4. A detailed analysis of the cases of infected corneal ulcers with hypopyon treated by different methods of penicillin therapy shows subconjunctival injections to be the method of choice. It was successful in 18 out of 21 cases so treated.

5. The mode of treatment is described. It consists essentially of 12 to 16 subconjunctival injections each of 50,000 units of penicillin (dissolved in 0.25 c.c. of 2 per cent. novocaine and 0.25 c.c. of 1:1,000 adrenalin) at intervals of six hours, followed by the 4-hourly instillation of penicillin ointment in a concentration of 100,000 units per gm.

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 THE LAMINA CRIBROSA AND ITS NATURE*

BY

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THE present knowledge of this subject is based mostly on the work of E. Fuchs (1916) as there have been no newer researches in this field. The cribriform lamina is generally taken to be a semi-independent structure. The dimensions of its anterior and posterior planes, its thickness and backward curve and other dimensions have been already measured. In cases of glaucoma the possibility of the cribriform lamina being pushed backward by the raised intra-ocular pressure has been generally accepted.

Birnbacher and Czermak (1885—1886) have likened the cribriform lamina to a membrane of India-rubber which can bulge under

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intra-ocular pressure. According to the generally accepted opinions the cribriform lamina is a part of the sclera. Lauber in his textbook, published in 1936, writes: "The internal layers of the sclera form in the scleral canal a network of lamina cribrosa sclerae; strictly speaking it is only the thinned part of the sclera." E. Fuchs states: "Part of the fibres of most internal layers of the sclera is stretched over the foramen sclerae . . . this part when cut looks like a sieve, and therefore it is called lamina cribrosa."

The opinions of other authors are almost similar. These views are not necessarily strictly accurate. For instance, in a case of deep physiological depression of the optic disc one sees through the ophthalmoscope the cribriform lamina lying 1—1.5 mm. below the level of the retina. Now it is known that the sclera in this region is 1—1.5 mm. thick. Round the optic nerve it becomes thinned to one-half or one-third by the inter-meningeal recess (recessus intravaginalis). So it can hardly be maintained that the cribriform lamina is really a thinned part of the sclera. In this case at least posterior trabeculae of the cribriform lamina must be derived from the pia mater of the optic nerve and not from the sclera.

Rather complicated relations in the arrangement of neuroglia in the optic disc, in the first segment of the optic nerve and in the insertions of meningeal sheaths of the nerve to the sclera can be understood only in view of certain facts derived from the development of the eye. The publications of Seefelder (1910), Kleczkowski (1913) and v. Szily (1921—1922, 1930) have the greatest bearing on this subject. All changes leading to the conversion of the optic vesicle into the optic cup aim at creating the best connections of nerve-fibres of the retina with the brain by forming the embryonic disc of the optic nerve (papilla primitiva s. epithelialis). Nerve-fibres of the retina grow into this embryonic disc, and so there develops the definite optic disc, collecting into a bundle all nerve-fibres of the retina. Cells of the stalk of the cup convert into neuroglial cells, and so neuroglial stroma of the optic disc and nerve are developed. Bundles of nerve-fibres are separated one from another by neuroglial tissue which forms the first septa of the optic disc and nerve. Only later—as Kleczkowski has shown—connective cells grow into these neuroglial septa, and supply the nerve with vessels. Connective tissue divides the nerve into smaller and smaller bundles forming first-, second- and third-grade septa; but still smaller septa are formed by neuroglia.

Bearing this in mind, one may understand the relations between neuroglial and connective tissue. Neuroglia completes connective septa and carries on the partition into still smaller bundles, forms a sheath between the walls of the scleral canal and the disc (intermediäres Gewebe), invests anteriorly central connective tissue

which envelops the vessels (Zentr. Bindegewebsmeniskus Kuhnt), penetrates into the disc along the vessels (Schaltgewebe), forms the so called neuroglial cribriform plate (lamina gliosa), and envelops each connective septum in the cribriform lamina and in the nerve. All these details in distribution of neuroglia are fairly clear, if one remembers that the stalk into which nerve-fibres have eventually grown, was of neuroglial origin, and that connective tissue has grown into primitive neuroglial septa, rather strengthening them than eliminating them completely.

All connective coats of the eye, such as the choroid, the sclera, meningeal sheaths of the optic nerve, septa of the optic nerve and the cribriform lamina are formed from the same mesenchymal mass, which envelops the embryonic eye when the retina, the optic disc and nerve have already been formed. That is why there is no sharp division between pia or dura mater and the sclera, but meningeal sheaths pass into and coalesce with the sclera.

In order to be thoroughly acquainted with the structure of the cribriform lamina, its relation to the sclera and septa of the optic nerve, with its function and importance, I have carried out a series of my own investigations. I have studied histological longitudinal and transverse sections of the cribriform lamina, not only of adults but also of the newly-born and embryos. I have also studied the structure of the cribriform lamina of the following animals: cat, pig, horse, and ape. The examination of the complete series of transverse sections seems to me most instructive.

When examining the preparations from different periods of the development of the eye, I could demonstrate that the cribriform lamina develops comparatively late, and its complete development is attained as late as the end of foetal life or even at the beginning of extra-uterine life. Trabeculae of connective tissue grow into the nerve and the disc from all directions and from all available sources of connective tissue, namely from the pia mater, from the sclera in the scleral canal and—as can be demonstrated in the series of transverse sections—also from connective tissue, which accompanies the central vessels. These connective trabeculae form the septal network of the nerve. By their ingrowth the nerve is supplied with vessels and its structure strengthened, delicate nervous tissue connected with the pia mater and the optic nerve inside the scleral canal fixed to the sclera.

In the embryonic eyes, where there is as yet no cribriform lamina and no connective septa of the nerve, it can sometimes be observed how the optic nerve slips out of the scleral canal (Fig. 1). Trabeculae which grow into the nerve from all sources of connective tissue in this region must be stronger, the more abundant the source of connective tissue. In that way one should explain the

FIG. 1.

The optic nerve in a human embryo, 6 months old, which has not been attached to the scleral canal by the cribriform lamina, and has slipped out of the canal.

fact that trabeculae in the cribriform lamina are much thicker than in the nerve, for septa of the nerve come from the comparatively thin pia mater, whereas trabeculae of the cribriform lamina come from abundant connective tissue of the sclera. Sometimes one can notice delicate trabeculae penetrating into the optic nerve from the choroid; they are called by the authors: *lamina cribrosa choroidealis*.¹ These trabeculae are rather scanty and thin, which can be explained by the fact that the choroid is rather a poor source of connective tissue. I consider fixation of the optic nerve in the scleral canal, *i.e.*, in the place where the optic nerve is exposed to the great danger of being pulled, as one of the most important functions of the cribriform lamina.

During my studies of the cribriform lamina I have made the first plastic model of this region of the eye which enables one to visualize the relations in three dimensions. This model has been constructed in the following way: from a complete series of histological sections of the optic nerve of a normal human eye—sections being 20 microns thick—I chose the sections comprising the whole scleral canal from the anterior plane of the sclera to the first segment of the optic nerve surrounded by the intermeningeal space. I took microphotographs of each section and magnified them 50 times on paper, under which I inserted a layer of mixture of paraffin and beeswax, 1 mm. thick. Thereby I obtained a series of plates, each corresponding to a microscopic section,

magnified 50 times. From these plates, using Graefe's knife and Gullstrand's binocular, I excised all the outlines of nerve-bundles, leaving only septal network of connective tissue. In this way I obtained the isolated connective scaffolding of the nerve surrounded by the sclera or pia mater. By sticking all the plates together I obtained a model which enabled me to study carefully all the details. While looking at the transverse sections of my series and putting the model together I became convinced that there is no substantial difference between the cribriform lamina and the septal system of connective tissue of the optic nerve. They actually form one common system whose parts can be differentiated only by their point of origin. In the scleral canal, trabeculae are thicker because they come from the sclera; in the nerve they are thinner because they come from pia mater.

The cribriform lamina is then not an independent structure but the foremost and strongest part of the septal system of connective tissue of the nerve.

Fig. 2 shows a section, 89, of my series. One can see in the upper part the septal network coming from the wall of the scleral canal; it is the cribriform lamina. In the lower part of this preparation, trabeculae must come from pia mater as the intermeningeal space can be clearly seen. These trabeculae belong to the septal system of the nerve. There is no difference between these two systems. They both form a uniform network whose trabeculae are

FIG. 2.

In the upper part of the preparation notice a trabecular network of the cribriform lamina coming from the sclera, in the lower part the septal network of the optic nerve coming from pia mater.

a little thicker in the part which has to be included in the cribriform lamina. On the whole one can compare this septal system to the canals of connective tissue in whose walls there are numerous gaps. The canals may join the neighbouring one or divide.

Fig. 3 represents the front view of the model. In the foremost part of the scleral canal there is an apparent shallow depression, at the bottom of which one may see the front of a septal system, i.e., the cribriform lamina. This depression, demonstrated for the first

FIG. 3.

The plastic model viewed from the front. Notice the depression called by the author "the nest of the optic disc."

time on my model, should be called the nest of the optic disc (*nidus seu nidulus papillae nervi optici*), because in this very depression lies the optic disc. The bottom of the nest is uneven, slightly knob-like. Trabeculae of the cribriform lamina lie there but not on the same level, some being a little higher than the others. Moreover some trabeculae come from the walls of the nest, sometimes even from the anterior surface of the sclera. From the bottom of the nest there arises towards the front a fairly thick bundle of connective tissue investing the central vessels. In the disc short trabeculae come from this bundle and join the tissues of the disc. As the diameter of the nerve increases with its further course, the lateral walls of the nest are inclined and divergent. The shape of the nest may change according to the shape of the optic disc. All the dimensions of the nest and the inclination of its walls can vary to a certain extent.

FIG. 4.

The model viewed from behind. Septal system of the optic nerve.

FIG. 5.

The model transilluminated from behind.

In my opinion introduction of the concept of the nest of the optic disc is advisable as much from the anatomical as the clinical point of view. This concept will permit more synthetic representation of the shape of the foremost part of the scleral canal.

Fig. 4 represents the septal system of the optic nerve viewed from behind in my model. Fig 5 part of the model illuminated from behind. One can see the interior of the canals in which there were bundles of nerve-fibres. Figs. 6 and 7 represent the model cut in the sagittal plane. One can see for the first time the outlines of septa at the same time in transverse and longitudinal sections.

FIG. 6

FIG. 7.

The relations between nervous and connective tissue are changing at various levels of the optic disc and nerve. In the disc there is almost complete lack of connective tissue. Beyond the cribriform lamina septa become thinner whereas bundles of nerve-fibres, developing myelin sheaths, become thicker. In order to determine strictly these relations I took the following measurements: from the microphotographs of the sections, magnified 50 times, I cut out with Graefe's knife the outlines of nerve bundles—as I did when making the model—leaving only the network of connective tissue. Then I cut out the neighbouring scleral tissue, the meninges and the outlines of the vessels. So, using the balance, I could strictly determine the relation between connective and nervous tissue in a given section. Then I calculated the area of the section, and knowing the percentage relation of the tissues and the magnification, I could easily calculate the real area occupied by each tissue in a given section. As I knew the number of holes, occupied by nerve-bundles in each section, I could calculate the average size of a nerve-bundle and the thickness of a septum of connective tissue. For my calculations I chose the sections at different levels of the disc, the cribriform lamina and the optic nerve. These are the sections of my series labelled 61, 65, 75, 79 and 95. Section 61 passes through the first part of the scleral canal in which there are no septa of connective tissue yet and nervous tissue still retains the structure of the disc. In the periphery of the section 65 there are already some short trabeculae of septa. Section 75 passes through the anterior part of the cribriform lamina, section 79 through the strongest part of the cribriform lamina, section 95 through the first part of the optic nerve, surrounded by the intermeningeal space. The results of these calculations are shewn on the Table I:—

Section	Area of section	Area of nervous tissue	Area of connective tissue	Nervous tissue in per cent.	Conn. tissue in per cent.	Amount of nerve bundles
61	1'35mm. ²	1'28mm. ²	—	per cent. ca.95	per cent. —	—
65	1'60 „	1'28 „	—	ca.80	ca.20	—
75	2'44 „	1'09 „	1'35mm. ²	44'7	55'3	350
79	2'50 „	0'9 „	1'60 „	36	64	394
95	3'10 „	1'78 „	1'32 „	57'4	42'6	398

It follows from this table that the area of section of the optic disc is 2·3 times smaller than the area of section of the first part of the optic nerve situated only 0·7 mm. below the former (sections 61 and 95). In the disc, 95—80 per cent. of the section is occupied by nervous tissue, compared with 36 per cent. in the most strongly developed part of the cribriform lamina where the remaining area is occupied by connective tissue. The figures of Table I can represent a real basis for any inferences concerning endurance of this area to endocular pressure, to stretching and to mechanical distortions, which occur in inflammatory processes, oedema, etc. From column 2 one can see that nervous tissue in the disc occupies greater area than in the cribriform lamina. As the amount of nerve-fibres is the same in both cases it follows that nerve-fibres in the disc lie more loosely, embedded in soft neuroglia. In the anterior layer of the cribriform lamina (section 75) the area of nervous tissue is a little greater than in the strongest part of the cribriform lamina (section 79) where nerve-fibres lie most tightly. Here, and not in the anterior opening of the scleral canal nor in the opening of lamina elastica choroidealis—as could be inferred from the longitudinal histological sections—there is the narrowest passage for nerve-fibres.

That is in the cribriform lamina that nerve-fibres can be most easily damaged by inflammatory processes, oedema, hyperaemia of trabeculae of connective tissue, etc.

Fig. 8 represents these relations in their true proportions, according to the calculations in Table I. The whole mass of nervous tissue lies in the centre of the drawing; it has the shape of an hour-glass. On each side there is a mass of connective tissue which varies in strength in different sections. In column 3 of Table I, section 75 contains nearly the same amount of connective tissue as section 95 which corresponds to the first segment of the optic nerve. It can be inferred that septa in the first segment of the

FIG. 8.

optic nerve are thinner than these in the first segment of the cribriform lamina not as a result of the smaller amount of connective tissue in the first segment of the nerve, but because these septa have been stretched by the bundles of nerve-fibres becoming thicker under the influence of myelinisation. The amount of connective tissue in the strongest part of the cribriform lamina is only 18·5 per cent. greater than in the anterior part of the cribriform lamina.

If one knows the area of connective and nervous tissue in the section and the amount of nerve-bundles one can calculate as well the average area and the diameter of a single nerve-bundle as the thickness of surrounding connective tissue. I calculated it for sections 79 and 95 (strongest part of the cribriform lamina and first segment of the nerve). The results are given on Table II :—

Section	Area of one nerve-bundle	Diameter of one nerve-bundle	Area of one nerve-bundle together with connective tissue surrounding it	Difference of diameter i.e., thickness of the sheath of connective tissue between nerve-bundles
79	0·00225mm ²	0·0534mm	0·00625mm. ²	0·0346 mm.
95	0·00445 „	0·075 „	0·00775 „	0·024 „

FIG. 9.

Fig. 9 represents the transverse sections 79 and 95, compared one with another. The dotted line shows how the longitudinal section of the optic nerve could cut only a septum of connective tissue in the cribriform lamina, and at the same time a nerve-bundle in the optic nerve. Fig. 10 represents it in a plastic way. Let us imagine the sections 79 and 95, made from a transparent material and lying one on another. The longitudinal section of the optic

FIG. 10.

FIG. 11.

nerve passing the cribriform lamina would cut a septum of connective tissue, but passing the nerve itself would cut a nerve-bundle.

That is how "typical" histological pictures of the cribriform lamina can be explained. These pictures depend on the plane of the section. One can see diagrammatically in Fig. 9 that it is not

FIG. 12.

FIG. 13.

the greater thickness of septa of connective tissue in the cribriform lamina, but the greater diameter of myelinised nerve-fibres in the optic nerve that plays here a rôle. In Fig. 10 one may see the possibility of another cut which would pass nerve-bundles as well in the cribriform lamina as in the optic nerve. In such a case, in histological sections the pictures of the cribriform lamina would not be so typical. It is clear that in the same optic nerve one may obtain some pictures of strongly, and some of weakly, developed

FIG. 14.

cribriform lamina according to the plane of cutting. By moving slightly the transparent cubes in Fig. 10 one could get the reversed pictures. A cut could have passed nerve-bundles in the cribriform lamina and septa of connective tissue in the optic nerve. In Figs. 11 and 12, the sharp back outline of the cribriform lamina is missing. Transverse fibres of connective tissue run across nerve-bundles in a similar way in the optic nerve as in the cribriform lamina. In Fig. 13, the lamina cribrosa seems to be composed of several levels. In Fig. 14 the cribriform lamina is hardly to be seen. Transverse fibres of septa run rather across the optic nerve.

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CONTACT LENSES *†

BY

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To us all here the subject of contact lenses is an interesting one and the foundation of a society for the scientific study of the problems connected with them needs no apology, but we are far from being a representative gathering. You will realise this when I tell you that only a short time ago an eminent scientist said to me "Why waste your time starting a contact lens society?" I replied "Why is it a waste of time?" and received the devastating answer, "Because everything is known about them. Optically they provide a beautiful answer to many problems and practically they are useless, as no one can wear them for more than an hour and a half." I think we can say that this statement is largely untrue. In the first place, I hope to show in this address that we certainly do not know all about them and, secondly, I think no one here will dispute the fact that some people cannot even wear them for an hour and a half, while others notice no discomfort after ten times as long.

There would, therefore, seem to be good reason for a society for their study, even though so much has already been written on them and so many experiments performed. These experiments differ from the usual scientific experiment in that they have practically all had to be done on man. Animal experiment will not give us any of the answers we seek, since obviously we cannot test visual acuity in

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† Presidential Address delivered to the Contact Lens Society.