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## COMMUNICATIONS

# THE LACRIMATION REFLEX*

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ABERDEEN

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## Introduction

IN the practice of ophthalmic surgery one of the most common complaints is that the eyes water, one of the rarest that the patient is unable to weep.

During the waking hours there is a constant flow of mucus and tears from the lacrimal and mucous glands. This secretion is distributed uniformly over the cornea by the blinking of the eyelids, and ensures adequate lubrication to maintain the brilliant polish on the main refracting surface of the eye. Normally very little secretion escapes through the canaliculi and lacrimal ducts, evaporation keeping pace with secretion.

## Physiology

This normal secretion can be maintained by the accessory lacrimal and mucous glands alone, as has been demonstrated by von Graefe (1854) and others, who extirpated the main lacrimal glands without endangering the eye in any way from lack of lubrication. Cases suffering from keratoconjunctivitis sicca, reported by Sjogren (1940), had defective secretion from the accessory lacrimal glands as well as from the main lacrimal glands.

Apart from the flow of normal secretion, a flow of tears can be produced by (*a*) stimulating the terminations of the 5th nerve, especially those branches ending in the cornea and conjunctiva; (*b*) sneezing, coughing and vomiting; (*c*) psychic stimulation.

The irritation reflex is common to both man and animals, but psychic weeping is a phenomenon confined solely to humans. Numerous animals have been said to weep, but on investigation this has been proved to be a myth (Collins, 1932).

In human beings the flow of tears is exceedingly variable. Babies do not shed tears until they are a few weeks old; they howl, grow red in the face, screw their lids tightly together, but there is no flow of tears. Some women are exceedingly emotional and can weep on the slightest provocation, while it is exceedingly rare to see an adult male weep.

## Nerve Supply

For the proper functioning of the lacrimation reflexes three nerves are said to be required. They are the 5th nerve, the 7th nerve, and the cervical sympathetic outflow. In addition, at least three ganglia take a part; they are the ganglion of the facial nerve (geniculate), the spheno-palatine, and the trigeminal ganglion (Gasserian). As the pathways and connections of these nerves and ganglia are very complicated, a description is added.

*The lacrimal nerve.*—This nerve is the smallest terminal branch of the ophthalmic division of the 5th nerve. It commences

in the fore-part of the cavernous sinus, and enters the orbit through the lateral part of the superior orbital fissure. It enters the lateral part of the fissure superior to the muscles and embedded in the periosteum. It then runs along the lateral wall of the orbit, superior to the lateral rectus and lateral to the lacrimal artery. Just before reaching the gland the nerve divides into two branches. The superior branch enters the gland, a few of its fibres ending there and supplying the secretory cells of the acini (Dogiel, 1893).

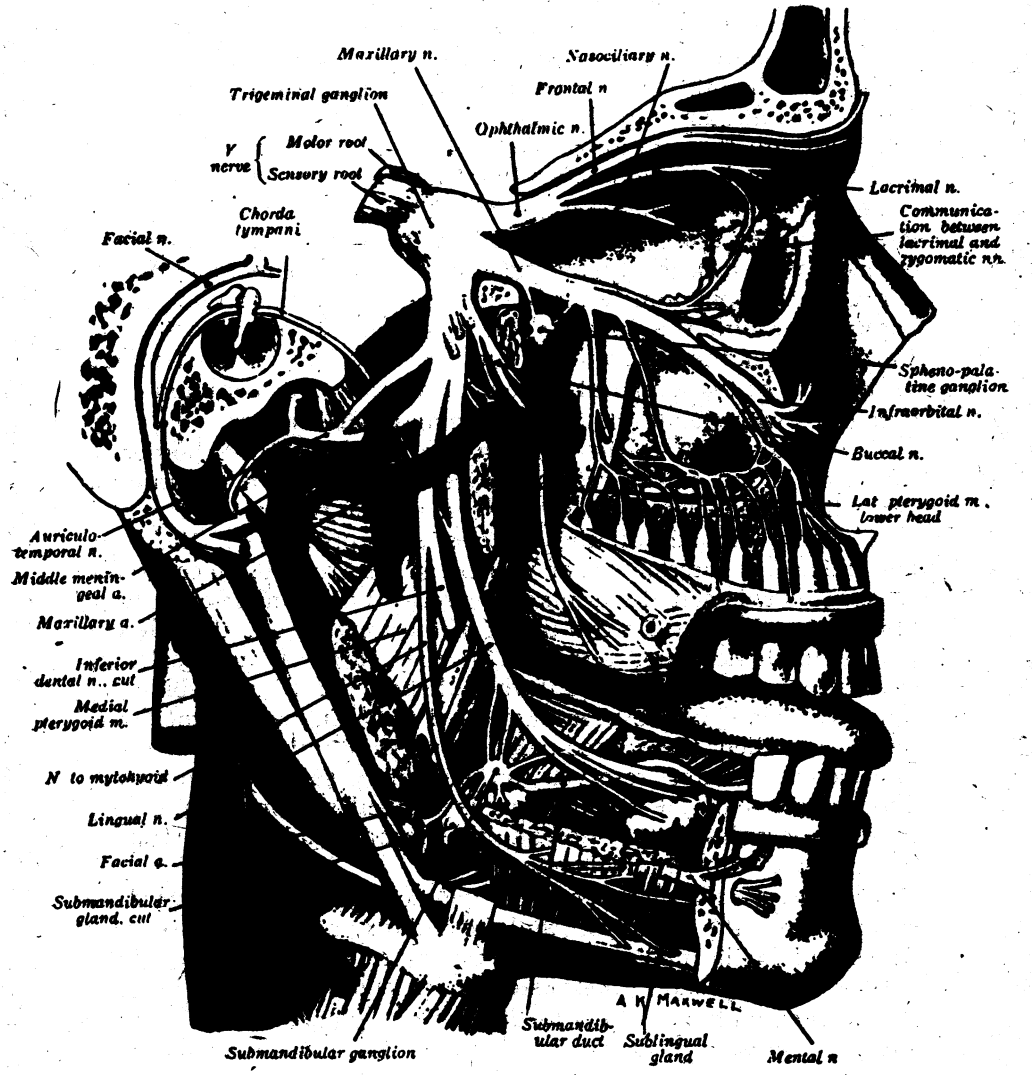


FIG. 1.

The right 5th nerve. (From Gray's Anatomy).

The majority of the fibres traverse the gland, pierce the septum orbitale, and end in the conjunctiva and the skin of the upper eyelid. Its peripheral terminations on the face join with filaments of the facial nerve. The inferior branch also enters the gland, but before doing so it gives off a branch which passes downward between the gland and the lateral orbital wall, and communicates with the zygomatico-temporal branch of the maxillary nerve (Fig. 1).

Occasionally the lacrimal nerve is absent, its place being taken by the zygomatico-temporal nerve (Gray, 1942).

*The zygomatic nerve.*—This nerve arises from the maxillary division of the 5th nerve in the pterygopalatine fossa, between the foramen rotundum and the spheno-palatine ganglion, enters the orbit through the inferior orbital fissure, and immediately divides into two branches, zygomatico-facial and zygomatico-temporal.

*The zygomatico-temporal nerve.*—This nerve runs along the lateral wall of the orbit embedded in the periosteum. Before it enters the canal in the zygomatic bone to reach the temporal fossa, it gives off a communicating branch to the lacrimal nerve. After passing through the canal in the zygomatic bone it passes upwards between the bone and the temporal muscle, and is distributed to the skin of the temporal region. Its terminal distribution communicates with the auriculo-temporal and facial nerves.

*The facial nerve.*—This nerve arises from the lower border of the pons lateral to the recess between the olive and the inferior cerebellar peduncle (Fig. 2). It consists of two roots, a motor root which supplies all the muscles of expression of the face, and the nervus intermedius of Wrisberg. This root, often called the sensory root, is actually a mixed nerve, and contains afferent taste fibres from the anterior two-thirds of the tongue, but also efferent parasympathetic fibres destined for the lacrimal and salivary glands by connections through the spheno-palatine and submandibular ganglia. It has been suggested that this part of the facial nerve be called the glosso-palatine nerve, the name "nervous intermedius" being reserved for the purely sensory component. The ganglion of the facial nerve is the cell station for the taste fibres only, the secretory fibres to the lacrimal and salivary glands being uninterrupted in this ganglion.

*The glosso-palatine nerve.*—The glosso-palatine nerve enters the pons between the motor root and the auditory nerve. The sensory fibres end in the nucleus of the solitary tract (Fig. 2), but those subserving taste end in the gustatory nucleus.

The preganglionic fibres to the salivary glands come from the superior salivary nucleus. The fibres for the lacrimal gland arise in the lacrimal nucleus. The higher centres for lacrimation are quite unknown.

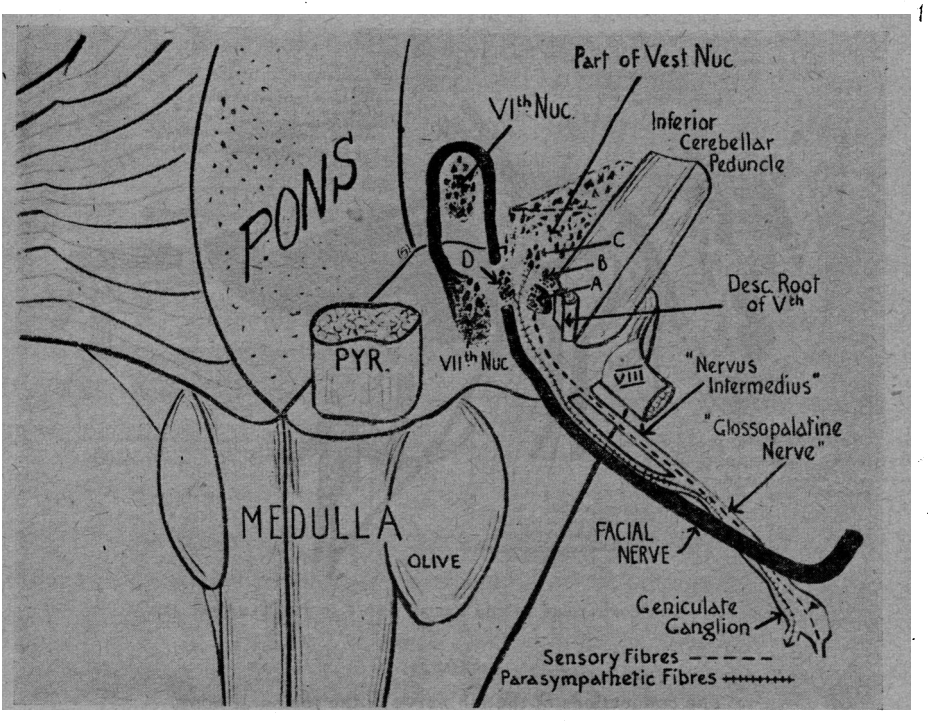


FIG. 2.

The 7th nerve and its central connections. The sensory fibres end in A (the nucleus of the solitary tract) but those subserving taste may end in B (the so called " gustatory nucleus ").
The preganglionic fibres to the salivary glands come from C (the superior salivary nucleus). Those for the lacrimal gland may come from this nucleus, but some believe that they arise in D (which is then called the " lacrimal nucleus ").

After the facial nerve enters the internal auditory meatus it passes outwards and forwards (Fig. 3). It then makes nearly a right-angled turn, the genu. From this point it proceeds backwards and slightly downwards to its exit at the stylo-mastoid foramen. In the facial canal, where the nerve bends sharply to form the genu, there is an oval swelling on the nerve, the *facial* (*geniculate*) *ganglion*. From the ganglion three small nerves arise, (*a*) *The greater superficial petrosal nerve*. This nerve passes forwards through the hiatus on the anterior surface of the petrous portion of the temporal bone, and enters a groove in the bone, covered by the dura mater. Before leaving the bone it receives a twig from the tympanic plexus. It passes deep to the trigeminal (Gasserian) ganglion and reaches the foramen lacerum, where it is joined by the deep petrosal nerve from the sympathetic plexus on the internal carotid artery to form the nerve of the pterygoid

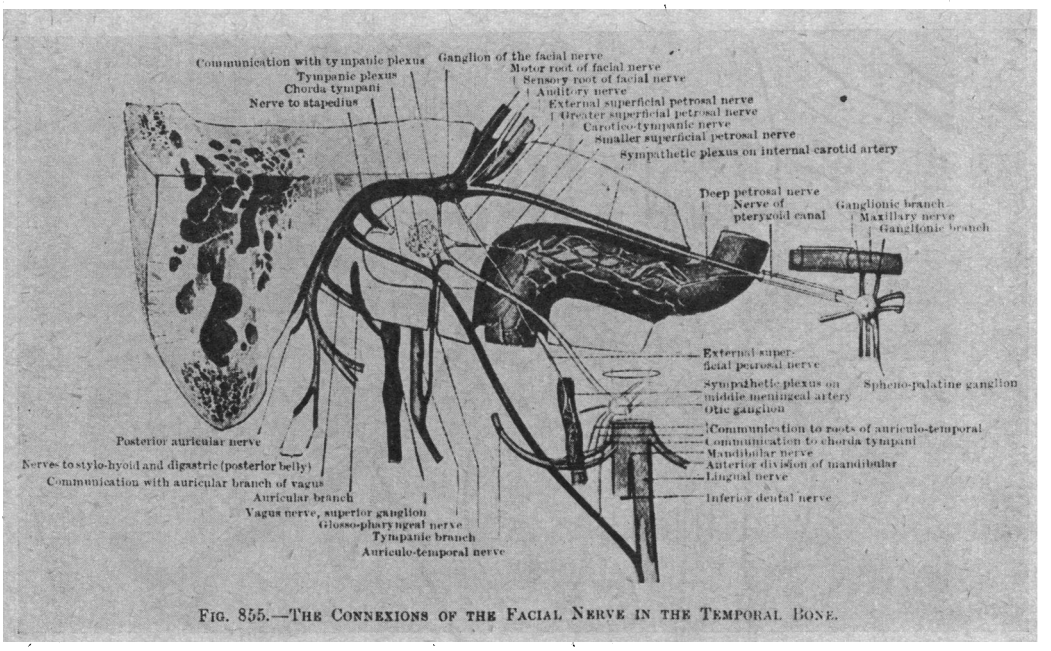


FIG. 855.—THE CONNEXIONS OF THE FACIAL NERVE IN THE TEMPORAL BONE.

FIG. 3.

**The connections of the 7th nerve in the temporal bone. (From Cunningham's Anatomy).**

canal or Vidian nerve, which passes forwards through the pterygoid canal and ends in the spheno-palatine ganglion. (*b*) A small branch runs in the bone to join with the tympanic branch of the glossopharyngeal, to form the *lesser superficial petrosal nerve* (Figs. 3 and 5). It is conveyed through this nerve to the otic ganglion. (*c*) *The external petrosal nerve* is an inconstant branch which connects the ganglion with the sympathetic plexus on the middle meningeal artery.

In the descending part of the canal three branches leave the facial nerve: (*a*) The nerve to the stapedius; (*b*) the chorda tympani. It arises from the facial nerve 6 mm. above the stylo-mastoid foramen and supplies the parasympathetic root to the submandibular ganglion, and taste fibres to the anterior two-thirds of the tongue. (*c*) Just before the nerve reaches the stylo-mastoid foramen a branch is given off which communicates with the auricular branch of the vagus.

*The spheno-palatine ganglion and its connections.*—The spheno-palatine ganglion lies in the upper part of the pterygo-palatine fossa, close to the spheno-palatine foramen (Fig. 1). It is a small reddish-grey body situated below the maxillary nerve. It receives three kinds of fibres, sensory by the spheno-palatine branches

from the maxillary nerve, and sympathetic and parasympathetic from the nerve of the pterygoid canal, the former coming from the carotid plexus by the greater superficial petrosal nerve.

The branches of the spheno-palatine ganglion are divisible into four groups—orbital, palatine, nasal and pharyngeal. Meantime only the first group concerns us. The orbital branches consist of two or three filaments which enter the orbit through the inferior orbital fissure and are distributed to the periosteum, the orbitalis muscle, to the optic nerve and sheath and, according to Cunningham, to the lacrimal gland. Only those fibres that are destined for the lacrimal gland are relayed in the ganglion.

*The sympathetic pathway—the deep petrosal nerve.*—This nerve arises from the cervical sympathetic plexus. It runs in the carotid canal lateral to the internal carotid artery. In the substance of the fibro-cartilage that fills the foramen lacerum, it joins with the greater superficial petrosal nerve to form the nerve of the pterygoid canal or Vidian nerve.

The important features of the anatomy are:—

1. The lacrimal nerve communicates with the zygomatico-temporal branch of the maxillary nerve and the terminal fibres of the 7th nerve, but ends chiefly in the conjunctiva and skin of the upper eyelid. Both branches traverse the lacrimal gland, and send filaments to the acini.

2. The zygomatic nerve leaves the maxillary nerve at an acute

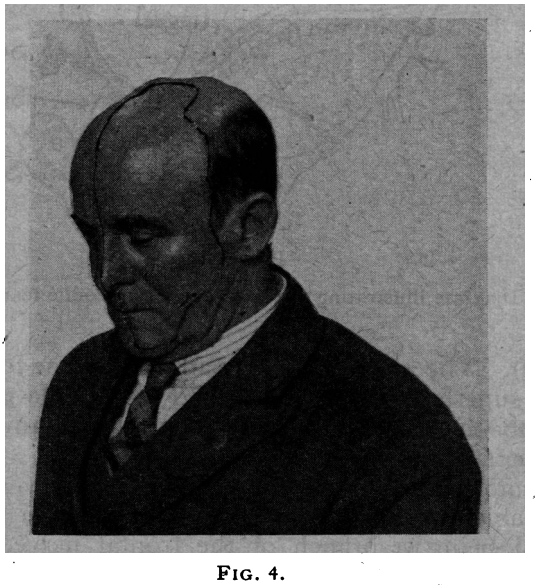

FIG. 4.

The connections of the 7th nerve in the temporal bone.

angle midway between the spheno-palatine ganglion and the trigeminal (Gasserian) ganglion (Fig. 1) and all the fibres can be traced into the latter ganglion. It would appear, therefore, that lacrimation impulses traversing the spheno-palatine ganglion must first pass to the trigeminal (Gasserian) ganglion along the maxillary nerve before they can enter the zygomatic nerve and pass along its zygomatico-temporal branch (Fig. 4).

3. Para-sympathetic fibres to the lacrimal and sub-lingual glands accompany each other in the glossopalatine nerve (nervus

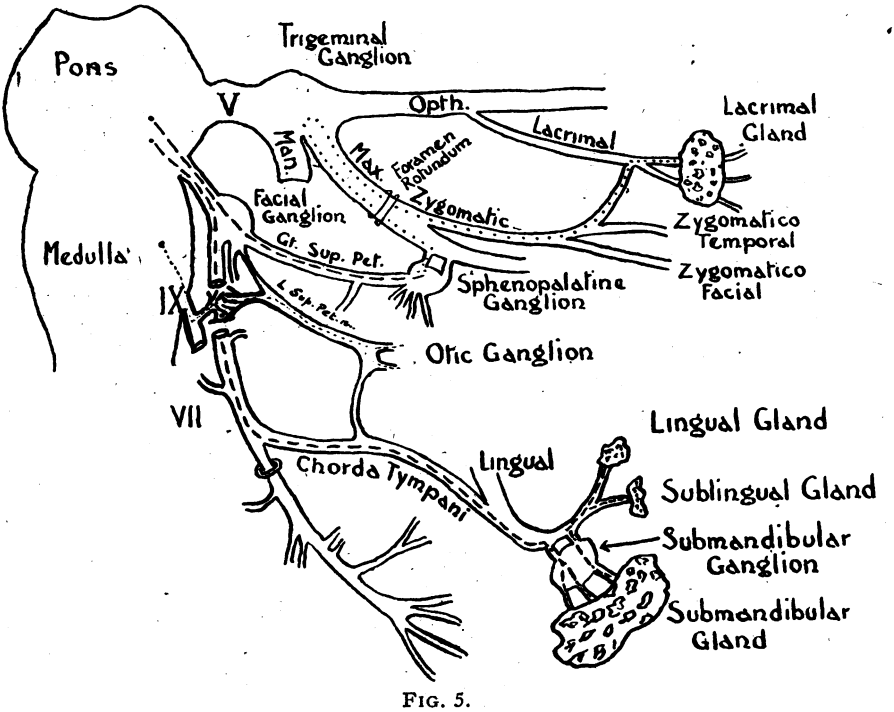


FIG. 5.

Diagram illustrating the syndrome of crocodile tears.

intermedius). The pre-ganglionic pathway for the former is along the greater superficial petrosal nerve to the spheno-palatine ganglion, and to the latter along the chorda-tympani and lingual nerves to the submandibular ganglion (Fig. 5).

These anatomical details have been verified by dissecting six still-born babies. Slight modifications have been seen, such as the lacrimal being a branch of the frontal nerve, the lacrimal communicating with the frontal nerve, and in one case with the ciliary ganglion.

## Clinical and Experimental Observations

A considerable amount of clinical and experimental evidence can be found to support the view that impulses for lacrimation actually pass along these nerves, and by examining patients who have had the various nerves sectioned by operation, the actual part taken by these nerves in the different reflexes can be surmised. As the lacrimal nerve traverses the lacrimal gland besides terminating in the conjunctiva and skin of the upper eyelid, the first point to be settled is whether efferent as well as afferent impulses run in this nerve. Parsons (1902) stimulated the peripheral cut end of the lacrimal nerve in the cat, dog and rabbit, and in no case did tears run down the face, nor was any activity shown microscopically in the gland. It would appear, therefore, that the fibres that terminate in the gland are those that come along the branch communicating with the zygomatico-temporal nerve, or from branches that pass directly from the spheno-palatine ganglion into the orbit.

Evidence that the 5th nerve is the afferent pathway for lacrimation caused by irritation of the eye and conjunctiva is fairly conclusive.

## Experimental

*Effect of tear gas upon the normal and anaesthetic eye.*—The left eye of a young normal subject was occluded with a pad and bandage and the nostrils were plugged with cotton-wool. The right eye was then anaesthetised by means of several drops of 4 per cent. cocaine. Tear gas* was then directed on to the right eye by means of a scent spray. No pain was felt in the eye and there was no lacrimation. The pad and bandage were then removed and the gas was projected on to both eyes. Great pain was felt in and around the left eye, and there was profuse lacrimation from this eye only.

*Effect of foreign body upon cornea of eye.*—A small piece of grit was placed on the cornea of a normal eye. There was great pain in the eye and profuse lacrimation from this eye only.

Lacrimation is, therefore, initiated by stimulation of the nerve endings in the cornea and conjunctiva and is unilateral.

## Clinical Investigations

*Foreign body on cornea.*—A foreign body had to be removed from a child's eye, so the eye was rendered anaesthetic by means of 2 per cent. cocaine. The child was frightened and wept, a profuse flow of tears taking place from both eyes as the result of psychical stimulation.

* Phenyl-bromo-aceto-nitrite. (Supplied by the War Office).

*Toxic neuritis of the ophthalmic division of the 5th nerve.*—A male, age 55 years, consulted me because his right eye had turned dim a few days previously. There was no pain, but the eye watered a good deal. Upon examination it was found that vision was reduced to counting fingers at 3ft. The eye was red, the cornea was hazy and covered with superficial dot-like opacities. The tension was normal. The cornea, eyelids, forehead, and right side of nose were found to be anaesthetic. There was no sign of herpes. His teeth were very bad, and pus was oozing from the gums. Toxic neuritis of the ophthalmic division of the 5th nerve was diagnosed. The teeth were removed, and the eye slowly recovered over a period of six months, but poor vision remained owing to corneal nebulae. During treatment there was profuse lacrimation from the right eye only, but pain was never present. As the cornea and eyelids were completely anaesthetic to touch and pain, the stimulus for the excessive lacrimation could not have originated in the conjunctiva or cornea, and as the lacrimation was unilateral it was not psychical in origin.

*Herpes ophthalmicus in a woman aged 65 years.*—The cornea became involved but cleared up well under treatment. The cornea was still anaesthetic six months after the appearance of vesicles. The patient was rather emotional and wept fairly readily, tears appearing equally in both eyes. In this case no undue lacrimation was observed during the acute phase, No interference, however, was present with the flow of tears from psychical stimulation.

*Post-operative 7th nerve paralysis.*—A woman, age 47 years, was admitted into the Ear, Nose and Throat ward of the Aberdeen Royal Infirmary on March 17, 1937, suffering from acute mastoid disease, and underwent operation upon the day of admission.

Immediately following operation it was noticed that she had a left facial paralysis peripheral in type. The skin of the forehead was flattened, she was unable to close the left eye, and the side of the mouth drooped.

For the next few weeks there was troublesome watering from the left eye and there was loss of taste on the left side of the tongue over the anterior two-thirds.

On September 22, 1937, there was still slight weakness of the left side of the face. The eyelids were in good position and it was possible to close the left eye voluntarily, although not so tightly as the right. She complained of slight pain over the supra-orbital notch. She still complained of watering of the left eye. The patient was very emotional during her illness and wept readily, tears flowing equally from both eyes. In this case, of course, there was no sensory loss in the eyes or eyelids. There was excessive lacrimation during the time of the paralysis, and the flow of tears on emotional occasions was normal, so both the

afferent as well as the efferent pathways were intact. As there was a loss of taste on the anterior two-thirds of the tongue, the lesion of the facial nerve must have been central to the point where the chorda-tympani nerve leaves it. If we assume that lacrimation impulses pass along the greater superficial petrosal nerve, the lesion must have been between where the chorda-tympani nerve leaves the 7th nerve and the facial (geniculate) ganglion (Fig. 3).

*Mixed-celled sarcoma invading the base of the skull.*—A woman, age 54 years, was admitted into Ward 8, Aberdeen Royal Infirmary, on April 9, 1936. She complained of pain and swelling of the left face and neck of six months' duration. The pain varied in intensity, being occasionally very acute, and extended from above the frontal eminence to below the angle of the jaw, and from behind the ear to the mid line of the face. There was no discharge from the left ear. The swelling in front of the ear did not increase in size before or during meals, and there was no loss of taste or undue dryness of the mouth.

Upon examination there was a large, hard, fixed swelling in front of the left ear. The swelling filled up the angle of the jaw and extended forwards on the cheek to near the side of the nose and angle of the mouth. The swelling also extended to behind the ear.

There were no palpable lymph nodes in the neck or axilla. There was an area of partial anaesthesia corresponding to the radiation of pain. There was no facial paralysis and the corneal reflex was present.

The swelling was explored with a needle, but no fluid was found. A piece of the tumour was then removed for biopsy, and upon examination it was found to be a mixed-celled sarcoma.

On September 19, 1936, a radium plaque was applied over the swelling and left in position for 80 hours.

The patient was discharged on September 30, 1936, free from pain.

On February 2, 1937, she was re-admitted to hospital. The patient said that shortly after she was discharged from hospital the pain again commenced, at times being very severe. It radiated over left cheek, side of head, nose, lips and chin as far as the mid-line. Upon examination it was found that the tumour had increased in size. There was still no facial paralysis and the corneal reflex was still present.

On February 8, 1937, the trigeminal (Gasserian) ganglion was exposed by the temporal route, and the sensory root of the 5th nerve was cut. No attempt was made to save the motor root. Tumour tissue was seen to be infiltrating the floor of the skull in the neighbourhood of the foramen ovale. Considering the

situation and extent of the tumour, it was thought that the sphenopalatine ganglion was possibly destroyed. To expose the trigeminal (Gasserian) ganglion the greater superficial petrosal nerve was cut.

During the following week the patient was mentally confused, but did not complain of pain. She was very emotional and wept readily, tears flowing from the right side only.

The tumour steadily increased in size, tumour tissue being occasionally discharged from the nose. The operation scar and soft palate became infiltrated, and she died on April 25, 1937.

*Section of the sensory root of the 5th nerve.*—A male, age 56 years, suffered from trigeminal neuralgia for many years. The sensory root of the 5th nerve was sectioned by the temporal route. The area as shown (Fig. 4) was completely anaesthetic to pain, touch, heat and cold. Four years after operation the eye was quiet, vision was 6/6. Neuro-paralytic keratitis had not at any time been present. The right eye was occluded with a pad and bandage, and tear gas was directed on to the left eye. There was no lacrimation. The pad and bandage was then removed and the gas was directed on to both eyes. There was pain in and around the right eye only, and tears ran down the cheek from the right eye. This patient was an actor, and he was asked to take particular notice if tears flowed from the left eye, if at any time he wept from any emotional cause. After a six months' interval he reported that tears flowed on emotional occasions from the right eye only.

Section of the sensory root of the 5th nerve has now been performed for many years for the relief of trigeminal neuralgia. In performing the operation by the temporal route, some surgeons make the approach to the trigeminal (Gasserian) ganglion by stripping the dura from the base of the skull (Rowbotham, 1939). In elevating the dura the greater superficial petrosal nerve may be torn or cut in the process. Some surgeons deliberately cut the nerve, as it is thought that it was by traction on the greater superficial petrosal nerve that the 7th nerve was injured in the Fallopian canal, causing transient facial paralysis after the operation. Some surgeons again approach the ganglion intradurally. By this method of approach any injury to the greater superficial nerve is prevented. It is interesting to note that this means of approach was advocated by Lockhart (1925) upon anatomical grounds, as being the easiest method of approach to the ganglion. When this method of approach to the ganglion is used no diminution of lacrimation takes place (Rowbotham, 1939).

Dandy (1929) approached the sensory root of the 5th nerve from the posterior fossa, and the root was sectioned just before it entered the pons. In all of his cases tears flowed equally from both eyes on emotional occasions.

By sectioning the sensory root of the 5th nerve no reflex lacrimation takes place owing to the break in the afferent pathway. If no other nerve is interfered with, emotional weeping should, however, still take place normally, as the stimulus probably originates in the cerebrum. When the operation is performed by the temporal route instead of by the posterior fossa route, the only additional nerve to be divided is the greater superficial petrosal. As the former operation interferes with weeping while the latter does not, motor impulses to the lacrimal gland must pass along the greater superficial petrosal nerve.

*Herpes of the geniculate ganglion.*—Patient is a male student, age 23 years. Four years ago, while he was walking along the street, he felt something wrong with the right side of his face, and when he reached home and looked in the mirror he saw that there was a complete paralysis of the right face. He was unable to close the right eye, and he was unable to whistle. During the evening he developed a temperature and was admitted to hospital. On examination it was seen that he had a flaccid paralysis of all the muscles of the right side of the face. The paralysis was at a maximum from the first. There was no rash on the face or ear, but there was a rash on the roof of the mouth well forward. There was no loss of touch sensation on the face or tongue, but sense of taste was lost on the anterior two-thirds of the tongue on the right side. Hyperpyrexia continued for four days, the maximum being 101°F. During his stay in hospital nothing distinctive about lacrimal secretion was observed.

Upon examination four years later partial paralysis of the right side of the face was found to be still present. The forehead was smooth, the right eye could only be partly closed, the mouth drooped at the corner, and he was unable to whistle. When he attempted to use one group of muscles, as in winking, the muscles of the mouth were also put into action. When he ate he did not weep.

Upon testing for lacrimal secretion with the blotting-paper test, both eyes were found to be equal. This case was diagnosed as herpes zoster of the geniculate ganglion. As there was a complete paralysis of the motor component of the 7th nerve along with the absence of taste on the anterior two-thirds of the tongue, one would have expected that there would have been some interference with lacrimation. While he was in hospital no special notice was taken about lacrimation, and no test was made to see whether or not it was absent. Upon questioning the patient four years afterwards, it appears to me significant, however, that during the time he was in hospital and when he subsequently got outside, he was not troubled with the eye watering, as invariably happens when the paralysis is peripheral to the geniculate ganglion. When

I examined him four years later a certain amount of power had returned to the facial muscles, so it is probable that the nerve to the lacrimal gland had also regained its function.

*Syndrome of crocodile tears.*—A male, age 60 years, came to the out-patient department, Aberdeen Royal Infirmary, with a complaint that when he ate tears overflowed from his right eye and water ran from his right nostril.

He gave a history of a sudden right-sided facial paralysis six months previously. The lacrimation commenced with the return of power to the face three months after the paralysis. Tears flowed most readily when hot tea or soup was taken. Thinking about food did not cause lacrimation. He did not complain of loss of taste, but he said there was a different feeling in the right side of the mouth from the left, and that he had a hot feeling below the right eye and a tight feeling in his cheek. He can now wrinkle his forehead and close his right eye. The mouth is slightly twisted and he is unable to whistle. When he wrinkles his forehead all the muscles of the right side of the face fibrillate. He is deaf on the right side.

When he was given a plate of soup, tears ran down his face on the right side and he had to blow his nose frequently.

Such a syndrome can only be produced by a lesion of the 7th nerve central to the facial ganglion, as the nerves divide at the ganglion (Fig. 5).

Ford (1933) published three cases of this condition and Savin (1939) described other three. For the relief of the condition the spheno-palatine ganglion was injected with alcohol through the nose by Gottesfeld and Leavitt (1942).

In his comment Ford maintains that the contracture is due to increased tonus of the muscles and not to fibrous shortening of the muscles. The contracture is not always present to the same degree, but is increased by any form of animation, and is at a minimum when the patient is relaxed. When it is desired to activate any single group of muscles so as to produce a simple action, such as blinking the eyelid, all the muscles of the side of the face are brought into action.

It is supposed that the regenerated fibres have become fused and misdirected, and instead of a single muscle being stimulated, all the muscles of the face are stimulated indiscriminately. As fibres to the lacrimal and salivary glands also run in the 7th nerve, misdirection of these regenerating fibres also takes place, so that the patient lacrimates when he salivates. It is interesting to note that lacrimation could be stimulated only by taking food into the mouth, and not by bringing into action any of the facial muscles.

No one has described the associated flow of water from the nostril of the same side. Two explanations are possible: (1) The flow

of water could come from the eye via the naso-lacrimal duct. (2) The nerve supply to the mucous membrane of the nose comes from the spheno-palatine ganglion via the palatine nerves.

It is possible, therefore, that secretory fibres to the nose accompany the secretory fibres to the lacrimal gland as far as the spheno-palatine ganglion.

*Foville's syndrome.*—A male, age 17 years, complained of double vision, and the following day he developed a left facial paralysis. He had no recent illness, no headache, but was actively sick on two occasions upon the day that diplopia occurred. He was very giddy and unable to walk straight.

Upon examination it was seen that he had a left facial paralysis of all the muscles of expression. He could, however, close the left eye.

Vision was 6/6 both eyes, and accommodation was normal for his age.

The left pupil was slightly larger than the right, but both reacted normally to light.

When vision was directed straight ahead there was no squint. Movement of either eye to the left was impossible.

Movement of the right eye to the right was restricted and was accompanied by a rough horizontal nystagmus. Movement of the left eye to the right was limited to about 5 degrees. Upward and downward movements were full. Convergence also was full.

With the blotting-paper test lacrimation was increased upon the paralysed side.

The fundi were normal and the fields were full. Apart from a positive Romberg the physical examination was entirely negative. This included a complete neurological examination, X-ray of skull, examination of the cerebro-spinal fluid and blood, and a culture from a throat swab. He had not a raised temperature.

From the fourth day after the development of the facial paralysis recovery began to take place, and within a fortnight he had returned to normal.

In 1989 I reported another case of this syndrome (Mutch, 1939), but the defect was permanent and the paralysis of the eye movements was confined to the one side. Both, however, had unequal pupils, the smaller pupil being at the opposite side from the paralysis.

The lesion is situated in the pons near the floor of the 4th ventricle where the fibres of the 7th nerve sweep round the 6th nerve nucleus, and come in close relation with the medial longitudinal bundle (Fig. 6).

As there is no loss of lacrimation the fibres destined for the lacrimal gland must join the 7th nerve peripheral to the 6th nerve nucleus.

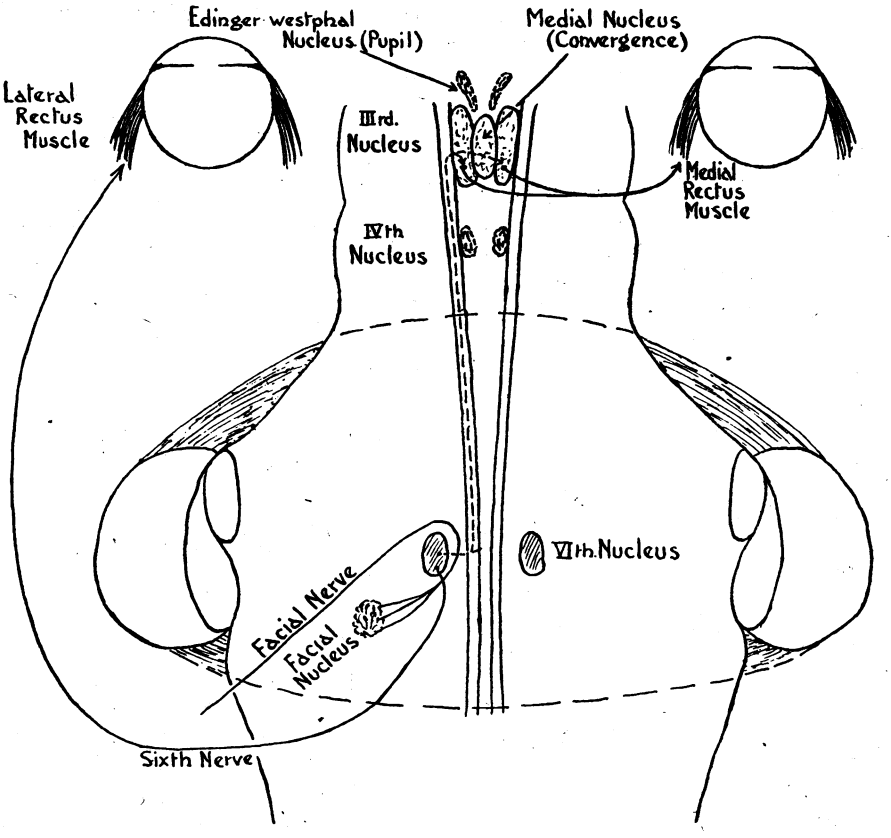


FIG. 6.

Diagram showing the nuclei, nerves, and tract involved in Foville's syndrome.

*Congenital absence of weeping.*—In 1930 Duke-Elder recorded two cases and reviewed the literature on the subject, and was able to find only three others. In no case was the absence of weeping associated with the absence of salivation. Duke-Elder in the same article also reviews the literature of recorded cases who developed loss of lacrimal secretion after birth. He divides these cases into two series: (1) Traumatic in origin, whereby the nerves to the lacrimal glands were injured by fracture of the skull, or the lacrimal glands were removed by operation. (2) Cases occurring spontaneously in women after the climacteric. In some cases the loss of lacrimation was associated with a dryness of the mouth and the skin. The majority, however, in all sections had an associated conjunctivitis or keratitis.

In 1940 Sjögren contributed to Modern Trends in Ophthalmology the section upon keratoconjunctivitis sicca. He states

that the condition is confined almost solely to women, and that a specific test for the condition is the instillation of a 1 per cent. watery solution of bengal red into the conjunctival sac. In positive cases the bulbar conjunctiva and cornea are stained a deep red over an area corresponding to the palpebral fissure.

Sjögren found xerostomia (dry mouth) present in ten out of twenty-two cases of kerato-conjunctivitis sicca, and associated arthritis in fourteen cases.

*Congenital absence of weeping associated with absence of salivation.*—Mrs. F., age 67 years. Height 4ft. 10in.

This old lady had never wept, and had suffered from defective secretion in her mouth all her life. While Mrs. F. was still an infant the family doctor noticed that when she cried no tears came. As the child grew older he learned that dry food could not be eaten, so came to the conclusion that salivation as well as lacrimation was defective. He even gave the girl a mixture to try to increase the flow of saliva and tears, but there was no response. The reaction to peeling onions was also negative. All her life she had had frequent attacks of indigestion, and had to be careful in the choice of food. While eating she took large quantities of liquid, and even between meals took frequent drinks of water. She had diphtheria, scarlet fever, and typhoid fever when young. She had worked hard all her life, and as her husband died five weeks after marriage she had to work to support herself.

She had no family, the menopause coming on at the age of 50. She had no complaint about her eyes. There was no undue dry feeling. Should a foreign body enter the eye the eye turned red, but there was no lacrimation. She had worn glasses for the correction of hypermetropia and presbyopia for many years. On examination the eyes were deep-set, with narrow palpebral fissures. The lids were in normal position. The puncta were present and patent. On everting the eyelids the conjunctiva was of healthy colour and moist. The corneae were clear, moist, and regular. The pupils were equal and active. There was no other eye abnormality present. Her doctor told me that he had looked at her mouth on several occasions and always found it dry. When I examined it her tongue and mucous membrane were dry but of good colour. She was given a sweet to suck, and two hours later the size of the sweet was very little reduced. She was then given a small cube of paraffin wax to chew and was instructed to spit any saliva that gathered in her mouth into a clean test-tube that was provided. At the end of three hours there was 2 c.c. of a mucoid secretion in the test-tube. It was analysed with the following result:—

1. Microscopic deposits. Squamous epithelial cells present. No crystals.

2. No thiocyanates present as usually found in saliva.
3. No ptyalin present.

This was compared with controls of normal saliva.

*Congenital absence of 7th nerve.*—A female child was born with a flaccid paralysis of all the muscles of one side of the face. From the appearance at birth it was assumed that there was a congenital absence of the 7th nerve on that side. The mother was asked to observe if tears flowed from both eyes. The child, although only beginning to speak, was very co-operative, and when she hurt herself she ran to her mother and said, " Look, tears, mummy." Tears flowed equally from both eyes.

*Unilateral sympathetic ganglionectomy.*—A female, age 19 years, was operated upon for the relief of Raynaud's disease, the sympathetic chain being cut below the stellate ganglion and again below the 3rd thoracic ganglion, and the intervening segment removed.

By saving the 1st thoracic white ramus communicans and the stellate ganglion, the sympathetic supply to the head and neck was left practically intact.

Several weeks after the operation, upon examination of the eyes, no Horner's syndrome was present on the operated side, and both pupils dilated equally when cocaine was instilled. Lacrimation was normal, tears due to irritation and to psychical stimulation appearing equally in both eyes.

*Unilateral cervical sympathetic ganglionectomy.*—A small boy, age 10 years, was operated upon for the relief of scleroderma, the stellate ganglion on one side being removed at operation. When he was examined one month after operation it was seen that he had a Horner's syndrome on the operated side, and the pupil failed to dilate with cocaine. During one experiment the boy's arm was pricked with a pin and he wept, tears running down his cheeks from both eyes.

Several other patients, both male and female (who had had unilateral ganglionectomy performed), were examined at various periods after operation, and on no occasion could any difference be seen in lacrimation or would the patients admit that there was any diminution or alteration in lacrimal secretion following operation.

*Bilateral sympathetic ganglionectomy.*—A girl, age 22 years, was operated upon three years previously for the relief of Raynaud's disease, bilateral cervical sympathetic ganglionectomy being performed, the stellate ganglion being removed at operation.

The patient had a bilateral Horner's syndrome. Upon examination the eyes appeared normal in every way, vision was 6/6, the fields were full, the pupils reacted normally to light and near vision, and the fundi were normal. The pupils failed, however,

to dilate upon the instillation of 4 per cent. cocaine. The patient complained that towards night the eyes felt small and uncomfortably dry. Upon weeping tears flowed normally from the eyes. Lacrimation was also profuse during vomiting and when a foreign body entered an eye.

## Conclusions

Reflex lacrimation is unilateral and can be inhibited by surface anaesthesia of the conjunctiva and cornea, and by section or paralysis of the ophthalmic division of the 5th nerve. This nerve is, therefore, the sensory or afferent pathway for reflex lacrimation.

The efferent pathway runs in the 7th nerve, but is independent of the motor fibres to the face muscles (syndrome of crocodile tears), and is separate from the 7th nerve in the brain near the 6th nucleus (Foville's syndrome) and also peripheral to the geniculate ganglion (Bell's palsy with loss of taste on anterior two-thirds of tongue).

If the greater superficial petrosal nerve be cut or the spheno-palatine ganglion be blocked no reflex or psychical lacrimation takes place, even although the ophthalmic division of the 5th nerve is left intact, while psychical lacrimation is normal if the sensory root of the 5th nerve be cut and the greater superficial petrosal nerve spared. Motor impulses must therefore pass along the greater superficial petrosal nerve.

Psychical weeping is bilateral and cannot be inhibited by surface anaesthesia or paralysis of the 5th nerve or section of the cervical sympathetic nerve.

Upon anatomical grounds it is assumed that the fibres from the spheno-palatine ganglion which enter the maxillary nerve run to the trigeminal (Gasserian) ganglion before they pass along the zygomatic nerve.

No interference with reflex or psychical lacrimation results from either unilateral or bilateral section of the cervical sympathetic chain in the neck. One patient did complain that her eyes felt unduly dry towards night, so there is a possibility that mucus from the glands in the conjunctiva may be inhibited, but on no occasion has keratitis sicca been observed in any patient who has had a sympathectomy done. It is unlikely, therefore, that the sympathetic nerve takes any part in reflex or psychical lacrimation.

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# VITAMIN P IN OPHTHALMOLOGY

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IN two cases of ocular haemorrhage recently under treatment vitamin P was used with very satisfactory results.

*In the first case* the patient had very extensive retinal haemorrhages and nasal and bladder haemorrhages, but on giving vitamin P the nasal and bladder haemorrhages ceased, no fresh retinal haemorrhages occurred, and those present absorbed. He suffered from myelomata, and the nasal haemorrhage was characterised by large clots of blood and serum.

*In the second case* the patient had recurrent haemorrhage into the anterior chamber after extraction of a cataract, but on giving vitamin P there was no recurrence, and the iris, which had become muddy, rapidly cleared. The eye, which was looking very unhealthy, rapidly took on a healthy tone. The patient improved greatly and rapidly in general appearance and mental agility when vitamin P was given.

## FIRST CASE—General History

A University graduate of high intellectual attainment and regular life was first seen in 1935 at the age of 47, and thereafter from time to time for refractive errors and the like.

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