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COMMUNICATIONS

EXPERIENCE IN CLINICAL EXAMINATION OF CORNEAL SENSITIVITY

CORNEAL SENSITIVITY AND THE NASO-LACRIMAL REFLEX AFTER RETROBULBAR ANAESTHESIA*

BY

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AN evaluation of the corneal sensitivity is an important part of many general clinical examinations and of all ophthalmological, neurological, and otological examinations.

Interest in corneal sensitivity was already alive at the beginning of the 19th century, but an exact method for measuring it was not known until von Frey (1894) introduced a method, using different calibres and lengths of hair. When a hair is pressed against a surface and thereby bent, the elastic power in the hair exerts a counter pressure, which may be measured by pressing the hair on to a scale.

For exact measurements of the corneal sensitivity, it is necessary to have a test-battery of hairs of different values, but, for clinical application this is often impracticable. Further, the constancy of the power of the hair varies to some extent with the moisture of the atmosphere. These disadvantages have prevented von Frey's method from becoming popular.

At the present time corneal sensitivity is usually tested by means of a piece of cotton wool finely twisted in the form of a pointed brush. The cornea is lightly touched or brushed with the cotton wool, and this somewhat unequal stimulus elicits a more or less painful sensation and a blinking reflex. The patient is asked to say whether this sensation is felt " normally ", or more on one side than the other.

There is therefore a need for a practical clinical test which will give reproducible and exact results in the hands of different examiners.

Apparatus

It is an advantage to substitute for von Frey's hair a nylon thread, which is round and even, and possesses constant physical properties. The coefficient of elasticity for nylon makes it possible, by varying its length between 55 and 5 mm., for a thread 0·11 in diameter to provide the range of pressures necessary for the measurement of normal and pathological corneal sensitivity.

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A special holder has been designed which makes it easy to vary the length of a standard nylon thread (Fig. 1). This is a simple and manageable instrument, easily adapted to clinical use, and with only a little experience it is easy to obtain constant and reproducible results.

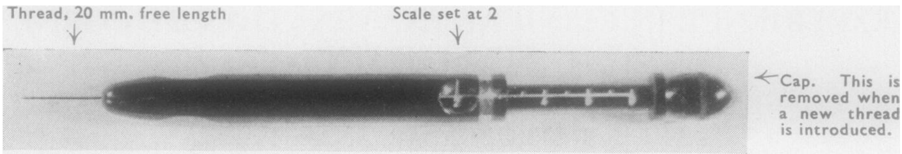


FIG. 1.—Special holder for variable nylon thread. The length of the thread is increased when the narrow inner handle is pressed into the outer cover. The scale measures the free length.

By calibrating the power of the thread against a set scale, only slight deviations were found from results previously obtained (Boberg-Ans, 1952), and several different examiners were able to obtain closely similar results.

Technique

The technique of examination is not complicated. The patient is first acquainted with the stimulus, which provokes a sensation varying in degree from " uncertain " to " definite ", " dry ", " astringent ", " unpleasant ", and " painful "—the last being accompanied by a flow of tears. The patient is asked to say when he feels the finest touch and his responses may be tested by feints.

It is necessary to look out for possible technical errors. The thread must be applied at right-angles to the cornea, the holder should be held just above the point of contact, and the bending of the thread should not exceed 5 per cent. of its free length. It is of great importance to the constancy of the stimulus that it should be applied as slowly as possible. If it is applied quickly the effect of the stimulus will be much increased.

It is not difficult to map out the sensitivity of the cornea, but this requires many contacts. If one wishes to denote the minimum perception, it is only necessary to examine the cornea at its centre and at four or eight paralimbal points.

NORMAL VALUES

The average minimum perception of the eyes of normal young people is shown in Fig. 2, with a central sensitivity of 15 mg. or less, and a limbal sensitivity of 20 mg., the sensitivity of the conjunctiva varying between 72 and 200 mg.

With advancing age sensitivity decreases. The mean sensitivity by age groups, based on earlier experiments (Boberg-Ans, 1952), is plotted in Fig. 3.

The ability of the cornea to localize stimuli is rather poor. It appears possible to tell whether the stimulus is lateral or nasal, up or down, but if the stimulus is very weak and especially as it approaches the centre, localization becomes more difficult.

Nor is it possible to distinguish between two simultaneous applications, as the stronger or the first perceived dominates; the second stimulus, if perceived at all, is usually identified with the first.

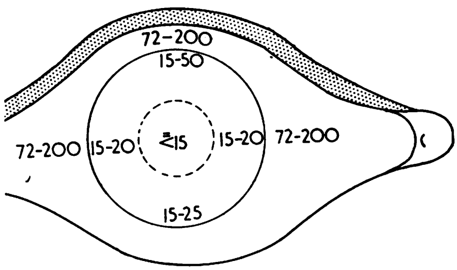


FIG. 2.—Normal sensitivity of different areas of the surface of the eye (mg.)

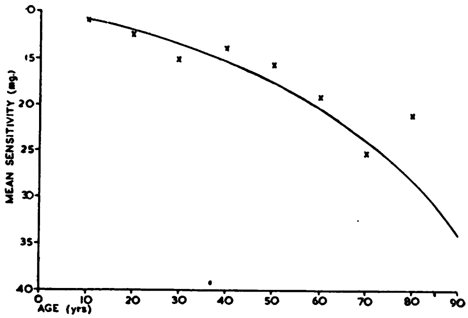


FIG. 3.—Mean corneal sensitivity (mg.) by age groups, showing decrease with advancing years.

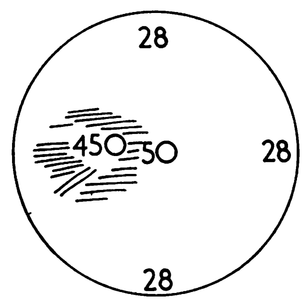
The localizing ability of the conjunctiva is a little better, but even here it is difficult to tell the exact position; it is only possible to distinguish simultaneous stimuli if they are some distance apart.

LOCALLY DECREASED SENSITIVITY

The sensitivity of the cornea is often considerably changed by local pathological processes.

PERFORATING INJURIES.—A decrease in local sensitivity is often limited to the degenerative area (Fig. 4).

FIG. 4.—Corneal sensitivity (mg.) in a man born in 1874, with a perforating wound in the left eye, traumatic cataract, and corneal maculae.



CHEMICAL INJURIES, especially burns with alkalis and acids, decrease corneal sensitivity.

CORNEAL ULCERS.—The sensitivity is always decreased in and near the ulcer. If the local oedema extends into the cornea, there is a corresponding decrease in sensitivity.

Fig. 5 (overleaf) shows an acute infected ulcer. The sensitivity was much decreased inside and surrounding the process; 10 days later, after treatment and healing, the sensitivity was only slightly decreased in areas corresponding to the deeper and more lasting changes.

Disciform keratitis may cause a well-defined decrease in sensitivity corresponding to the affected area, the sensitivity in the rest of the cornea being only slightly reduced.

The case seen in Fig. 6 (overleaf) showed clinical improvement, improved local sensitivity, and normal sensitivity in the remainder of the cornea after 50 days' treatment.

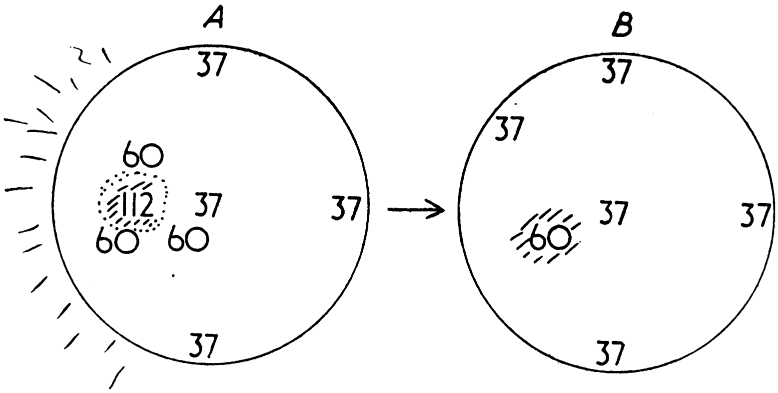


FIG. 5.—Corneal sensitivity (mg.) in a woman born in 1870, with a corneal ulcer in the right eye, showing improvement with healing after 10 days.

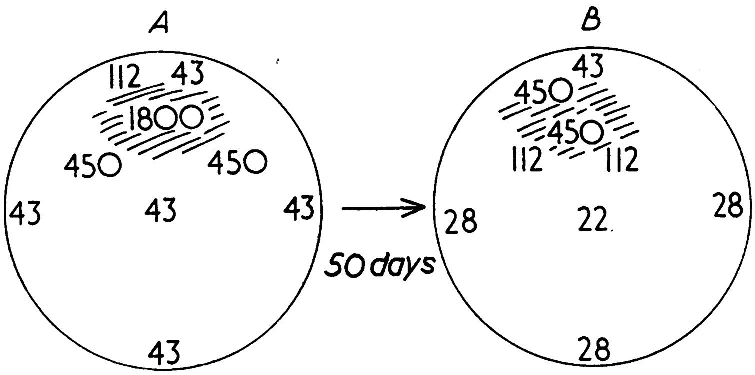


FIG. 6.—Corneal sensitivity (mg.) in a man born in 1921, with disciform keratitis in the right eye, showing improvement after 50 days.

In these cases it has been impossible to find other neurological or local changes in sensitivity—the sense of smell, lacrimal secretion, and trigeminal sensitivity in the face and mouth being normal.

Hypopyon keratitis in the acute stage frequently causes a considerable decrease in sensitivity, extending to the conjunctiva. This form of inflammation is often so extensive that it is difficult to define the influence of various factors on the corneal nerves.

When the ulcer heals, frequently leaving maculae, the sensitivity begins to return to normal; later it may be possible to find a nearly normal degree of sensitivity, even inside the finer maculae (Fig. 7, opposite).

Dendritic keratitis causes a general lowering of the sensitivity of the affected area.

HERPES ZOSTER.—This causes a considerable decrease in corneal sensitivity, frequently without other local corneal lesions. It is well known that if the naso-ciliary nerve is involved with affection of the tip of the nose, changes in the cornea will nearly always be found, and frequently even local inflammations. The decrease in sensitivity persists for a long time and will never disappear completely.

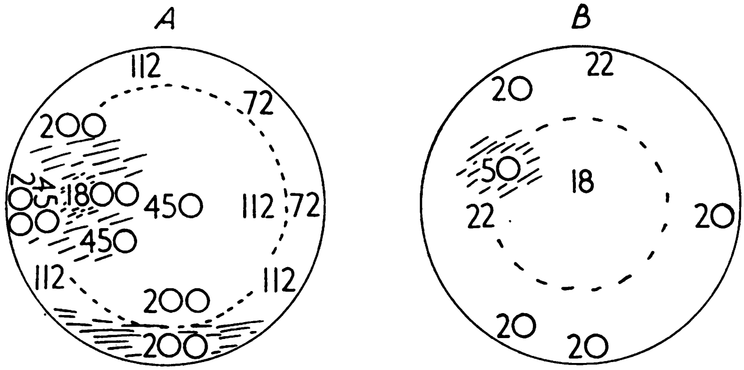


FIG. 7.—Corneal sensitivity (mg.) in a man aged 54, with hypopyon keratitis in the right eye, showing considerable improvement after healing.

In the affected area there often remains a pigmentation of the skin, and here also pronounced changes in sensitivity occur.

A case of acute inflammation in the cornea with an ophthalmic zoster 40 years previously shows the relative variations in sensitivity within the cornea. The acute corneal inflammation caused a considerable decrease in the local and general sensitivity (Fig. 8). Clinical improvement was followed by an improvement in both general and local sensitivity, but owing to the earlier herpes zoster, the corneal sensitivity never returned to normal. No change in sensitivity was found in the mouth or face, apart from changes in the first trigeminal branch.

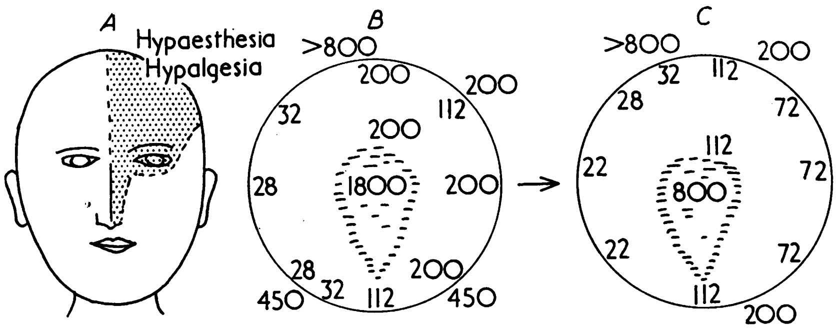


FIG. 8.—Corneal sensitivity (mg.) in a man born in 1897, with herpes zoster, showing facial involvement (A). The corneal sensitivity was much decreased (B) and remained low in spite of clinical improvement (C).

CYSTINOSIS.—In a 5-year-old boy, with cystine crystals generously distributed in both cornea and conjunctiva, the corneal sensitivity was diffusely decreased, centrally to approximately 50 mg.

HEREDO-DEGENERATION OF THE CORNEA may influence sensitivity (Fig. 9, overleaf).

CORNEAL DYSTROPHY (Groenouw's nodular type).—Corneal sensitivity may be almost abolished centrally.

In the case shown in Fig. 10 (overleaf), a corneal graft was performed to the worse eye, and 17 days later there was a definite sensitivity in the most peripheral part of the graft; this is in accordance with the findings of other investigators (Marx, 1925; Schröder, 1923; Zander and Weddell, 1951).

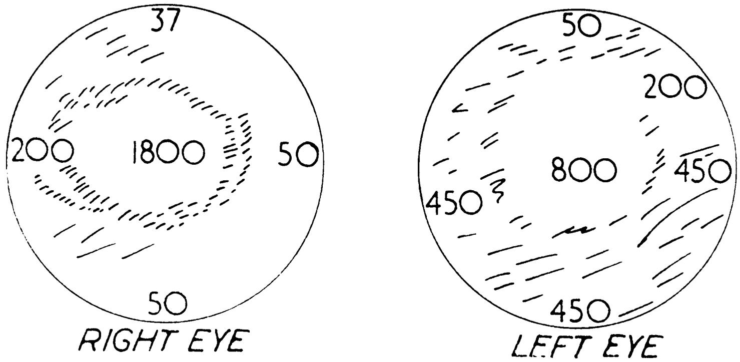


FIG. 9.—Corneal sensitivity (mg.) in a man aged 54, with hereditary corneal degeneration. The right eye is more acutely affected centrally; the left eye is more generally affected.

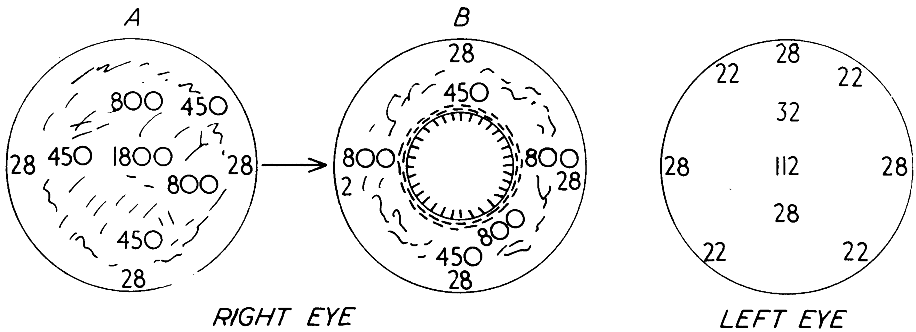


FIG. 10.—Corneal sensitivity (mg.) in a man born in 1899, with Groenouw's keratitis in the right eye, showing the result of corneal grafting after 17 days. There is definite sensitivity in the most perfect part of the graft.

SCLERAL NERVES.—If the corneal nerves are influenced in their scleral course, lesser changes in corneal sensitivity will ensue. After extensive diathermal treatment of the sclera for retinal detachment, the local corneal sensitivity may be decreased to some extent, and repetition of the treatment will increase these changes.

In the case illustrated (Fig. 11, opposite), diathermy from 5 o'clock to 1 o'clock was followed a fortnight later by further diathermy and a small sclerotomy at the equator at 8 o'clock. The corneal sensitivity was noted 19 and 21 days after the operation.

A certain regeneration of sensitivity may occur, but the eye rarely returns to normal.

CHOROIDITIS AND SCLERITIS.—One would expect the corneal nerves to be influenced, but very often no change in sensitivity is encountered, and such changes as may occur are of varying intensity and extent.

The changes shown in Fig. 12 quickly disappeared when the scleritis improved. Diffused transient changes are often encountered in choroiditis.

GLAUCOMA.—Corneal sensitivity often varies with intra-ocular pressure and local conditions in the cornea. If the tension is high and the cornea hazy, the

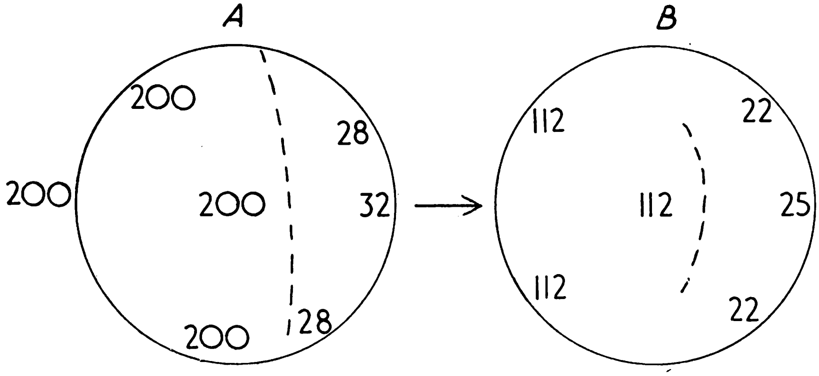


FIG. 11.—Corneal sensitivity (mg.) in a woman aged 26, after diathermy of the right eye for retinal detachment (A). After a fortnight an improvement was observed (B).

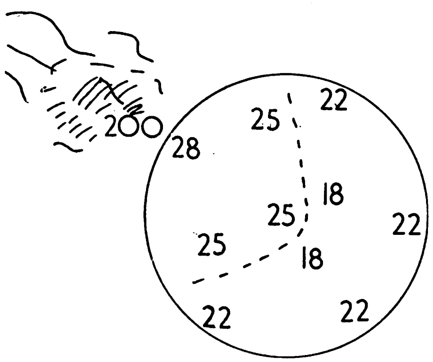


FIG. 12.—Corneal sensitivity (mg.) in a woman born in 1931, showing decrease in the area nearest a site of scleral inflammation in the right eye.

sensitivity is always much decreased, to around 200 mm. Small variations in the intra-ocular tension are followed by corresponding variations in the sensitivity. When the measurements are carried out by the same examiner with the same apparatus, they are reliable, even when technical errors are taken into consideration (Fig. 13, overleaf).

Intra-ocular pressure below 30 mm. Hg gives no change in sensitivity, but a rise above 30 mm. Hg is followed by alterations in the sensitivity which may vary from 18-20 to 50-72 mg.

An acute attack of glaucoma, with high ocular tension and a hazy cornea, considerably reduces corneal sensitivity.

Fig. 14 (overleaf) shows the case of a 32-year-old man who had suffered from diabetes mellitus for 20 years. There was rubeosis iridis, the retinae showed proliferative diabetic changes, the left eye developed an acute attack of glaucoma with an intra-ocular pressure of 80 mm. Hg, and the corneal sensitivity was greatly reduced. After treatment with miotics, the ocular tension dropped but still remained above the normal level. The sensitivity did not become normal, but remained at about 50-72 mg.

CONTACT LENSES

In nine patients wearing contact lenses of the Mini type, a slight decrease in sensitivity was observed after 1 or 2 hours' use. It may fall from 25 to 72 mg., and there is frequently a slight difference between the eyes. If the Mini contact lenses fit too closely, the reduction in sensitivity is greater. A slight decrease is to be expected, but if the decrease is particularly pronounced

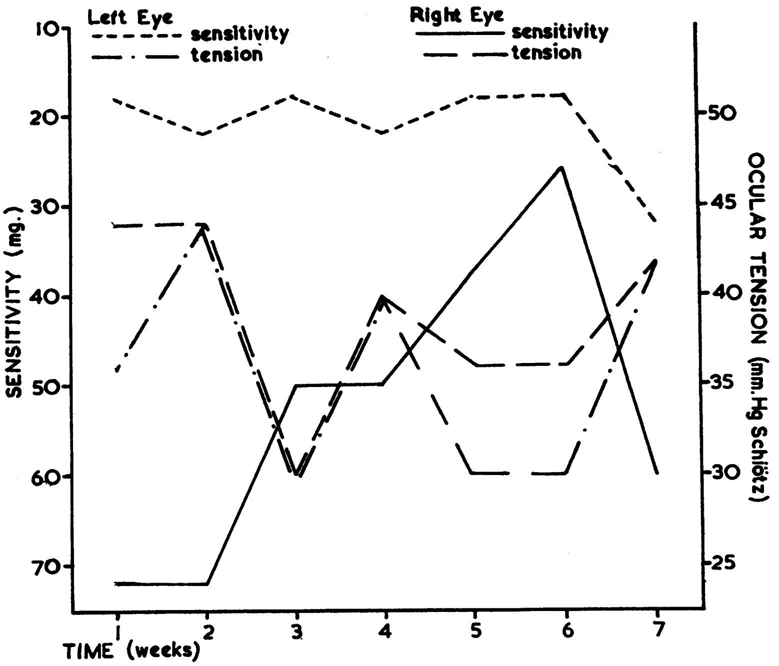


FIG. 13.—Ocular tension (mm. Hg) and corneal sensitivity (mg.) in a woman aged 72, with glaucoma simplex, observed weekly for 7 weeks. Increased tension lowers the sensitivity; when the tension becomes normal the sensitivity increases.

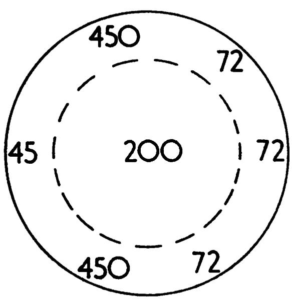


FIG. 14.—Corneal sensitivity (mg.) in the left eye in a man born in 1922, with diabetes mellitus, rubeosis iridis, and retinal proliferation, during an acute attack of glaucoma. The ocular tension was 80 mm. Hg (Schiötz).

in one eye, this lens very probably does not fit correctly. It is essential first to ascertain the normal sensitivity without glasses; normal sensitivity should be regained 2-3 hours after removing the contact lenses. An examination of the corneal sensitivity in patients wearing contact lenses is thus of both diagnostic and prognostic value.*

CORNEAL SENSITIVITY IN NEUROLOGICAL CASES

The corneal sensitivity is of diagnostic importance in neurological examinations. The cotton wool method is of doubtful value here, as it depends very much on the technique of each examiner and on the patient's subjective evaluation of the sensation of the stimulus; it is thus impossible to assess fine grades of sensitivity. In examining 500 neuro-surgical patients (Zilstorff-Pedersen, 1954), the sensitivity changes observed could not be made to check with previous neurological examinations, and it was not possible to confirm changes previously noted. A closer study of 160 of these patients showed a decrease in sensitivity in fourteen cases. Three out of five cases of acoustic neurinoma showed a slight but definite decrease in sensitivity of the homolateral cornea (15/22 mg., 22/15 mg., and 15/50 mg.). Two cases of cystic arachnoiditis and one of meningioma of the partis petrossae showed considerably lowered sensitivity.

Out of 22 cases of intra-cranial tumour, (glioma, astrocytoma, pituitary adenoma, meningioma), two showed a definite decrease in corneal sensitivity.

No changes were found in 24 cases of neuralgia of the second and third branch of the trigeminal nerve, but after treatment with alcohol injections into the nerve or into the semilunar ganglion, or after partial trigeminotomy, a slight decrease was noted in some cases.

After decompression of the semilunar ganglion (Tårnhøj, 1954, nine cases), no changes appeared in the corneal sensitivity.

Alcohol injection or exaeresis of the supra-orbital or infra-orbital nerves did not influence the sensitivity.

In neuralgia of the first branch of the trigeminal nerve, slight or more pronounced changes may appear (Zilstorff-Pedersen, 1954; Tårnhøj, 1954). Even in the course of the same day, tests carried out by different examiners on patients with trigeminal neuralgia gave different results, but this may be explained by the inexactness of the method used. A study of five cases of ophthalmic zoster, and of cases of corneal anaesthesia and hypaesthesia after electro-coagulation of the semilunar ganglion, gave no evidence of changes in sensitivity in the palate, cheeks, gums, or other sites outside the affected trigeminal area.

Corneal Sensitivity and Naso-Lacrimal Reflex after Retrobulbar Anaesthesia

By following the variations in corneal sensitivity after the retrobulbar injection of a local anaesthetic, it is possible to observe the development, distribution, spread, and duration of the anaesthesia. It may be of importance to know this in deciding upon the appropriate technique and anaesthetic.

After the skin of the lower lid has been disinfected, the retrobulbar injection is made laterally through the skin above the inferior orbital margin, and the cannula is introduced 3·5 cm., aiming towards the apex of the orbit (Fig. 15).

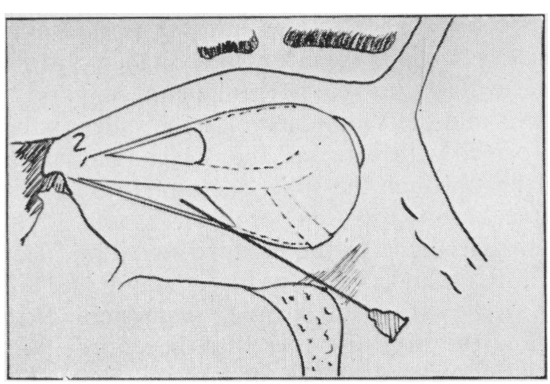


Fig. 15.—Technique of retrobulbar injection (after Atkinson, 1952). The eye is turned upward away from the site of injection, so that the fascial extension is moved forward and upward out of the way.

The point of the cannula is more easily inserted into the correct retrobulbar position if the patient is told to look upward and inward, away from the site of the injection. It is an advantage to use a needle with a rounded point, as suggested by Atkinson (1952). In all experiments the injections were carried out by the same examiner, and as far as possible the anaesthetic was deposited in the same retrobulbar position; 2 per cent. xylocaine was used, in some cases with adrenaline and in others with a solution of hyaluronidase.

Simultaneously, in eight cases, I followed the variation and distribution of the corneal sensitivity and measured the tear-production.

Tears were elicited by the naso-ocular reflex (Wernøe, 1927) provoked by a constant intra-nasal stimulus, as suggested by Kristensen and Zilstorff-Pedersen (1953). By this device (Fig. 16), a constant flow of air (500 ml./min.) passes over petrol in a bottle and then into the nose. In 30 sec. a profuse tear-production is evoked, and the amount of fluid is measured by Schirmer's method, employing 8-mm. wide strips of 0:15 mm. filter paper; 5 mm. at the end of the strip is folded and fixed into the conjunctival sac, and the amount of fluid is judged by the length of the wetted part of the paper.

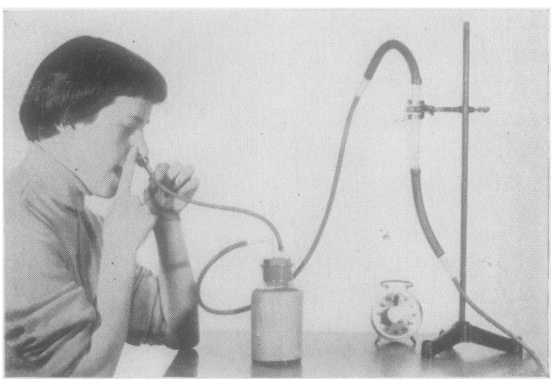


FIG. 16.—Apparatus for naso-lacrimal stimulus. It was made for examinations of the sense of smell (Kristensen and Zilstorff-Pedersen, 1953), but is here used to give a constant stimulus for provoking the naso-lacrimal reflex.

The centripetal impulse goes first through the ethmoidal nerves, then through the first ramus of the trigeminal nerve and, from the inner part of the nasal mucosa, through the second branch of the trigeminal nerve *via* Gasser's ganglion. The impulse goes from the trigeminal nuclei to the nucleus salivalis superior, and further centrifugally by the facial nerve, the intermediate nerve, the geniculate ganglion, the superficial major petrosal nerve, and the Vidian nerve, to the sphenopalatinal ganglion; there a synapsis is formed with neurons, the postganglionic fibres of which carry the impulse further through the sphenopalatinal nerve to the maxillary nerve, zygomatic nerve, zygomatico-temporal nerve, and *via* the ramus anastomoticus cum nervo lacrimale to the lacrimal nerve and lacrimal gland.

In pathological conditions, it may be possible to provoke tear-production by a reflex from the tongue (gusto-lacrimal reflex). The impulse may then follow the lingual nerve and the chorda tympani, whereby it reaches the facial nerve and thence the lacrimal gland (Ehlers, 1932; Duke-Elder, 1952).

A decrease in the amount of tears provoked by the naso-lacrimal reflex may be due to an interruption of the reflex-arc at any place. The reflex may, therefore, prove to be of importance in testing the function of the facial nerve from its origin to the geniculate ganglion, presuming, of course, that the sensitive part of the reflex-arc is intact.

Stimulation of the trigeminal nerve through the mucosa in one side of the nose gives a bilateral conjunctival hyperaemia and tear-flow, but the reaction on the contralateral side is much less than on the homolateral. A vaso-dilator reaction throughout the homolateral trigeminal area is not infrequently encountered; a sneeze may even be released (De Jong, 1950).

Jacobsen (1952) employed the naso-ocular reflex in examining patients suffering from migraine and headache.

At an examination by Dr. K. Zilstorff-Pedersen, at the Ear Department of the Rigshospital, of the naso-lacrimal reflex, eight cases of rheumatic paralysis of the facial nerve all showed a normal reaction on the affected side.

Retrobulbar anaesthesia influences both the naso-lacrimal reflex and the corneal sensitivity in all cases. The decrease in both follows mostly the same course; the pupil often dilates and varying pareses occur. If the tension of the eye is normal, it is lowered only slightly or not at all, but, if the tension is high, it is frequently considerably lowered (Fig. 17).

This fall in sensitivity is a little delayed in comparison with the other

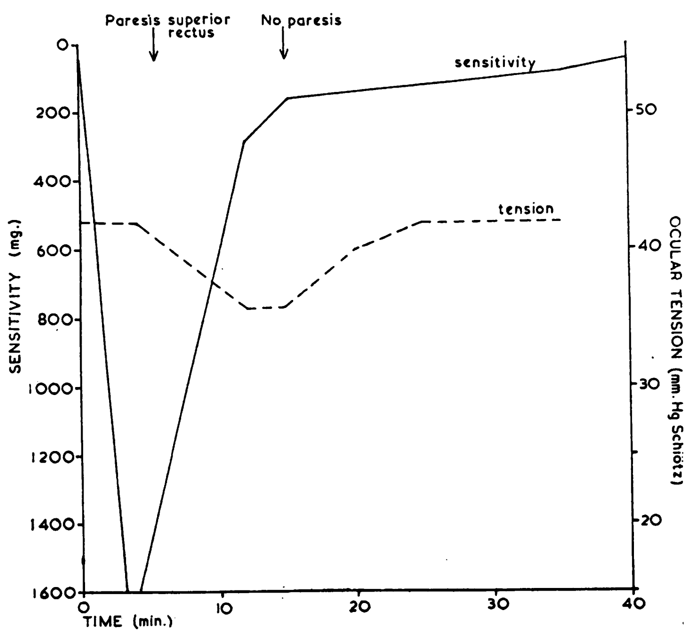


FIG. 17.—Corneal sensitivity (mg.) and ocular tension (mm. Hg) in the right eye in a woman born in 1882, with bilateral glaucoma simplex, after retrobulbar injection of 0·8 ml. one per cent. xylocaine (Astra) with hyaluronidase 2·5 VRU/ml., showing effect of anaesthetic.

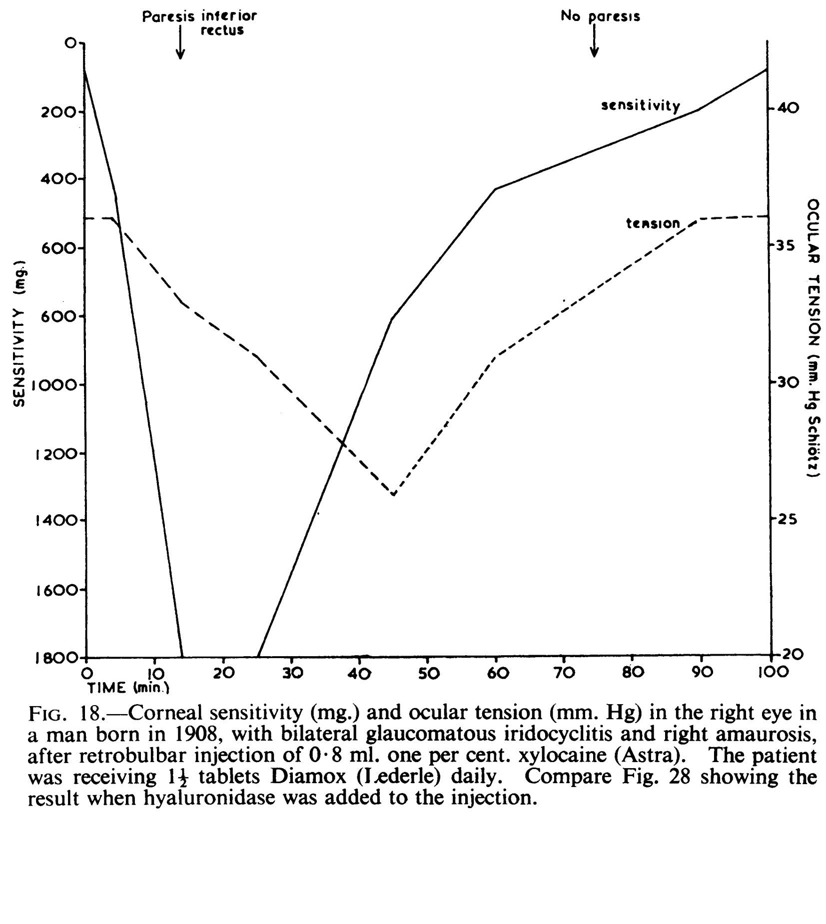


FIG. 18.—Corneal sensitivity (mg.) and ocular tension (mm. Hg) in the right eye in a man born in 1908, with bilateral glaucomatous iridocyclitis and right amaurosis, after retrobulbar injection of 0·8 ml. one per cent. xylocaine (Astra). The patient was receiving 1½ tablets Diamox (Lederle) daily. Compare Fig. 28 showing the result when hyaluronidase was added to the injection.

manifestations (Fig. 18). Even when every care is taken to deposit the retrobulbar anaesthetic in exactly the same site, the effects often vary surprisingly from the case to case. The injection of xylocaine, with or without adrenaline, is not always followed by the same effect on the corneal sensitivity or on the lacrimal reflex (Figs 19, opposite, and 20, overleaf). This variation may sometimes be due to differences in the spread of the anaesthetic in the retrobulbar space, or to small unavoidable differences in the position of the cannula.

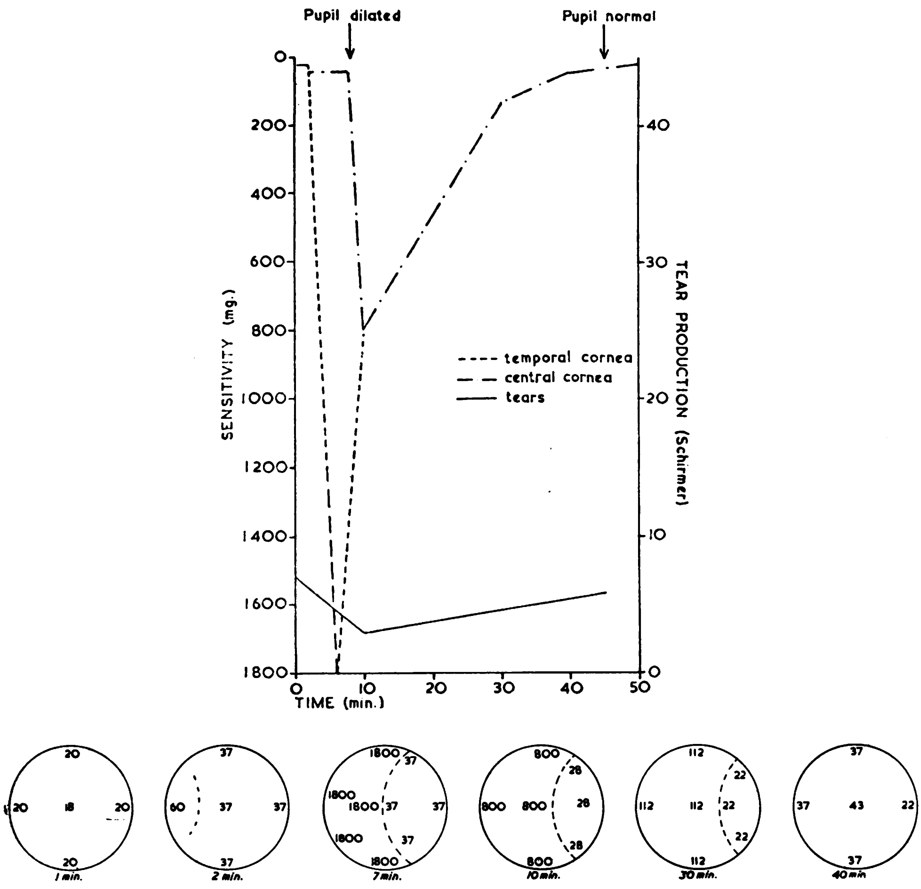


FIG. 19A (and B).—Corneal sensitivity (mg.) and tear production in the right eye of a normal subject (male born in 1927) after retrobulbar injection of 0·8 ml. xylocaine 0·5 per cent. Note local discrepancies in sensitivity, and that the tear-flow is also influenced, only part of cornea being fully anaesthetized. The pupil is paralysed, but there is no extra-ocular paresis.

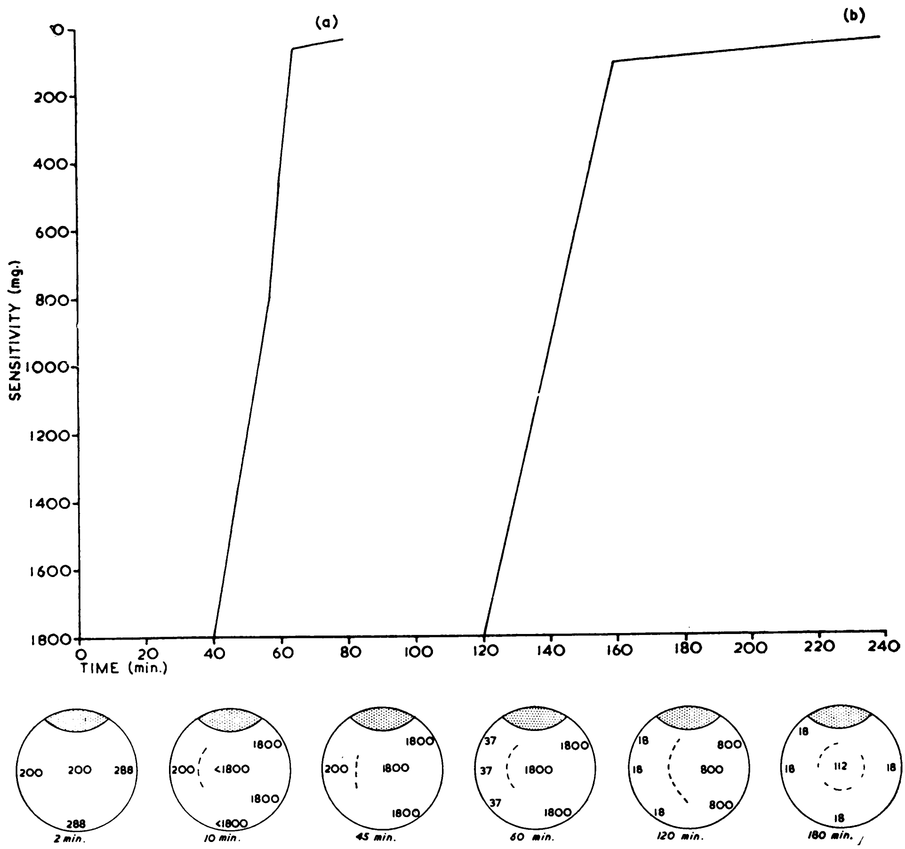


FIG. 20A (also B).—Corneal sensitivity (mg.) in the right eye of a man born in 1878, with early phthisis bulbi, after an Elliot's scleral trephine.
(*a*) after retrobulbar injection of 1 ml. one per cent. xylocaine.
(*b*) after retrobulbar injection of 1 ml. 2 per cent. xylocaine with adrenaline. Note local distribution of anaesthesia in the cornea. Ocular tension unchanged at 12 mm. Hg (Schiötz).

The tear-flow is in all cases considerably lowered by the retrobulbar injection, but this takes place after the decrease in corneal sensitivity (Fig. 21, opposite, and Figs 22 and 23, overleaf).

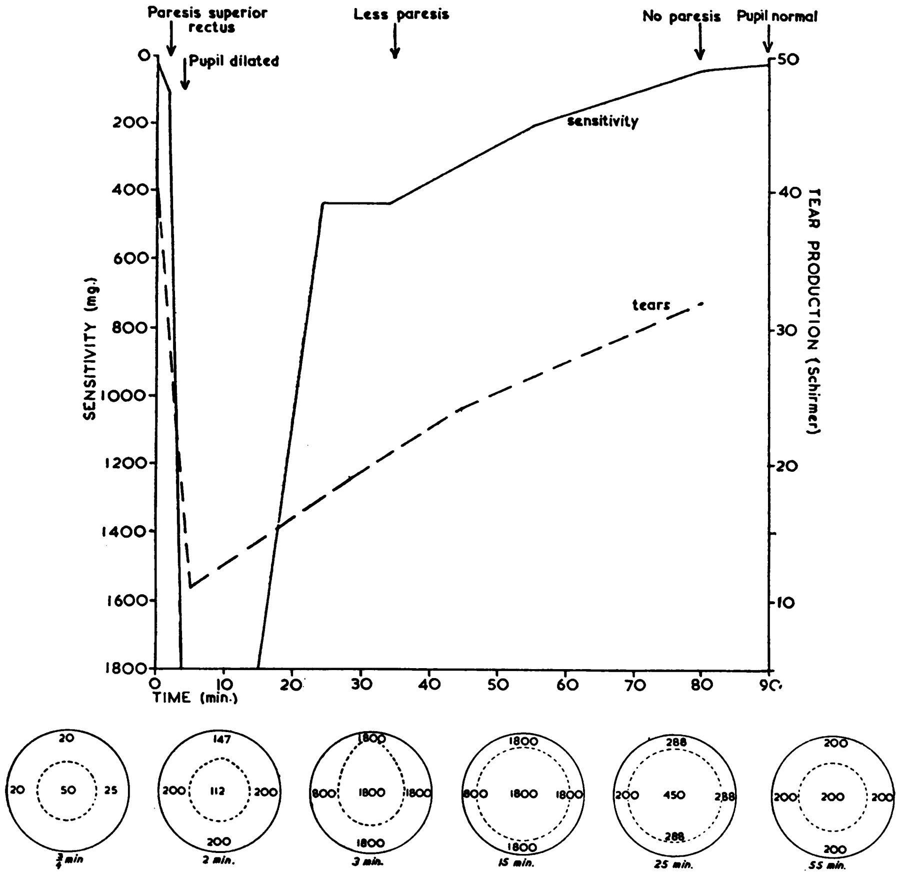


FIG. 21A (and B).—Corneal sensitivity (mg.) and tear production in the left eye of a normal subject (female born in 1931) after retrobulbar injection of 0·8 ml. xylocaine one per cent. Note the uneven distribution of corneal sensitivity and the few muscles influenced. Compare Fig. 24, showing the result in the same subject when hyaluronidase was added to the injection.

The anaesthetic must take effect simultaneously on the ciliary nerves and on the secretory nerves of the lacrimal gland. This means a rapid and even distribution of the anaesthetic inside the retrobulbar space, but does not correlate with the fact that the changes in corneal sensitivity are often uneven, as is also the paralytic effect on the muscles and on the pupil.

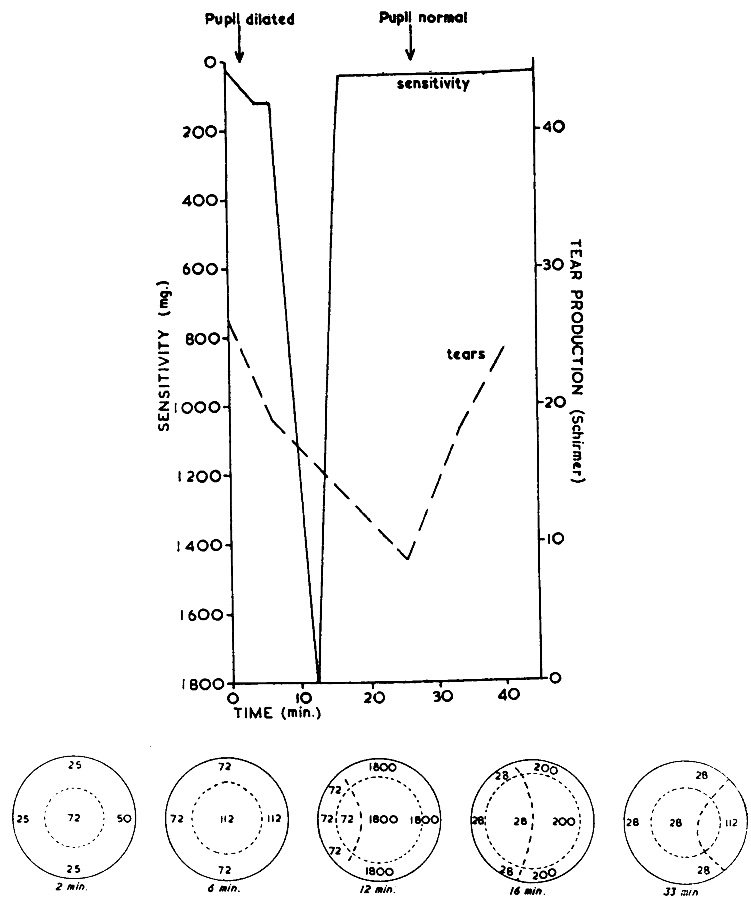


FIG. 22A (and B).—Corneal sensitivity (mg.) and tear production in the left eye of a normal subject (female born in 1927) after retrobulbar injection of 0·4 ml. xylocaine one per cent.

Note the uneven course and distribution of the anaesthesia, the absence of paresis, and the interval between the anaesthesia and the inhibition of tear-production. The pupillary dilatation is also unequal.

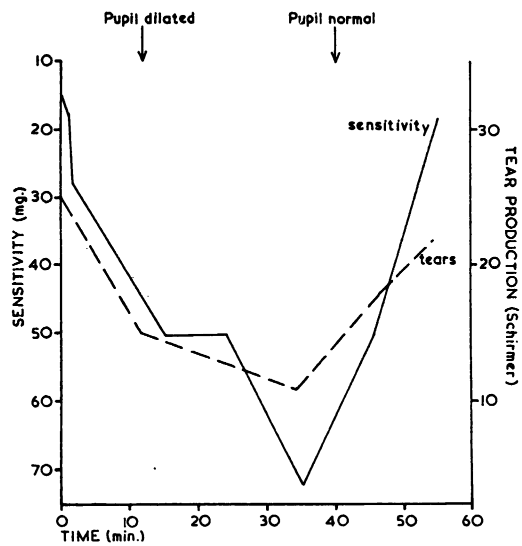


FIG. 23.—Corneal sensitivity (mg.) and tear production in the left eye of a normal subject (female born in 1926) after retrobulbar injection of 0·4 ml. xylocaine 2 per cent. There was no paresis, and owing to the small effect the ordinate differs from that used in the other graphs.

Addition of Hyaluronidase.—As it seemed probable that small irregularities in the placing of the anaesthetic solution might influence the distribution of the effect, one might have expected that the addition of a medium with dispersive abilities would give a better and more even effect and possibly allow the use of less fluid.

In six cases Invasin (Lundbeck)* was added to the anaesthetic solution. Atkinson (1952), who added hyaluronidase 6-10 TRU per ml. solution, stated:

> This causes a greater diffusion of the anaesthetic solution producing a larger area of anaesthesia with less ballooning of the tissues. More rapid anaesthesia is obtained and the duration is about the same as without hyaluronidase. Larger retrobulbar or cone injections may be safely given for cataract extraction because the solution diffuses rapidly and the proptosis that has been produced by the injection quickly subsides. With the use of a larger volume of anaesthetic solution, it permeates the orbit thoroughly, so that more complete anaesthesia and akinesia is produced.

*Invasin (Lundbeck) containing 2·5 VRU (viscosity reducing units) corresponding to 5 TRU (turbidity reducing units). The different brands of hyaluronidase are difficult to compare. but it may be mentioned that 1 unit of D-M.K. (Dalgard-Mikkelsen, Kvorning, and Møller, 1948) roughly corresponds to 50 TRU.

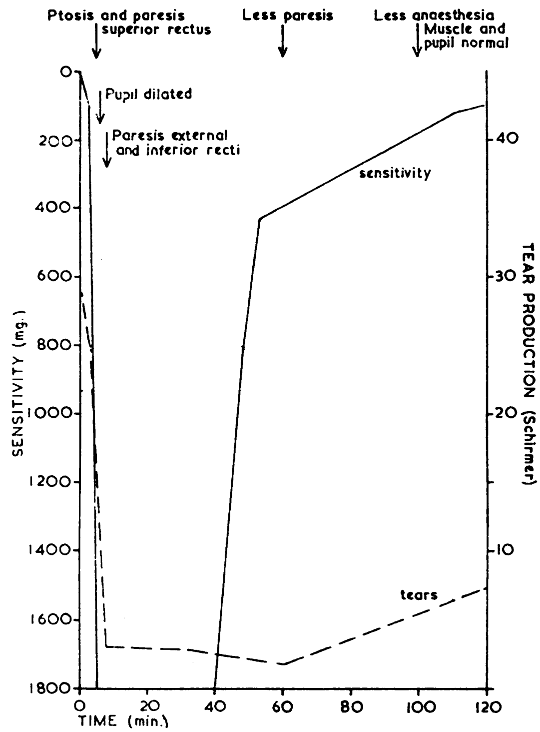


FIG. 24.—Corneal sensitivity (mg.) and tear production in the left eye of a normal subject (female born in 1931) after retrobulbar injection of 0·8 ml. xylocaine 2 per cent. with hyaluronidase (Invasin) 2·5 VRU/ml. The anaesthetic and paralytic effects were rapid. All structures were equally effected, and the corneal anaesthesia was evenly distributed. Compare Fig. 21 showing the result without hyaluronidase. Ocular tension unchanged at 18 mm. Hg (Schiötz).

The addition of Invasin in the six cases examined caused a more even distribution of corneal anaesthesia (Fig. 24), but the course of the anaesthesia was similar to that observed in earlier experiments in increase, depth, and duration (Figs 24 and 25, opposite).

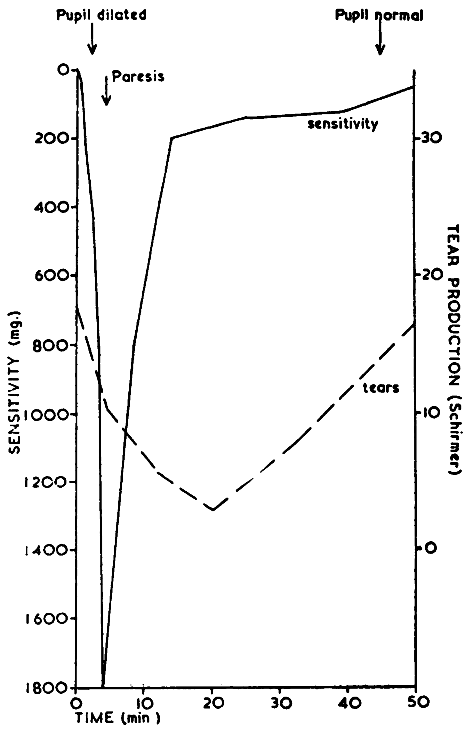


FIG. 25.—Corneal sensitivity (mg.) and tear production in the right eye of a normal subject (female born in 1930) after retrobulbar injection of 0·8 ml. xylocaine one per cent. with hyaluronidase (Invasin) 4 VRU/ml. Ocular tension unchanged at 18 mm. Hg (Schiötz).

Invasin causes a quicker influence on the muscles, and more of the outer eye muscles are affected, but the duration of the paresis is not increased (Figs 26, 27, and 28, overleaf). The influence on the ocular tension and the naso-lacrimal reflex is unaltered. The effect of the retrobulbar anaesthesia may be prolonged, but, as the graphs show, this is not always the case.

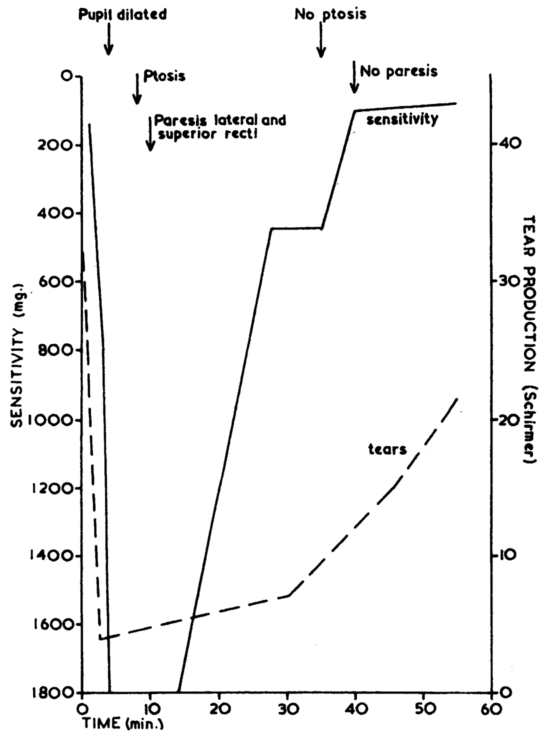


FIG. 26.—Corneal sensitivity (mg.) and tear production in the right eye of a normal subject (female born in 1928) after retrobulbar injection of 0·8 ml. xylocaine one per cent. with hyaluronidase (Invasin) 1·25 VRU/ml. Ocular tension unchanged at 18 mm. Hg (Schiötz).

A better and quicker effect may also be obtained for other forms of anaesthesia through the addition of hyaluronidase. Atkinson (1953) writes:

> Some surgeons experience difficulty in obtaining complete paralysis of the orbicularis after an injection to block the temporo-facial nerve. The addition of hyaluronidase, which produces greater diffusion of the anaesthetic solution, practically obviates this difficulty, so that a second injection is rarely necessary. The same is true of other injections for block anaesthesia.

I have, in several cases, been able to confirm this in akinesia of the facial nerve in front of the ear. Very often it may be difficult to obtain a satisfactory akinesia, by this method, even if one allows some time to elapse after the injection. The addition of hyaluronidase renders small technical inaccuracies unimportant, and causes the akinesia to appear quickly in all cases even if the amount of injected fluid is less than usual.

In conclusion, it may be stated that the addition of hyaluronidase to an anaesthetic solution causes a better and more even effect and requires less fluid. In these small amounts hyaluronidase has no ill-effects.

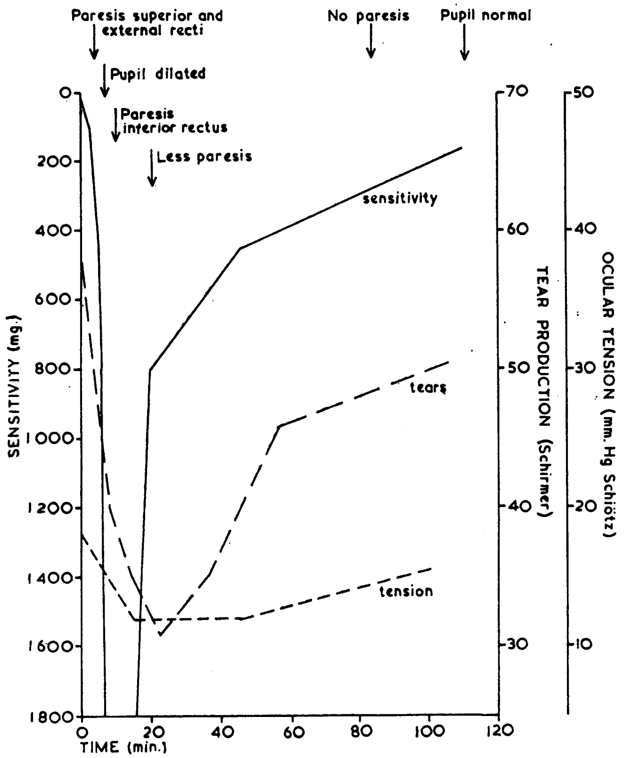


FIG. 27.—Corneal sensitivity (mg.), tear production, and ocular tension (mm. Hg) in the right eye of a normal subject (female born in 1931) after retrobulbar injection of 0·8 ml. xylocaine one per cent. with hyaluronidase (Invasin) 2·5 VRU/ml. Note the rapid course of the anaesthesia, especially the rapid disappearance of the paresis. The effect on the tear-flow follows closely that on the corneal sensitivity. Though the ocular tension remained within normal limits, it was certainly influenced.

Summary

The present clinical method of examining the corneal sensitivity by using a wisp of cotton is inexact and should be replaced by the von Frey method modified by the use of an adjustable nylon thread in a special holder. Normal sensitivity measured in this way is 15-20 mg.

Various pathological conditions causing decreased sensitivity are surveyed. In glaucoma the sensitivity varies with the intra-ocular pressure. Corneal sensitivity may also be of interest in patients wearing contact lenses. The value of the exact determination of corneal sensitivity in neurological cases is discussed.

It may be of interest in otological cases with paralysis of the facial nerve to examine the corneal sensitivity and the nasolacrimal reflex. Similar methods are used to evaluate the effect of retrobulbar anaesthesia and the advantage of adding hyaluronidase to the anaesthetic solution is proved.

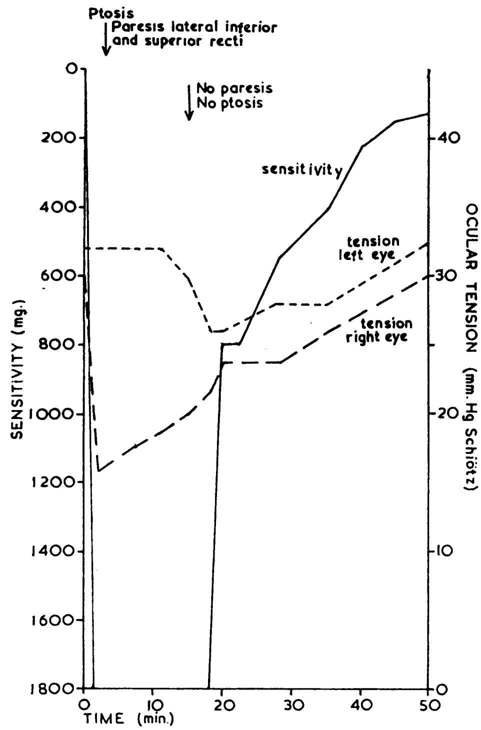


FIG. 28.—Corneal sensitivity (mg.) in the right eye and ocular tension (mm. Hg) in both eyes in a man born in 1908, with bilateral glaucomatous iridocyclitis, after retrobulbar injection of 0·8 ml. xylocaine one per cent. with hyaluronidase (Invasin) 5 VRU/ml. The patient was receiving 1½ tablets Diamox (Lederle) daily. The effect of the rather large amount of hyaluronidase (Invasin) injected was rapid. Note the masked effect on the left eye, which also suffered from iridocyclitis with high tension. Compare Fig. 18 showing the result without hyaluronidase.

REFERENCES

ATKINSON, W. S. (1952). *In* " Progress in Ophthalmology ", vol. 1, p. 271. Grune and Stratton, New York.

——— (1953). *Amer. J. Ophthal.*, **36**, 1255.

BOBERG-ANS, J. (1952). " On Corneal Sensitivity ". Thesis, Copenhagen.

DALGÅRD-MIKKELSEN, S., KVORNING, S. A., and MØLLER, K. O. (1928). *Nature (Lond.)*, **162**, 221.

DE JONG, R. N. (1950). " The Neurologic Examination ". Harper, New York.

DUKE-ELDER, S. (1952). " Text-book of Ophthalmology ", vol. 5, p. 5200. Kimpton, London.

EHLERS, H. (1932). *Acta psychiat. neurol. scand.*, **7**, 79.

FREY, M. VON (1894). *Ber. sächs. Ges. (Akad.) Wiss.*, **46**, 185, 283.

JACOBSEN, H. (1952). *Acta psychiat. neurol. scand.*, **27**, 63.

KRISTENSEN, H. K., and ZILSTORFF-PEDERSEN, K. (1953). *Acta oto-laryng. (Stockh.)*, **43**, 537.

MARX, E. (1925). " Empfindlichkeit der menschlichen Hornhaut ". Hirzel, Leipzig.

RODGER, F. C. (1953). *Arch. Neurol. Psychiat. (Chicago)*, **70**, 206.

SCHRÖDER, E. (1923). *v. Graefes Arch. Ophthal.*, **111**, 17.

TÅRNHØJ, P. (1954). Personal communication.

WERNØE, T. B. (1927). *Acta psychiat. neurol. scand.*, **2**, 385.

ZANDER, E., and WEDDELL, G. (1951). *J. Anat. (Lond.)*, **85**, 68.

ZILSTORFF-PEDERSEN, K. (1954). Personal communication.