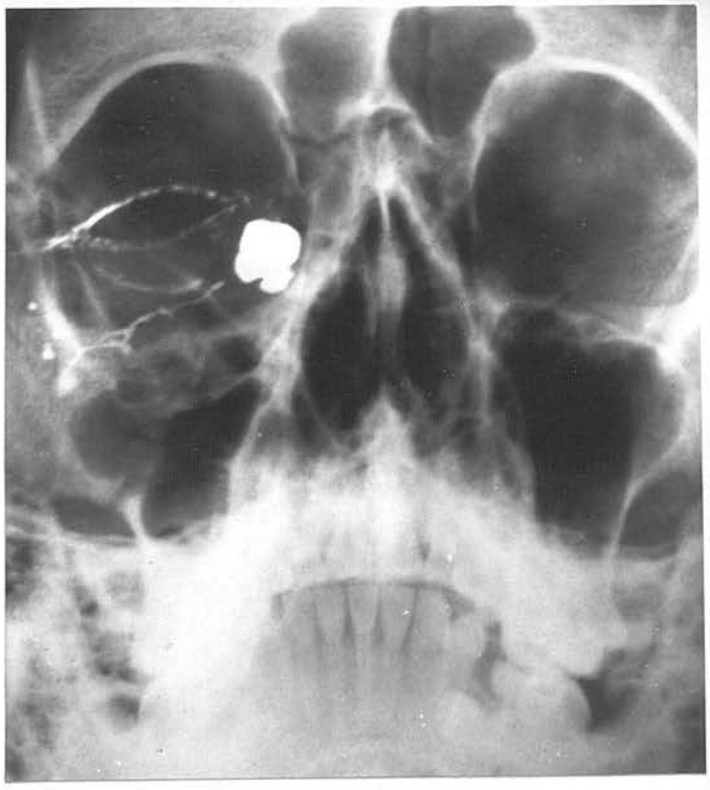
Mrs. Edith Cockle.

history of injury. The same radiological appearances are found in cases of a failed dacryocystorhinostomy or from more violent and uncalculated trauma. In the case of Mrs. Margaret Mayer (page58.) I carried out a dacryocystogram on her right eye which had been watering for two years. When the fluid Neohydriol was injected into the lower canaliculus it flowed out of the upper punctum during the injection. The radiographs showed that no filling of the lacrimal sac took place, and thus there was communication between the upper and lower canaliculus. The obstruction to the flow of the tears was therefore in the common entrance to the sac at the valve of Rosenmuller. A right dacryocystorhinostomy was carried out. A month later the watering had not stopped but was less. Ten months later the patient was readmitted with watering from the right eye as bad as before, and a similar dacryocystogram was obtained showing patency of both canaliculi but occlusion in the region of the surgical opening through the nasal bones. Dissection of the area revealed complete occlusion of the bony ostium by fibrous tissue. A nasal mucous flap was fashioned and rubberised polythene tubes were inserted through the canaliculi. The lower tube was passed down through the catheter into the nose; and the upper on the outside of the catheter.

This case illustrates the common cause of failure of the operation of dacryocystorhinostomy, and demonstrates the importance of knowing whether or not a dacryocystorhinostomy has been attempted before interpreting the cause of a high obstruction from the radiographic appearances. The opening in the nasal bone is rarely visible.



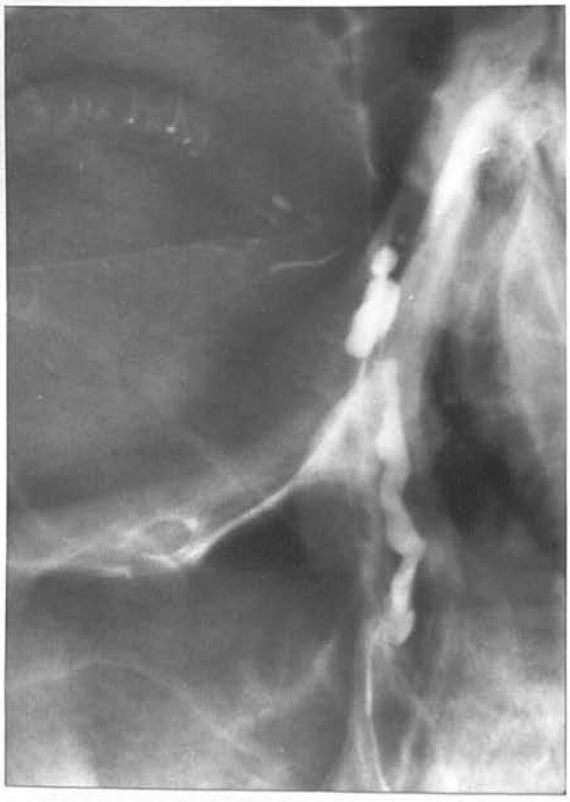
Case no. VII. David Drummond



Case no. VIII. Raymond Wood.

Case no. IX Miss Jill Booth.

Case no. X Michael Quinn.



Mid Level Obstructions

The middle level type of obstruction commonly found is illustrated by the case of Edith Cockell (page 58) who gave a history of watering of both eyes since childhood, with no history of injury. The dacryocystograms show considerable dilatation of the lacrimal sacs of both sides, with obstruction at two different levels but both above the bony canal within the orbit. Regurgitation of Neohydriol through the upper punctum occurred on either side, but the medium was retained only on the left side in the canaliculi.

These may equally well be the appearances associated with fracturing of the facial bones when the examination is carried out some months or years after the injury, and when infection has gained access to the lacrimal sac, as the following cases of mid level obstruction show.

The case of David Drummond (page 62) illustrates a grossly dilated right lacrimal sac resulting from rupture of the lacrimal duct on that side by severe injuries to the middle third of the face.

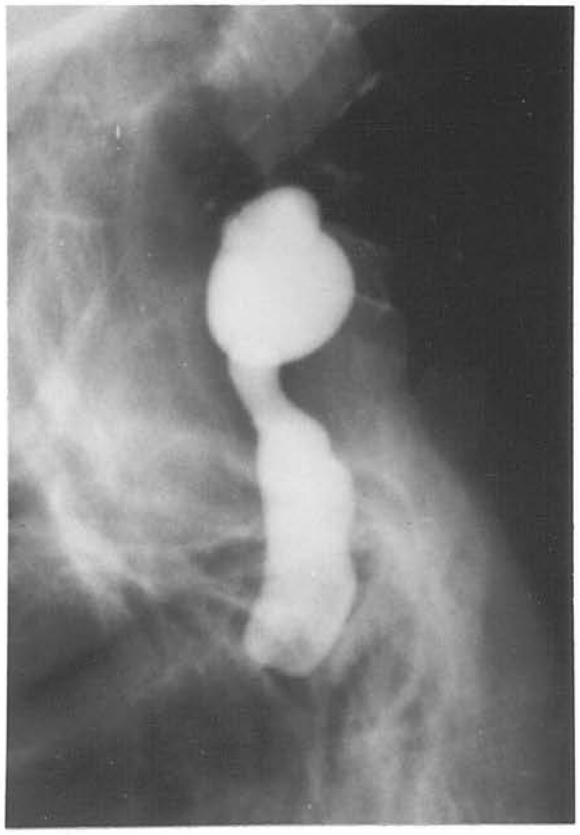
The dacryocystograms of Raymond Wood (page 62) taken a year after sustaining facial fractures and lacerations also show a grossly distended sac, and this communicates by a long track to a sinus over the right malar bone. He had complained of watering of the eye and of a persistent discharge on the cheek. This was corrected by a right-sided dacryocystorhinostomy.

Cystic diverticula may form as the result of chronic infection, and should be differentiated from traumatic dislocation of the lacrimal sac. The cases of Jill Booth and

Case no. XI. Mrs. Ada Temple.

Case no. XII. Rosalind Watterer.

Actual size of sac and duct on macro-radiograph.

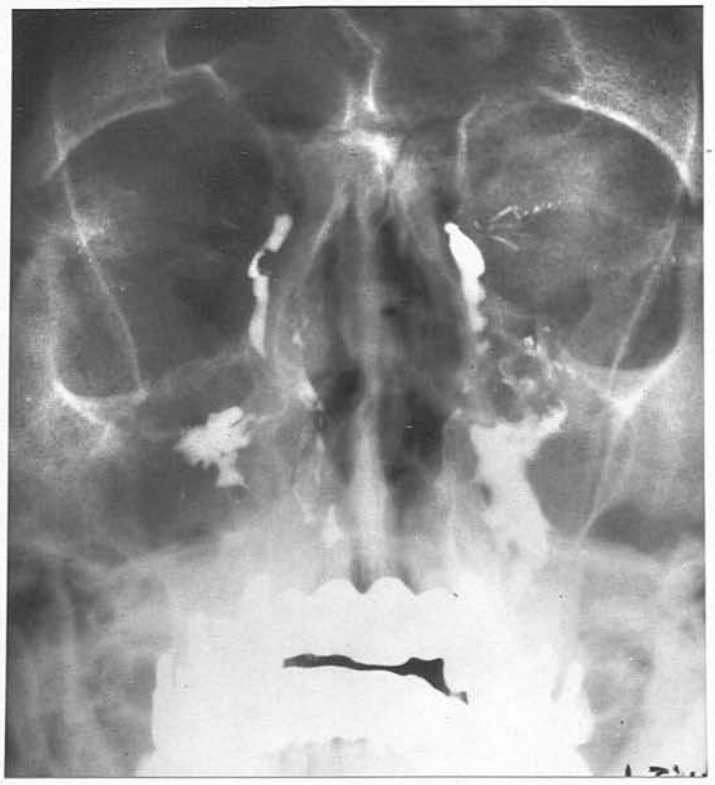


Michael Quinn illustrate the similarity of these conditions (page 63). In the former a true cystic diverticulum of the sac was found at operation, whilst in the latter case the sac was found to be displaced in association with fibrosis and fracturing. They also show that with gross distension and deformity of the lacrimal sac from a mid level obstruction, some patency may exist into the nose.

Combined Mid and Low Level Obstructions

A combination of strictures may exist and these are most commonly found to be middle and low level strictures. These are usually at the level of the bony rim of the canal and at the valve of Hasner. These obstructions are well illustrated by the cases of Mrs. Ada Temple and Rosalind Watterer (pages 68 & 69). The dacryocystogram of Ada Temple shows both canaliculi filled with Neohydriol. The lacrimal sac is grossly dilated and it narrows rapidly through the neck of the sac to the bony rim of the canal. Some of the medium trickles into a stenosed segment of lacrimal canal extending from just below the neck of the sac to the lower border of the inferior turbinate. Here there is again dilatation consistent with some expansion of the lower end of the lacrimal canal. Some of the medium passes into the nose. The appearances are consistent with a partially occluded lower end of the lacrimal canal and fibrosis of the middle third of the lacrimal canal itself.

In the case of Rosalind Watterer (page 69) the left eye had watered since infancy and the duct had been probed from time to time without success. The dacryocystograms show the bony part of the canal fully distended because of a complete block of the



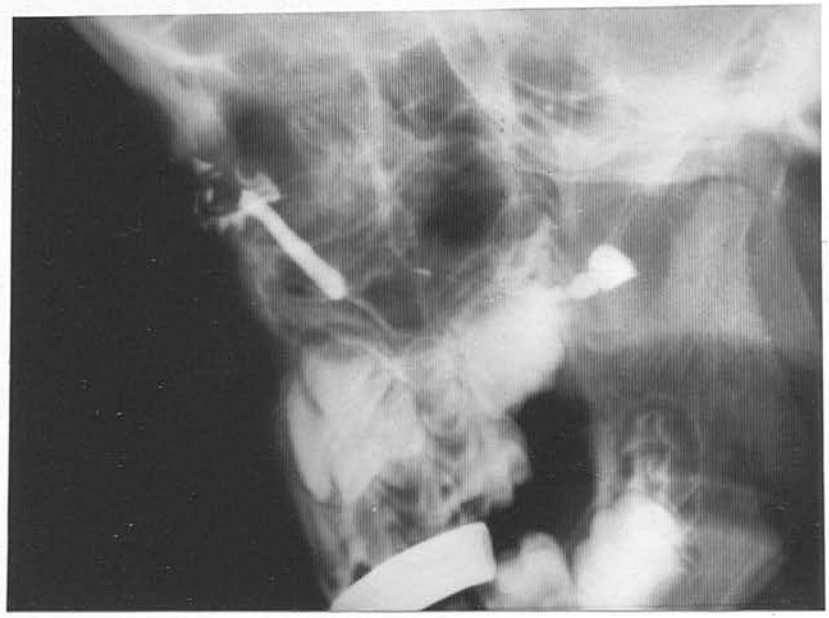
Case no. XIII. Leslie Doust.

lower end of the duct. This case shows to advantage the relatively great width of the canal at the bony rim in the infra-orbital margin. Above this the tight split fascia of the orbicularis is constricting the neck of the sac so that occlusion here is imminent.

Low Level Obstructions

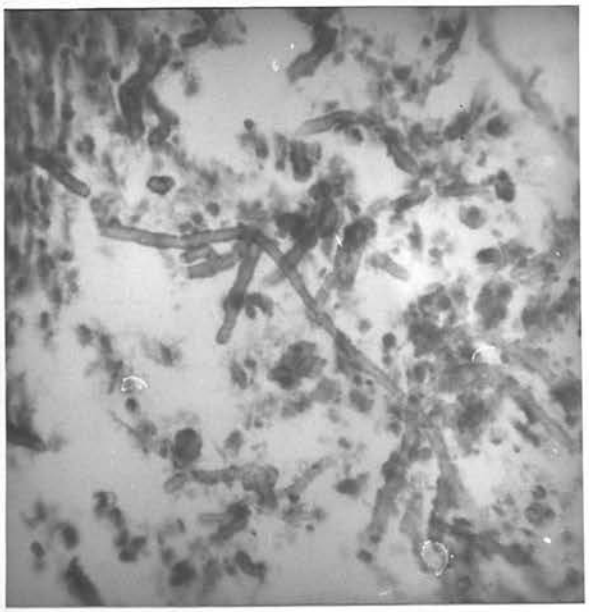
Obstruction at the lower end of the naso-lacrimal duct I found to be usually incomplete, and in traumatic cases was occasionally associated with drainage of the ducts into the antral cavities. The case of Leslie Doust (page 74) is a classical example of this disorder. The dacryocystograms were taken a month after a road traffic accident in which he suffered severe fractures of the central middle third of the face. They show bilateral communication between the tear ducts and the antral cavities, but some patency into the nose exists on both sides, probably because infection has been prevented throughout that period of a month by the antibiotic umbrella shielding the injured structures since the time of the accident.

The lower end of the lacrimal duct is occasionally the ~~common~~ site of occlusion in congenital stenosis of the duct. The dacryocystogram (page 78) of Richard Harman, aged five years, was carried out under anaesthesia, and it shows a dilated duct partially occluded at its lower end. The epiphora was successfully relieved by ~~dacryocystorhinostomy.~~ canthocystostomy.



Case no. XIV. Richard Harman.

Case no. XV. Mrs. Olive Harman.



Case no. XVI. Miss Vera Poile.

GENERAL OBSERVATIONS

Dacryocystography thus gives valuable information with regard to the site of a stricture in the lacrimal system, and to the state of the sac and duct.

The extent to which they are affected by disease is also demonstrated particularly in the cases of mycotic infection. The case of Olive Harman (page 78) shows the tortuosity of the canaliculi and the distortion of the sac, associated with a streptothrix infection.

The case of Vera Poile (page 79) shows not only an apparently polycystic sac but one with a negative shadow in it which was proven at operation to be a dacryolith or calculus. The infecting organism was the Aspergillus. The gross distortion of the canaliculi and the sac is characteristic of the mycotic infections, and the diagnosis of a calculus is possible by the examination of dacryocystography.

The presence of external pressure distorting the sac is also revealed by this examination, as in the case of Gillian Hart (page 83).

Dacryocystography was carried out on this young woman because of watering from the left eye and because of a palpable swelling in the region of the lacrimal sac. This showed Neohydriol to be transmitted without difficulty through the duct into the nose, and revealed early destruction of the bone structure in the region of the anterior ethmoidal air cells and floor of the frontal sinus on that side. These cells were opaque and a soft tissue swelling was distinguishable. The appearances were those of a mucocele of the ethmoidal air cells. This was proven at operation. The tumour was removed and the epiphora was cured.

Case no. XVII. Miss Gillian Hart.

ANALYSIS of 200 CASES OF MACRO-DACRYOCYSTOGRAMS

Traumatic Cases	27
Other Causes	173

OBSTRUCTIONS (200 cases)					
High Level		Mid Level			Low Level
Canalic.	Ampulla	Sac Neck	Bony Rim	Canal	Low
5	39	83	31	11	31
44		125			31

COMPLETE OBSTRUCTIONS					
High Level		Mid Level			Low Level
Canalic.	Ampulla	Sac Neck	Bony Rim	Canal	Low
3	36	53	15	1	4
39		69			4

INCOMPLETE OBSTRUCTIONS					
High Level		Mid Level			Low Level
Canalic.	Ampulla	Sac Neck	Bony Rim	Canal	Low
2	3	30	16	10	27
5		56			27

} = 200 cases.

CONGENITAL OBSTRUCTIONS					
High Level		Mid Level			Low Level
Canalic.	Ampulla	Sac Neck	Bony Rim	Canal	Low
-	-	8	3	-	1
-		11			1

TRAUMATIC CASES				
Large Sac	Large and deformed sac	Small Sac	Deformed Sac	Normal
5	7	2	2	2
12		2	2	2

The remaining nine cases of trauma were high level obstructions.

THE NORMAL DACRYOCYSTOGRAM

A normal dacryocystogram is rarely to be seen, for two reasons. The first is that cases subjected to this examination have it carried out because of the presence of an obstruction in the system. The second is that the visualisation of the lacrimal duct depends upon the surface tension, viscosity and miscible nature, or otherwise, with the tears of the fluid used. Using fluid Neohydriol as the opaque medium the normal duct empties rapidly. It empties in 15 to 60 seconds, so that the upper part of the duct is almost invariably emptied before a lateral projection can be taken, if the occipito-mental projection is taken first.

In 1958 I injected the normal lacrimal system of the ophthalmic surgeon, Dr. A. Werb, with fluid Neohydriol, using the image intensifying system of Dr. R.E. Steiner at the British Postgraduate School at Hammersmith, and a cine radiographic record was made. The definition at that stage of development of the apparatus was not sufficiently good to determine detail of movement, but was good enough to show the rate of flow to be such that the duct emptied itself within 15 - 30 seconds.

The description given here of the normal dacryocystogram in the living subject, using fluid Neohydriol as the opaque medium, is built up on the appearance of those cases with minimal obstruction to the flow at the lower end of the duct, also on those patients whose non-watering eye was injected for comparison with the watering side, and in whom some of the medium remained sufficiently long to define the passageway.

The normal dacryocystogram presents as a smoothly irregular passageway commencing at the inner canthus of the eye, and ending

Post-mortem dacryocystogram.

Post-mortem dacryocystogram.

below the inferior turbinate bone, on the lateral wall of the nose. In the postero-anterior view, the passageway is very narrow at the top, that is at the apex of the sac, and widest at the level of the rim of the bony canal. It maintains approximately this width, except at the valve of Taillefer, to its lower end. The irregularities correspond to the named valves or mucosal folds, but they differ slightly in shape and position from one person to another. The flow of the medium is apparent from the lower end of the passageway flooding the nasal cavity and naso-pharynx.

In the lateral view of the normal duct the sac is approximately three times as wide as in the P.A. view. The width of the remainder of the duct is fairly uniform with the exception of two definite constrictions; one at the neck of the sac well above the level of the bony rim of the naso-lacrimal canal, the other above the inferior turbinate at the level of the valve of Taillefer. At these two points there is some change in direction of the passageway. The change in direction is often acute at the valve of Taillefer, and is usually backwards.

This description does not apply to the cadaver (pages 90, 91.). The difference is most evident in the P.A. view. In the cadaver the sac is the widest part of the passageway. This is probably because I used considerable pressure to fill the system and the fibres of the orbicularis are without tone. There is a definite indentation at the neck of the sac caused by the split fascia resisting the pressure of the distending fluid.

An anatomical point of interest brought out by both the P.A. and lateral views in the cadaver radiographs is that the canaliculi enter the apex of the sac on its lateral aspect, and they tend to

be slightly posterior because of the distension.

The lateral view of the injected cadaver lacrimal system shows a great variation in width. The sac is three times the width of the remainder of the duct in this sagittal plane. The sac of the specimen contains either an air bulb or fluid.

I obtained the post-mortem radiographs by using a specially made long cone, on a portable X-ray unit, and no grid. Whilst the definition of the original size of the radiograph as reproduced is satisfactory, a $2\frac{1}{2}$ times enlargement illustrated below this, made in an attempt to bring up the detail of the structures, does not compare with the detail obtained with macro-radiographic technique.

THE INDICATIONS OF ABNORMALITY

(1) Regurgitation through the opposite punctum during the injection.

(2) Retention of the opaque medium in the canaliculi.

(3) The absence of flow of the opaque medium into the nasal cavity in both radiographs.

(4) Flow into the nose but retention of the medium in the sac and duct with an increase in the overall width of the sac or duct.

(5) Variations in the calibre of the system more than would account for the mucosal folds which exist at various levels, with retention of the fluid above the constriction.

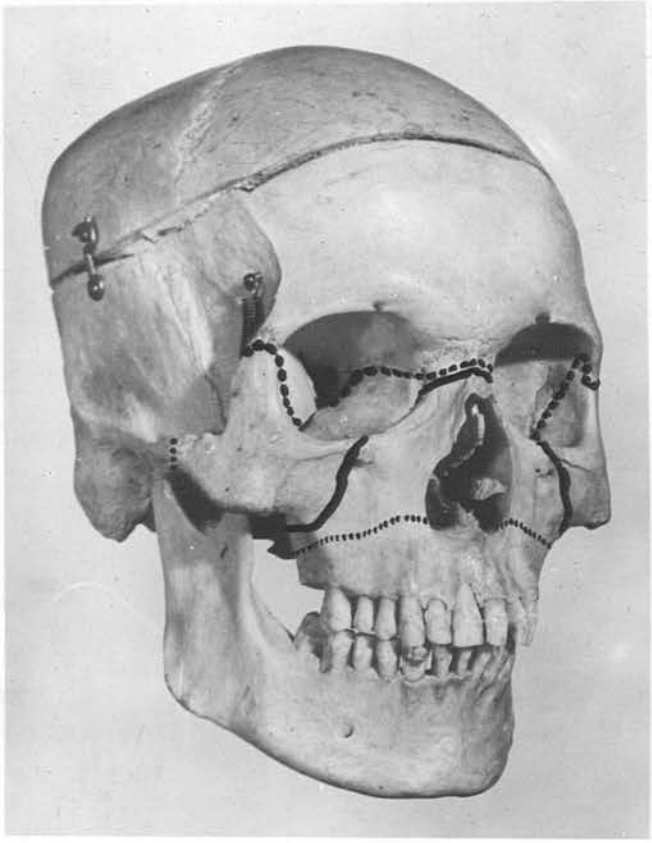
(6) Retention of the fluid throughout the duct over the period of time required for both P.A. and lateral projections to be taken.

THE OPAQUE MEDIUM

I used several opaque media in an attempt to find a substance which would coat the mucosal lining of the canaliculi and the naso-lacrimal duct, and one which would be miscible with retained secretions in the lacrimal sac to obviate the globule formation which takes place using an oily medium. Micropaque in whatever form it is presented has a particulate nature so that small concretions form in the conjunctival fornices where, if left, they would behave as foreign bodies with considerable irritation. I tried Dionosil, oily and fluid, but this suffered from a defect, found also with Micropaque, namely, that the non-transparent nature of the fluid obscured the minute punctum as soon as the first drop touched it, and when the conjunctiva was flooded with the regurgitated fluid the cornea was obscured and the appearance was very alarming both for the patient and myself. The watery solutions, Pyelosil 30% and Hypaque were excreted too rapidly and caused a certain amount of discomfort, probably in part because they are not isotonic with the tears. Fluid Neohydriol remains quite the most suitable medium because of its non-irritating nature and the fact that it is transparent, thereby not obliterating but rather magnifying the size of the punctum when a droplet comes into contact with it.

EPIPHORA IN FRACTURES OF THE FACE

When a blow of sufficient force is delivered to the centre of the face, the pyramidal block of bone comprising the maxilla, nasal bones and alveolar process of the maxillae, is separated from the floor of the frontal fossa and from the malar bones of either side.



Facial fracture lines.

This block of bone is driven backwards and downwards along the inclined plane of the base of the skull formed by the sphenoid bone. With even greater violence the whole of the face is separated by a high transverse fracture from the skull vault. And yet, with these devastating injuries, now so common with the high speed traffic of today, the incidence of associated epiphora when healing is established is surprisingly uncommon. I found the incidence in 100 unselected cases of central middle third facial injuries was only 12%.

The probable reason for the small incidence of epiphora in these cases is because in both the high transverse fracture and in the pyramidal type of fracture the lacrimal fossa and canal tend to escape the fracture line.

These fractures commence by separation of the fronto-nasal sutures or in the nasal bones close to the sutures. From this region the high transverse fracture runs backwards along the upper border of the lacrimal bone and orbital plate of the ethmoid to the optic canal, where it is deflected downwards to the medial aspect of the posterior limit of the inferior orbital fissure. The lacrimal fossa therefore tends to escape and, when involved, the medial canthal ligament and the split lacrimal fascia help to protect the sac. (page100).

The anterior and posterior lacrimal crests deflect the pyramidal fracture of the central middle third of the face. This type of fracture runs from the upper part of the nasal bones or the fronto-nasal suture on either side again across the frontal process of the maxilla to the upper limit of the lacrimal bone, and then turns downwards and inclines behind the posterior

lacrimal crest into the orbital plate of the ethmoid. It then inclines forwards, crossing the orbital plate of the maxilla to reach the middle of the infra-orbital margin, and continues over the antral wall. Its subsequent path is not relevant to this discussion.

The complete transverse fracture of the alveolar process of the maxilla, which frequently accompanies the pyramidal fracture, commences at the anterior nasal aperture just above the floor of the nose and passes laterally across the cannine fossa, the lateral wall of the antrum and finally above the tuberosity of the maxilla, to be joined by the medial leg of the fracture which has traversed the lateral wall of the nose immediately above the floor. The lower end of the naso-lacrimal duct thus usually escapes damage. When fistula of the lacrimal ducts form into the antral cavities it is because of this type of unilateral or bilateral transverse fracture of the alveolar process of the maxilla - the Guerins or Le Fort I type of fracture. This is illustrated in the case of Leslie Doust (page 74).

THE SURGICAL VALUE OF THE DACRYOCYSTOGRAM

The value of dacryocystography to the surgeon is primarily in the location of the level of the obstruction causing epiphora. Secondly the state of completeness of the obstruction helps in the early cases where probing should be considered. Thirdly, a knowledge of the size, shape and position of the obstructed lacrimal sac is of help in anticipating any surgical difficulties. Lastly, the diagnosis from the radiographs of the causes of extrinsic pressure upon the system by disorders in the face, or infection in the sinuses, is of great value.

The surgical procedure for the relief of epiphora is determined by the level of the block. In 78% of the cases investigated in this series, the radiographs showed the sac and canaliculi to be intact, in association with a mid or low level block. Under these conditions, the operation of choice is that of dacryocystorhinostomy. Clinically the indications for this operation are when there is occlusion of the naso-lacrimal duct in young or middle aged persons which either fails to respond to one or two probings, or is so obstructed by dense fibrous tissue or bone as to be impermeable to a probe.

The method of Dupuy-Dutemps dacryocystorhinostomy procedure has been employed in the cases described here. The principle of the operation is to effect the drainage of the tears into the middle meatus of the nose through a short circuit made in the lacrimal bone and nasal mucosa. The stages in the procedure are, briefly, to mobilise the lacrimal sac approached through an incision 3 cm long centred over the medial palpebral ligament and crossing 3 mm internal to the inner canthus. The bone of the lacrimal fossa is exposed down to the lacrimal duct. At this stage the Rycroft rhinostomy lamp is passed along the vestibule of the nose to transilluminate the lacrimal fossa. If the illumination is dull the presence of an anterior ethmoidal air cell is suspected. By means of a hand trephine, a disc of bone is removed, centring the trephine at the lower posterior part of the lacrimal fossa close to the commencement of the naso-lacrimal duct, the corresponding opening then falls just anterior to and below the middle turbinate bone. If an anterior ethmoidal air cell is encountered at this stage it is easily seen by the

Successful dacryocystorhinostomy.

rhinostomy lamp and is nibbled away in the nose. The result of such an encounter is that the nasal mucosa lies at a greater depth for the next stage, which is the mobilisation of flaps. Anterior and posterior flaps are fashioned from the lacrimal sac after passing a probe through the inferior punctum. Similar flaps are fashioned from the nasal mucosa and these sutured to those of the lacrimal sac to form a continuous passageway over a rubber tube leading into the nose. The upper end of the tube lies between the flaps for a week and ensures that the anterior and posterior flaps do not stick to each other. The tube is removed at the end of a week. Daily lacrimal irrigation is continued for ten days from the third post-operative day. A control dacryocystogram is taken before the patient is discharged from hospital (page 108).

The value of the post-operative control dacryocystogram is appreciated in the small percentage of unsuccessful operative results. When such cases return with watering of the eye a dacryocystogram reveals evidence of fibrosis of the mucosa on the nasal aspect of the bony opening or the appearance associated with an ampullary block.

I have never been able to offer definite radiological help over the problem of the anteriorly placed ethmoidal air cell. Concerning this I quote Stallard -

"In practice the rhinostomy lamp during operative procedure gives the most reliable information with regard to the presence of the anteriorly placed ethmoidal air cell".

Where the upper canaliculus, sac and duct are intact but the inferior canaliculus is obliterated, simple cantho-cystostomy or

the opening of the lacrimal sac into the conjunctival fornix restores the lacrimal drainage.

The lower canaliculus suffers more frequently than the upper from wounds at the medial canthus of the eye and is more important for drainage of tears. The occlusion of the upper canaliculus is of little consequence and does not cause epiphora when the lower canaliculus is patent.

CRITICISMS OF THE LITERATURE

Sydney A. Fox in his article on Lipiodol studies in dacryocystitis draws a distinction between traumatic chronic dacryocystitis with an intact sac and traumatic chronic dacryocystitis with sac involvement, stating that the most striking differentiating feature is that all the latter sacs are much smaller than normal. In the cases I have examined this generalisation is proven to be incorrect. In the 200 cases of epiphora reviewed, 27 of these were of traumatic origin in the form of severe facial injuries. Of these only two presented with small sacs. The greatest number of the sacs took the form of mucoceles. When the sac itself was involved it was deformed, but not small, as the analysis on page 85 shows.

Fox also states that the typical appearance of the sac of a non-specific dacryocystitis is a sac with a narrow dome above and wide below. This series of cases shows that there is great variation in the shape and size of the obstructed sac. It is commonly oval in the vertical plane but not typically narrow at the dome. He further states that a cause for this shape is that the upper fundus of the closed sac is covered by the internal

canthal ligament which allows only a little distension. My dissection of the cadaver showed the covering of the upper end of the lacrimal sac by the internal canthal ligament to be no more than 1 mm. The distended sac must and does bulge forwards away from the ligament, which does not therefore influence its shape, as seen in the dacryocystogram. The distended sac is limited by the lacrimal fascia and the fibres of the orbicularis muscle. The most important, constant and determining factor of the shape of the obstructed sac is the nature of the split fascia surrounding the neck of the sac which prevents its expansion and thereby causes its obstruction. This subdivision into non-specific and traumatic dacryocystitis with and without sac involvement, has no practical value to commend it. In general, the dacryocystogram reveals the size and shape of the sac in mid-level obstructions, and the associated cause - whether it be fracturing of the face, or disease or infection of the anterior group of nasal sinuses.

Of greater practical value from the point of view of possible surgical procedures is the classification into high, middle, or low obstruction of the system.

J. Thomson and E.R. Elstrom in their article on the "Radiography of the naso-lacrimal passageways", make certain statements which do not hold true or satisfactory in practice. They state that if an opening is to be made into the nasal cavity for naso-lacrimal drainage, radiography may assist in determining the best location. I have not found this to be so in any of the 300 cases examined, since the operative approach to the procedure of dacryocystorhinostomy is in the first instance limited by the incision, which must be within 2 mm of the lacrimal crest because

of the angular vein and its tributaries. Secondly, the anteriorly placed air cell is localised by the rhinostomy lamp. These authors specify a particular quantity 1.5 - 2 ccs of iodised oil as the quantity of fluid to be injected. This is a vast amount of fluid relative to the volume of the system. The amount used varies with each case, being less than 0.5 ccs in the normal and partial obstruction cases. When the patient says he tastes the fluid, this is the signal to stop the injection and commence radiography. They suggest plugging the upper punctum to prevent regurgitation by using a common pin. Whilst it is true that the upper canaliculus can be done without, this would seem to be courting disaster. These authors advocate a large number of projections, the initial ones being preliminary to the injection of the passageways to assess any abnormality of the anterior group of sinuses. Using the 40° occipito-mental projection and lateral only, as I have done, the state of the anterior group of sinuses can be assessed at the time of the injection. This is of importance at the present time, when it is understood that the dose of radiation to the patient should be kept to a minimum. If any pathology exists in the face then, if necessary, further projections can be made to examine this.

Milder and Demorest in their article on Dacryocystography of the normal lacrimal apparatus base their findings on thirty patients, using an opaque medium (* Pantopaque: Keleket), which is a substance of greater viscosity than fluid Neohydriol. Elimination of this medium from the lacrimal system must present the system with a more difficult mechanical task than the excretion of tears or the more fluid substance Neohydriol, thus making assessment of

* The viscosity of Pantopaque is 38 centistokes at 20°C.
The viscosity of Neohydriol Fluid is 33 centistokes at 20°C.

abnormality a function of time, and bringing about considerable distension of the normal system. Neohydriol flows so freely through the normal system that very little distension is brought about, and a follow-up film after an interval is not necessary. These authors concern themselves with the establishment of patency of the system and state that they did not consider poor filling to be abnormal. The issue of dacryocystography is not to this end, but to determine the cause of an impaired flow through the system, for this clinical fact initiates the investigation. The duct may be patent and incomplete filling visualised, revealing an area of fibrosis and narrowing in the duct sufficient to justify dacryocystorhinostomy.

In their description of the normal radiographic anatomy of the naso-lacrimal duct they interpret a shallow constriction at the lower end of the sac to lie at the upper end of the osseous portion of the naso-lacrimal duct. The investigations I have described show this to be erroneous. They also state the canaliculi empty into the sac at the junction of its upper third and lower two-thirds. Here it is shown that this entry is much closer to the upper end of the sac (cadaver radiographs, page 91) and virtually at its apex.

SUMMARY

This part of the thesis is based on examination of over 300 cases of epiphora. 200 of these cases were examined by a new approach to routine radiography of the lacrimal system, by using an original arrangement of apparatus for macro-radiography. This method enhances the value of the examination. The levels of obstruction of the lacrimal system are illustrated, analysed and classified into 22% high level, 63% middle level, and 15% low level obstructions, and the state of completeness of these obstructions at the different levels has been determined for the first time. The commonest level of complete obstruction is shown to be in the region of the neck of the sac and not, as generally accepted, at the bony rim of the lacrimal canal or in the canal itself. The cause of this obstruction is found, by macro-radiographs and dissection of the cadaver, to be due to the nature of the split fascia of the orbicularis muscle at this level.

The frequency of epiphora in severe central middle third fractures of the face is determined as 12%. This rarity of epiphora is due to the direction of the fracture lines. The state of the lacrimal system under these conditions is shown to be no different than when obstructed from other causes, and various states of obstruction are illustrated.

The appearance of the normal dacryocystogram in the living subject, and in the cadaver, are described and represented diagramatically. The indications of abnormality are tabulated.

The work of others in recent literature is criticised.

REFERENCES

ARRUGA H. "Ocular Surgery" p. 227 1952.

BRITISH AUTHORS "A Textbook of X-ray Diagnosis" 3rd Edition Vol. 1 p. 415 1957.

DUKE-ELDER Sir Stewart "Text Book of Ophthalmology" Vol.V. The Ocular Adnexa. pp. 5279 - 5286 1952.

FOX Sydney A. "Lipiodol Studies of Dacryocystitis" American Journal of Ophthalmology Vol. 30 No. 7 pp. 878 - 884 1947.

HARTMANN E. GILLES E. "Radiodiagnostic Ophthalmologic" Masscon et Cie pp. 187 - 208 1955.

MILDER B. and DEMOREST B.H. "Dacryocystography" A.M.A. Archives of Ophthalmology Vol. 51 No. 2 pp. 180 - 195 1954.

RYCROFT B.W. "Surgery of External Rhinostomy Operations" British Journal of Ophthalmology Vol. XXXV pp. 328 - 338 June 1951.

STALLARD H.B. "Eye Surgery" 2nd Edition p. 272 1950.

THOMSON J. and ELSTROM R.T. "Radiography of the Naso-lacrimal Passageways" M. Radiog. & Photog. 25 pp. 66 - 69 1949.

VEIRS E.R. "The Lacrimal System" pp. 72 - 73 1955.

WOLF Eugene "The Anatomy of the Eye and Orbit" 4th Edition pp. 197 - 208 1954.

APPENDIX I

SUMMARIES OF CASES AND RADIOLOGICAL REPORTS

CASE NO. I

Case History: Mrs. Hilda Walling, aged 47, presented complaining of watering from the right eye. Four years previously she had had elsewhere a right-sided dacryocystorhinostomy operation which had been unsuccessful. A year later another operation to the right eye was done and described as an operation on the right lacrimal sac. Finally in that year the lacrimal sac was said to have been excised. Epiphora had continued from that time. She had also had a short period of watering from the left eye a year before the present examination.

On general examination of the eyes a film of fluid was present on the right eye almost spilling over on to the face. There was no such film on the left eye. The lids were normal and their movements full, but the right lower punctum was somewhat dilated although in good apposition to the globe. The upper right punctum and the puncta of the left eye were normal in size, shape and position. The ocular movements and the pupils were normal. There was no regurgitation on pressure over the lacrimal sac area.

Preliminary syringing with normal saline through the lower right punctum brought about regurgitation through the upper and there was no patency into the nose. On the left side there was patency into the nose.

Dacryocystography - Neohydriol fluid injected into the right lower canaliculus regurgitated through the upper punctum. When the upper punctum was occluded regurgitation took place past the cannula in the lower canaliculus. Injection of the upper canaliculus brought about regurgitation from the lower.

Both canaliculi of the right eye retained the medium and they united into a moderately large ampulla (sinus of Maier). The fundus of the lacrimal sac remained and was distended by the Neohydriol and an air bubble. Below this there was narrowing of the passage and it was occluded, so that none of the medium entered the nose.

On the left side the lower canaliculus was injected and the lacrimal duct retained the fluid throughout its length but none remained in the canaliculus. There was flow into the nasal cavity.

Conclusion: The appearances on the right side were those of a high obstruction associated with fibrosis in the region of the fundus and ampulla, secondary to an attempted dacryocystorhinostomy.

On the left side there was evidence of low level partial obstruction at the valve of Hasner.

At operation the original trephined hole was identified and found to be somewhat lower than the sac remnants. A dissection was made through a lot of fibrous tissue and the bony opening in the nose was increased upwards to bring it into line with the sac remnants and canaliculi. Flaps were fashioned and a dacryocystorhinostomy completed.

CASE NO. II

Case History: Mrs. May Rainbird, aged 38, had complained of periods of watering from both eyes for over a year, and it had been constant for the last nine months. There was no history of injury or sinus infection.

A general examination of the eyes showed an increase in the tear strip on the lower lid on both sides but no overflow at the time of examination, because she had just wiped her

eyes. The lid movements were normal and the puncta were in good apposition with the globes. There was no regurgitation on pressure over the lacrimal sac. The ocular movements were full in all directions. The pupils were equal and reacted normally to light and the eyeball tension was normal on both sides.

Preliminary syringing of the right side showed that there was an obstruction some 5 mm from the punctum along the lower canaliculus. No entrance was gained into the sac and there appeared to be no communication with the upper. Syringing by the upper canaliculus showed a similar obstruction near the entrance of the sac, with no communication to the lower, but on forcible pressure some fluid went into the nose.

Syringing on the left side showed an obstruction along the lower canaliculus again about 5 mm from the punctum. Some regurgitation occurred through the opposite punctum and some entered the nose. There was patency of the upper canaliculus.

Dacryocystography - The right lower canaliculus was obstructed. Fluid Neohydriol injected through the right upper canaliculus brought about complete filling of the lacrimal duct, secondary to an incomplete obstruction of the duct at its lower end.

Injection of the opaque medium through the left lower canaliculus caused regurgitation through the upper punctum, but some fluid flowed into the nose. There was narrowing of the duct in the upper part of the bony canal, causing an incomplete obstruction.

At operation a right dacryocystorhinostomy was carried out. The common opening of the canaliculi was identified

and the obstructed canaliculi were roped. The obstructions were overcome and polythene tubes were then threaded through both upper and lower canaliculus and down an indwelling nasal rubber catheter.

The operation was successful.

CASE NO. III

Case History: Mrs. Hammerton, aged 46, complained of watering from both eyes over a period of ten years, but gave no history of infection or injury.

A general examination of the eyes showed epiphora on the right side with over-spilling of tears on to the face. On the left side there was a fine excessive tear film but no over-spilling. The lids were normal, and the puncta were in good apposition with the globes. The ocular movements were full in all directions. The pupils were equal and reacted to light, and the eyeball tension was normal on either side.

Preliminary syringing of the right side with normal saline revealed a gritty sensation to the entering cannula in the lower canaliculus, and some obstruction had to be overcome. Regurgitation of the fluid took place through the upper punctum, but fluid passed into the nose. Regurgitation also occurred on the left side, but there was patency into the nose.

Dacryocystography of the right side, immediately after the syringing, was accompanied by a sensation of lack of resistance to the injected fluid suggesting the presence of a false passage. The periorbital tissues were infiltrated with Neohydriol about the medial and inferior orbital borders. Some of the medium entered the nose.

Conclusion: A false passage is present in the lower canaliculus, a partial obstruction in the naso-lacrimal duct cannot be excluded because of this.

The patient was admitted three months later with watering worse than before. The right eye now watered all the time whilst the left one watered only when outside in cold weather or wind. During the interval she had had "cysts" removed from the breasts and had a discharging ear.

Dacryocystography at this time showed that almost all the Neohydriol had been absorbed from the peri-orbital tissues. Mucosal thickening had developed in the right antrum. Injection of the right lower canaliculus brought about regurgitation through the upper and this canaliculus retained the medium. The area of the sac was represented by only a large globule, and none entered the naso-lacrimal duct.

On the left side there was again regurgitation through the upper punctum during the injection and both canaliculi remained filled. There was no dilatation of the sac but the medium was retained in it, the remainder entered the nose.

Conclusion: The appearances were consistent with bilateral mid-level obstructions :- of a minor order on the left side, but complete on the right.

At operation an anteriorly placed ethmoidal air cell was encountered but the procedure of dacryocystorhinostomy was carried out without difficulty.

CASE NO. IV

Case History: Arthur Weston, aged 64, complained of watering from the left eye. He was hit by the branch of a tree which he was felling the year previously. He suffered a fractured mandible and facial scarring.

A general examination of the eye showed scarring of the left inner canthal region and some left lid ectropion. The puncta were in good apposition to the globe. The ocular movements were normal. There was no regurgitation on pressure over the sac area.

Preliminary syringing revealed a block in the lower canaliculus.

Dacryocystography was effected by injection of the upper canaliculus, which brought about filling of the distal part of the lower canaliculus revealing the site of the block. Patency into the nose was demonstrated.

A Canthocystostomy of the upper canaliculus was carried out, and six months later the patient was completely free from watering in spite of his continued outdoors occupation.

CASE NO. V

Case History: Margaret Mayer, aged 47, had complained of watering of the right eye for two years. There was no history of injury or infection.

A general examination of the eyes revealed no abnormality.

Preliminary syringing showed regurgitation through the upper punctum and no patency into the nose.

Dacryocystography revealed both canaliculi

throughout their length, but no opaque medium in the region of the sac or in the naso-lacrimal duct. There was regurgitation of Neohydriol through the upper punctum.

Conclusion: The appearances were consistent with an occlusion in the region of the sinus of Maier.

At operation for dacryocystorhinostomy an anterior ethmoidal air cell was revealed by the rhinostomy lamp. The sac was small and fibrotic. The nasal mucosa was torn from probable middle turbinate trauma. Only an anterior flap was fashioned and sutured. A very adequate ostium was made, but there was insufficient nasal mucosa for a posterior flap. A nasal rubber catheter was left in situ and stitched.

This brought about some relief of the watering, but six months later the patient reported with watering again from the right eye.

Examination at that time showed the conjunctiva obviously moist, but revealed no palpable mass in the lacrimal region, and no material could be expressed into the conjunctiva by pressure in the region of the lacrimal incision.

Preliminary syringing again showed no patency into the nose, and regurgitation occurred through the upper punctum.

This was confirmed by Dacryocystography which demonstrated both canaliculi in their entirety, but no fluid in the lacrimal sac region.

Conclusion: The appearances were those associated with post-operative fibrosis of the rhinostomy opening.

At operation - from a curved incision, made over

the right lacrimal region about 2 mm posterior to the previous scar, there was revealed massive scarring and complete occlusion of the bony ostium by fibrous tissue. Rubberised polythene tubes were inserted through the canaliculi and one was passed down the catheter and secured into position in the nose, whilst the other, the superior one, was passed down the outside of the catheter. The anterior flap which had been fashioned was closed and the operation was completed by closure of the skin by interrupted black silk sutures.

CASE NO. VI

Case History: Mrs. Edith Cockle, aged 61, had been complaining of watering from both eyes since childhood. There was no relevant ophthalmic history.

A general examination showed her to have full ocular movements, white eyes, and pupils equal and reacting normally to light. The puncta were minute, but there was no regurgitation on pressure over either sac area, and they were in good apposition to the globes.

Preliminary syringing brought about regurgitation of a muco-purulent material from the opposite punctum in both eyes, and there was no patency into the nose on either side.

Dacryocystography showed dilatation of the lacrimal sac of the right side. It was completely occluded at its neck. Some of the medium was retained in the canaliculi secondary to regurgitation from the opposite punctum. On the left side the upper third only of the lacrimal sac was distended. Again both canaliculi were visualised secondary to regurgitation.

Conclusion: The appearances were those of mid-level obstructions

in association, on the left side, with extensive fibrosis.

Bilateral Dacryocystorhinostomy was successfully carried out. The only point of note made in the operation notes was that an anterior ethmoidal air cell was encountered on the left side.

CASE NO. VII

Case History: David Drummond, aged 25, a Chief Inspector in the Rhodesian Police, was involved in an aeroplane accident four months before being seen. After the accident he was treated in East Africa and left with a depressed nose in its upper part and with splaying of the nasal bones. He complained of watering from the right eye and a swelling in the region of the lacrimal sac and poor airway on both sides.

The preliminary operative procedure was mobilisation of the nasal bones and correction from their splayed out position. When this was done it was found possible to syringe through the lacrimal apparatus on the right side and obtain flow into the nose. This had previously been impossible, and prior to the elevation of the nasal bones muco-pus had been expressed from the lacrimal sac area. The profile was corrected by fashioning and implanting stored cadaveric cartilage.

Operation on the lacrimal apparatus was postponed until the present stage had settled.

A month later Dacryocystography showed the lacrimal sac of the right side to be grossly dilated and dislocated laterally from the region of the lacrimal fossa. There was no communication with the canal and the canaliculi did not retain the medium. The

ampulla of the sac was deformed. There was considerable disturbance of the bone structure of the lacrimal fossa, frontal process of the maxilla and nasal bones. On the left side the lacrimal canal was patent.

Conclusion: The appearances were those of a mid-level obstruction, associated with fracturing of the lacrimal fossa and canal, and injury to the sac.

A successful Dacryocystorhinostomy was carried out together with bilateral resection of the medial orbital wall and reattachment of the canthal ligament.

CASE NO. VIII

Case History: Raymond Wood, aged 21, was involved in a motor cycle accident a year ago, whilst in the services in Germany. He was treated for fractures of the face. He presented complaining of a persistent discharge from a gap in the right cheek and said his eye used to water.

A general examination showed a sinus on the cheek below the outer canthus of the right eye, and linear scars of the right and left eyebrows and right upper lid. The puncta were normal and there was no regurgitation on pressure over the sac area. The ocular movements and pupil reactions were normal.

Preliminary syringing brought about a distension of the lacrimal sac and regurgitation through the upper punctum. Pressure over the distended sac increased the regurgitation and with it came muco-pus from both canaliculi. At the same time a muco-purulent discharge appeared through the sinus on the cheek.

Dacryocystography - Injection of the lower canaliculus brought about regurgitation through the upper but

Neohydriol was not retained in the canaliculi. The lacrimal sac was grossly distended and slightly irregular on its lateral aspect. It communicated by a tortuous channel to the sinus area of the right malar bone.

Conclusion: The appearances were those of a traumatised sac with a fistula from it to the cheek.

At operation it was found that the fracture line ran through the lacrimal fossa, and the lacrimal sac was rotated laterally and backwards leaving a considerable area of bone between the sac and the middle meatus. The bony opening was enlarged and a posterior flap adequately sutured. The anterior flap was sutured to the orbicularis with retention of the catheter in the usual way. There was considerable haemorrhage from fibrous tissue in spite of low-pressure technique.

A month later the eye was no longer wet and the fistula on the cheek had closed.

CASE NO. IX

Case History: Miss Jill Booth, aged 13, complained of watering from the right eye. This commenced a year ago after an abscess had developed on the right lower lid. When the abscess burst it did not appear to be associated with the lacrimal system. She was examined at that time and the tear duct was patent.

A general examination of the eyes showed a swelling of about 8 mm in diameter in the right lacrimal sac area. This swelling did not disappear on pressure and there was no regurgitation from the puncta. The puncta were in good apposition to the globe and the lids were normal in other respects. The ocular movements were full in all directions. The pupils were

equal and reacted to light, and the tension on either side was normal.

Preliminary syringing with a normal saline through the lower canaliculus brought about some increase in size of the swelling, followed by patency into the nose.

Dacryocystography revealed a grossly distorted lacrimal sac which communicated through a stenotic neck with the naso-lacrimal duct and the nose. On the lateral aspect of the neck of the sac was a large diverticulum. The communication between the two was very narrow.

Conclusion: The appearances were those of fibrosis of the lacrimal sac associated with a mid-level obstruction and a cystic diverticulum.

At operation the lacrimal sac contained a lot of thick yellowish green material, and when this was cleared it was found that a fair-sized diverticulum extended laterally and corresponded with the swelling that was noted pre-operatively on the lower lid. Anterior and posterior flaps were fashioned and a catheter was placed in position to complete a dacryocystorhinostomy.

CASE NO. X.

Case History: Michael Quinn, aged 28, was hit by a saddle seven years ago and sustained fractures of the facial bones. From the time of the accident his right eye had watered and been of great trouble when out of doors.

A general examination showed considerable asymmetry of the face, the left side being flatter than the right, but the orbital margin of the right was intact. The lids were

normal, the eyes were white and the ocular movements full. The pupils were equal and reacted to light normally. The puncta were of normal size and in normal apposition to the globes. There was no regurgitation from them on pressure over the sac area but the right side was rather tender.

Preliminary syringing showed easy patency into the nose on the left side and also on the right, but on the right side a small obstruction was felt in the lower canaliculus about 3 mm from the punctum.

Dacryocystography showed patency into the nose, but the right lacrimal sac was dislocated forwards and there was considerable displacement of the sinus of Maier relative to the sac. The communications between the sinus, the sac and the naso-lacrimal duct were very narrow, and did not retain the medium. The sac was distended.

Conclusion: The appearances were those of fibrosis and displacement associated with old fracturing of the adjacent bone structure.

At operation the sac was exposed with an anterior incision. It was found that the periosteum was adherent to the underlying bone and the bony surface was irregular from the presence of a previous fracture. A bony spur, probably misplaced turbinate, had to be removed. Anterior and posterior flaps were fashioned and a cystorhinostomy was completed.

CASE NO. XI

Case History: Mrs. Ada Temple, aged 40, complained of a swelling in the corner of the right eye, and watering of the eye. The

swelling began two years ago, together with the watering, but after a year the swelling subsided and the watering persisted. Two months later the swelling came back.

A general examination of the eyes showed no external evidence of a mucocele of the lacrimal sac, but pressure over the right sac area brought about regurgitation of muco-purulent material from the puncta. The puncta were normal and in good apposition to the globes. The lids, eye movements and reactions to light were normal, and the tension was also normal.

Preliminary syringing through the lower punctum of the right side showed some patency through the sac into the nose, but regurgitation took place through the upper punctum. Syringing through the upper punctum brought about regurgitation from the lower.

Dacryocystography showed both canaliculi to be slightly deformed, secondary to dilatation of the right lacrimal sac. They were visualised because of regurgitation of the medium during the injection. The grossly dilated sac was narrowed at its neck and almost completely occluded at the bony rim of the canal. Some of the medium trickled into a narrow segment of the naso-lacrimal canal, extending from the rim of the canal to the lower border of the inferior turbinate. Here there was dilatation consistent with a partial stenosis of the lower end of the canal at the valve of Hasner. Some of the medium passed into the nose.

Conclusion: The appearances were consistent with incomplete middle and low obstructions of the lacrimal system, probably due to fibrosis.

At operation the sac was found to be full of thick pus. It was emptied, the bone was trephined, but the mucous membrane was perforated posteriorly. A posterior flap could not be fashioned. Anterior flaps only were fashioned and sutured together over an indwelling catheter.

Six months later a successful dacryocystorhinostomy was established, with no watering.

CASE NO. XII

Case History: Rosalind Watterer, aged 12, had suffered from watering of the left eye since infancy. The left naso-lacrimal duct had been probed from time to time without success, and she was referred from another hospital for dacryocystorhinostomy.

A general examination showed an excessive tear film in the left lower lid, but the lids themselves appeared normal and the puncta were in good apposition with the globe. Pressure over the lacrimal sac area yielded a considerable quantity of muco-pus through the puncta. The ocular movements were full, the pupils were equal and reacted to light and the eyeball tension was normal on either side.

Preliminary syringing with normal saline of the left side through the lower punctum brought about regurgitation of muco-pus through the upper canaliculus, and none passed into the nose.

Dacryocystography - the lacrimal sac was emptied of muco-pus, by pressure, before fluid Neohydriol was injected. Injection into the lower canaliculus eventually brought about regurgitation of the medium through the upper canaliculus. No opaque fluid was present in the nasal cavity, and the duct in the

bony part of the canal was distended secondary to a complete obstruction at the lower end of the duct. The lacrimal sac was grossly dilated because of the block at the lower end of the duct and commencing occlusion at the neck of the sac. The sac was distorted on its medial aspect.

Conclusion: The appearances of the lacrimal sac suggested fibrosis of the medial part, probably due to damage from probing. There were combined mid and low level obstructions, the latter was complete.

A successful dacryocystostomy was carried out.

CASE NO. XIII

Case History: Leslie Doust, aged 39, was involved in a motor cycle accident four weeks ago and presented complaining of epiphora from the right eye and double vision.

A general examination of the eye region showed some deformity of the nose, and a scar just below the lower orbital margin on the right side pulling the lower lid slightly downwards and exposing more of the sclera on that side. There was an increase in the strip of tear fluid on the right. The eyes were white and the gross ocular movements were full and the patient did not see double within the scope of these movements. Convergence was present. The pupils were circular equal and reacted to light. Both puncta were of adequate size and in good apposition to the globes. A Hess Chart demonstrated restriction of the right inferior rectus movement.

The initial X-ray examination at the time of injury showed the central block of the face to have been displaced backwards and slightly downwards and the alveolar segments of the

maxillae to have been separated from it, as a whole. This latter fragment was also displaced backwards and downwards. There was evidence of fracturing of the cribriform plate and the frontal sinus was involved. The nasal bones were fractured but the profile was not depressed. The nasal septum had been crushed. The zygomatic arches of both sides were fractured and the malar bone of the right side had been displaced slightly medially, with separation of the fronto-malar suture. The appearances described were also consistent with the presence of a high transverse fracture of the face.

Preliminary syringing of the right side showed no patency into the nose but some regurgitation occurred through the upper punctum. On the left side syringing showed partial patency into the nose and again regurgitation through the opposite punctum.

Dacryocystography at the time of examination of the eyes showed the naso-lacrimal sacs and ducts of both sides to be dilated and deformed, and Neohydriol flowed from them into the nose. The fracturing of the antral walls in the region of the lower ends of the ducts allowed a considerable quantity of the medium to enter the antral cavities on either side.

Conclusion: The appearances were consistent with fistula between both lacrimal ducts and the antral cavities, and the presence of associated partial bony and/or fibrous obstruction to the lower ends of the ducts. The restriction of movement of the right inferior rectus was probably due, therefore, to haemorrhage and scarring.

CASE NO. XIV

Case History: Richard Harman, aged 5, was admitted for examination and investigation because of watering from the left eye.

A general examination showed the lids to be apparently normal, with full closure. There was a small scar in the region where it was expected to find the left lower punctum, but no punctum was visible. There was a history of probing of the left duct on two occasions in the last six months, and correction of a left convergent squint by operation. At the time of examination the eye movements were full and there was no manifest squint and no deviation under cover. There was a slight mucoid discharge from the left eye.

Preliminary syringing under general anaesthesia, via the upper punctum of the left eye, showed free patency into the nose.

This was followed immediately by Dacryocystography with a portable unit. A dacryocystogram revealed a patent naso-lacrimal duct, but dilated, secondary to delay in flow through the region of the valve of Hasner.

Operation was subsequently carried out to effect drainage, and the lower lid punctum was discovered about 3 mm lateral to the normal site, and the canaliculus ran to a blind end 5 or 6 mm medially. The posterior wall of the sac was sutured to the bulbar side of the conjunctiva in front of the caruncle to maintain an opening into the sac, and the incised wound in the lower lid was closed by interrupted sutures.

This posterior wall cystostomy was entirely successful and three months later there was no watering at all.

CASE NO XV

Case History: Mrs. Olive Harman, aged 47, had complained of a discharge from the right eye for five years. Five years ago watering had started and gradually became worse and was associated with the discharge. She had been treated with antibiotics without success.

A general examination showed full movements of the lids in the presence of considerable swelling of the tissues of both lids and extending on to the right cheek. The lid margins were crusted and the palpebral conjunctiva was velvety. The bulbar conjunctiva showed multiple small cysts between the plicae and the limbus. There was virtually no redness. The inferior punctum was displaced forwards and was just visible. It was much increased in size with pouting lips. The superior punctum was normal in position but it, too, was increased in size with pouting lips. There was some discharge from this punctum. On palpation some deep swelling was felt through the oedematous tissues in the naso-lacrimal sac region, but no material was expressed on pressure and there was no tenderness.

Preliminary syringing of the right side showed patency into the nose when the cannula was passed into the sac. When it was left in the canaliculus there was some regurgitation of haemorrhagic fluid via the upper canaliculus.

Dacryocystography - the lid shadows were displaced laterally in association with gross distortion, tortuosity and dilatation of the lower canaliculus. Neohydriol was retained in the region of the sac, which was not enlarged. There was patency into the nose.

Conclusion: The distortion of the canaliculus was consistent with the presence of a chronic inflammatory state, and was the appearance associated with a mycotic infection.

At operation the canaliculi were inspected. The lower one was slit some 4 mm medially from the punctum. Exploration with the probe showed the presence of hard masses inside the canaliculus. The canaliculus was curetted with a lens curette and many sulphur crystallines of streptothrix were obtained. All the lining granulous tissue was removed. The same procedure was adopted for the upper canaliculus. At the end of the operation the canaliculi were syringed with chloromycetin solution. No rhinostomy was done. Syringing and antibiotic treatment was continued for six weeks, and then a three snip operation was performed. Finally dacryocystorhinostomy had to be carried out.

CASE NO. XVI

Case History: Miss Vera Poile, aged 38, presented as an outpatient complaining of recent attacks of swelling and pain over the lateral side of the nose close to the left eye, and of a discharge and watering from that eye.

A general examination showed white eyes, but with a purulent discharge in a corner of the left eye. There was a swelling in the left sac area. On pressure over this lacrimal sac region a muco-purulent discharge appeared at the puncta. The puncta were normal in size and position, relative to the globes. The ocular movements were normal in all directions, and the light reaction of the pupils and the eyeball tension were also normal.

Preliminary syringing showed an initial increase, in size, of the swelling on the left side, followed by regurgitation. No patency was demonstrated into the nose.

Dacryocystography revealed a grossly irregular and dilated lacrimal sac containing a translucency on its upper medial aspect. The sac was occluded at its neck. There was regurgitation of the Neohydriol during the injection and some was retained in the canaliculi. They were slightly distorted.

Conclusion: The appearances were consistent with gross fibrous changes within the sac and probably the presence of a calculus. The appearances were those associated with a fungus infection.

At operation the sac was exposed through an anteriorly placed incision. On trephining the bone, an opening was made over an ethmoidal air cell. The opening was, therefore, extended downwards and the cell left intact until the necessary size of opening was obtained. The sac was then opened. A huge granuloma was removed, as well as a calculus the size of a pea. This calculus was lodged in a loculus. Anterior and posterior flaps were fashioned and sutured and an indwelling catheter was left in situ. A successful dacryocystorhinostomy was completed.

CASE NO. XVII

Case History: Gillian Hart, aged 21, presented complaining of watering from the left eye for three years. There was no history of infection or injury on the left side. Syringing and probing had been unsuccessful.

A general examination of the left eye showed the inferior punctum to be normal and in good apposition, and the superior punctum was also normal. Over the region of the lacrimal

sac there was some swelling which had displaced the inner canthus forwards and slightly downwards. There was no evidence of inflammation. On pressure over the sac a soft swelling was felt and it was tender. The swelling extended above and below the internal tarsal ligament. There was no regurgitation through the puncta on pressure over the swelling or sac area.

Dacryocystography showed ready patency of the lacrimal system into the nose, but minute quantities of Neohydriol remained in the canaliculi and at the neck of the sac. The bone structure in the region of the ethmoidal air cells on this side, and in the area of the floor of the frontal sinus, showed evidence of early destruction. The left frontal sinus and ethmoidal air cells were opaque. A soft tissue swelling was evident in the area on the radiograph.

Conclusion: The appearances were consistent with a mucocele of the frontal or ethmoidal air cells on the left side, causing slight delay in flow through the canaliculi and sac by its pressure.

A month later the patient was admitted for operation, and the mass had increased in size and was obvious on gross inspection, presenting particularly above the medial tarsal ligament and displacing the eye slightly laterally and causing a little proptosis. There was no pain, nasal discharge or double vision.

An X-ray examination of the anterior group of sinuses at that time showed a relative opacity of the frontal sinus on the left side and of the anterior ethmoidal air cells on this side. Both maxillary antra had in them considerable thickening of the mucosal lining. The appearances were those of a chronic

hypertrophic sinusitis of the maxillary antra, and chronic infection of the left frontal and ethmoidal air cells. The soft tissue swelling, previously described, appeared to be related more to the ethmoidal group of cells than to the frontal sinus. The distinction was not possible on the radiographs.

An operation was carried out under low blood pressure anaesthesia. An incision was placed in the area of the tumour, from the junction of the inner and middle third of the lid, curving downwards to the centre of the internal tarsal ligament. The orbicularis was split and the tumour easily exposed. It was separated from the surrounding structures, and was bluish-grey in colour with a thin covering. At one point the tumour was opened and about 5 ccs of milky white fluid was evacuated. The entire cavity of the tumour was then aspirated, and as much of the inner wall as could be mobilised was excised. Fluid was sent for culture. The inner wall of the mucous membranes was sent for section. Exploration showed no communication with the nose and frontal sinus, so that an opening was made into the most dependent part of the nose. The cavity of the tumour was then packed. There were no operative incidents.

The operative diagnosis was an ethmoidocele. Subsequent examination showed the epiphora to be cured.