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ANATOMY AND CONGENITAL DEFECTS OF THE LIGAMENTUM PECTINATUM

BY

E. TREACHER COLLINS.

The arrangement of the ligamentum pectinatum and of the parts about the angle of the anterior chamber in nearly all mammals differs considerably from that which is met with in man.

In man the ligamentum pectinatum begins by the splitting up of the hyaline layer of DESCEMET's membrane into a number of trabeculae, which, lined by endothelial cells are prolonged outwards. Some of the innermost of these turn round the angle of the chamber and pass to the root of the iris; others give origin to the ciliary muscle and the outermost are inserted into the sclerotic.

The structure in antero-posterior sections has a laminated appearance and between the trabeculae are narrow slit-like spaces.

The distance between the point where DESCEMET's membrane begins

to split up into the ligamentum pectinatum, and the extreme angle of the anterior chamber, measures, on an average, 0.8 of a millimeter.

The canal of Schlemm overlies the ligamentum pectinatum and the extreme outer part of the angle of the chamber. So that if a line vertieal to the surfaee of the eye was drawn backwards through the eentre of the canal of Schlemm, it would pass into the angle of the anterior ehamber.

If the same line was continued backwards it would almost pass through the large eireular artery at the base of the iris, and only a small portion of the ciliary processes would lie to its inner side.

The ligamentum pectinatum reaches its greatest development in the ungulata. Amongst them I have examined seetions from the eyes of horses, sheep, oxen and pigs.

In these it is eomposed of an external laminated part with slit-like spaces, having mueh the same arrangement as the ligament in man, and an inner part eonsisting of an irregular network of trabeculae with large eavernous spaees between them ; whilst, in some sections, on the side bounding the anterior ehamber a prolongation of fibrous tissue, like that on the anterior snrfaee of the iris, passes forwards to be attaehed to the back of the eornea.

The angle of the anterior ehamber in these animals does not extend outwards beyond the point where Descemet's membrane begins to split up ; so that a line drawn baekwards vertically to the surface of the eye through the centre of Schlemm's canal, will not pass through the angle of the anterior ehamber, but will be some distance outside it, and the large eireular artery of the iris together with a large portion of the eiliary proeesses will be to its inner side.

In the kangaroo the arrangement is very similar to that in the ungulata, the eavernous part of the ligamentum peetinatum, however, not being quite so extensive.

In the earnivora, amongst which I have examined the eyes of dogs, cats and foxes, the trabeculae of the ligamentum pectinatum are very delieate, the laminated portion small but the eavernous portion very extensive, extending baekwards a considerable distance beyond the termination of Descemet's membrane and having very large spaces in it. The angle of the ehamber, as in the ungulata, ends where Descemet's membrane begins to split up, and the line drawn back through the canal of Schlemm would be some distance outside it and have the

circular artery of the iris and a large part of the ciliary processes to its inner side.

The same applies to the eyes of rodents in whom the laminated portion of the ligament is still less marked than in the carnivora, while the spaces between the trabeculae of the cavernous portion are very large.

Among the quadrumana I have examined sections of the eyes of a South American monkey (Capuchin) and Indian monkey (Rhesus) and a chimpanzee.

In them the arrangement of parts about the angle of the anterior chamber has a much closer resemblance to that met with in human eyes than that in other mammals.

There are, however, slight differences to be observed. In them, and especially in the chimpanzee, the innermost trabeculae of the ligamentum pectinatum are more widely separated, bend down sooner to be attached to the root of the iris, and have larger spaces between them than in the human eye. They form a modified cavernous zone.

No prolongation forwards of fibrous tissue from the anterior surface of the iris to the back of the cornea on the anterior chamber side of the ligamentum pectinatum is met with in them, as in other mammals. The angle of the anterior is not so rounded as in man. A line drawn vertically backwards through the canal of Schlemm would, as in man, pass into the extreme angle of the anterior chamber, and leave the greater part of the ciliary processes external to it.

During development of the human eye the parts about the angle of the anterior chamber pass through stages which represent those which exist in the lower animals.

Thus, in the sections of an eye which I have from a human foetus of between the 4th and 5th months, though the parts are very small, a portion of the ligamentum pectinatum which corresponds to the cavernous zone can be distinctly made out.

In them the angle of the anterior chamber does not extend outwards beyond the termination of Descemet's membrane, and a vertical line drawn backwards through the canal of Schlemm is external to the angle of the anterior chamber, while the large circular artery of the iris and the ciliary processes are internal to it.

In a foetal eye at the 7th month the trabeculae of the cavernous zone are well spaced out and a line drawn vertically backwards through

Schlemm's canal passes across it external to the angle of the anterior chamber.

In the sections of a human foetal eye at birth, I have found delicate trabeculae of fibres stretching across what would have ultimately become the angle of the anterior chamber, much in the same way as I have found fibres of the ligamentum pectinatum bend down to the root of the iris in the eye of the chimpanzee.

In association with this difference in the arrangement of parts about the angle of the anterior chamber in man and other mammals I wish to call your attention to another difference, that is in the relation which the size of the cornea bears to that of the globe.

In the following table the figures show the diameters of the eyeballs in a series of mammals and the diameters of their corneae.

	DIAMETERS OF EYEBALL.		DIAMETERS OF CORNEA.	
	anterio-posterior.	lateral.	lateral.	vertical.
Man.	24.8	24.4	11.6	11
Chimpanzee.	19	18	10.5	
Rhesus Monkey (India).	19.5	19	12	11
Capuchin Monkey (S. America).	18.5	19	11	10.5
Rabbit.	16	20	15	
Mouse.	4	5	3	
Civet Cat.	11	17	13	
Cat.	22	21	18	
Horse.	45	51	26	
Sheep.	27	28	19	15.5
Ox.	36	38	27	22
Pig.	23.5	24	17	14
Wallaby	18	19	14	

Measurements are in millimeters.

From it, it will be seen, that in all mammals below man the diameter of the cornea measures more than half the anterio-posterior diameter of the globe.

In the chimpanzee it is about half. In man it is less than half. Consequently the area covered by the ligamentum pectinatum in man compared with the size of the globe is less than in other mammals.

The same difference I have found to exist in the relation between the size of the cornea and the globe, by comparing a series of human foetal eyes, that I have measured, with the adult human eye.

This next table shows that in foetal life the lateral diameter of the cornea is always more than $^1/_2$ the anterio-posterior diameter of the globe, but that in the adult it is less than half.

Age.	No. of eyes examined.	Measurements of Eyeball.			Measurements of Cornea.	
		Anterio-posterior.	vertical.	lateral	vertical.	lateral.
4th month	2	8.5	8	8	4.5	5
6th month	2	10 3	9.75	10	5.5	6
7th to 8th month	8	14.3	12.6	13.2	7.5	8
9th month	1	17	15.5	16	10	10.5
Adult		24.8	24	24.4	11	11.6

Measurements are in millimeters.

The next table shows the measurements of the eyeball and the cornea from six cases of microphthalmos which I have examined.

	EYEBALL.			CORNEA.	
No.	Anterio-posterior.	lateral.	vertical.	lateral.	vertical.
1	19	18	18	9.5	8.5
2	17	18	16 5	8.25	7.5
3	15.5	—	14	9	—
4	13.5	12	12	8 5	5.5
5	19	20	20	11.5	10.5
6	20	20	20	11	10.5

Measurements are in millimeters.

In four of them it will be seen that the lateral diameter of the cornea was more than half the anterio-posterior diameter of the globe, in one it is exactly half and in the remaining one slightly less than half, whereas, in the normal adult as I have already said it is less than half.

No. 2 in the above table was an eye which had coloboma of the iris, displacement of the lens backwards and other congenital defects (a full description of it is published in the Transactions of the Opthalmological Society vol. XIII. p. 116). In sections of it the extreme angle of the anterior chamber is seen to be almost on a level with the termination of DESCEMET's membrane. Directly this membrane has split up into the ligamentum pectinatum some of the fibres of the latter curve back almost at a right angle and pass to the root of the iris. Between the trabeculae of the ligamentum pectinatum nearest the angle of the anterior chamber the spaces are large. A line drawn vertically backwards through the canal of SCHLEMM passes through the ligamentum pectinatum not through the angle of the anterior

chamber. The position of the ciliary processes is much distorted owing to the faulty position of the lens.

No. 3 in the table was an eye with a congenitally persistent and patent hyaloid artery, and fibrous tissue formation in the vitreous chamber (a detailed description of it is given in the Royal London Ophthalmic Hospital Reports vol. XIII, p. 92). In sections of it, the canal of SCHLEMM is seen some distance external to the angle of the anterior chamber.

The ciliary processes and large circular artery of the iris are well internal to a line drawn vertically backwards through it. There is a well marked cavernous zone to the ligamentum pectinatum.

No. 4 in the table was a microphthalmic eye kindly sent to me for examination by Dr. MCKENZIE of Torquay, no detailed description of it has yet been published. In it there was congenital defect of development in the iris, lens and vitreous. The condition of the ligamentum pectinatum and the relation of parts about the angle of the anterior chamber is seen to be similar to that in No. 3.

No. 5 in the table had considerable defect in the development of the iris in its whole circumference, which led to its being described clinically as a case of irideraemia. (A detailed description of it is published in the Transactions of the Ophthalmological Society. Vol. XIII. p. 128). The condition of the ligamentum pectinatum in this case closely resembles that met with in the ungulata. In some sections, portions of the fibrous tissue from the anterior part of the iris seem to pass forwards to the posterior surface of the cornea, in the position where DESCEMET's membrane ends and the ligamentum pectinatum begins. External to this prolongation forwards of iris tissue are some irregular trabeculae with large space between them, and anterior and external to this cavernous zone are the laminated fibres of the ligamentum pectinatum with slit-like spaces between them.

In previous writings I have pointed out that in cases of congenital glaucoma or buphthalmos, as it is termed, bands of adhesion are frequently seen stretching across the angle of the anterior chamber between the root of the iris and the periphery of the cornea. These sometimes consist of delicate fibres only and are sometimes quite

broad adhesions. As the eyeball enlarges and the anterior chamber becomes deepened, these adhesions may break through, then loose tags of fibres are met with.

Mr. Richardson Cross in the Transactions of the Ophthalmological Society of the United Kingdom, vol. XVI, published the description of a careful microscopical examination he had made of three congenitally glaucomatous eyes. Speaking of the filtration area in these eyes he says: "There was in No. 1, a definite adhesion of the root of the iris to the ligamentum pectinatum; No. 2, no definite adhesion, but strands of tissue suggestive of a former contact of iris and cornea which has given way; No. 3, distinct block of considerable width occluding the angle."

I have described these adhesions as due to a congenital failure in the complete separation of the anterior surface of the iris from the posterior surface of the cornea. This they certainly are, but the more extended examination which I have recently made of animals' eyes, leads me to think that some of them are better spoken of as an abnormal persistence of the prehuman or prenatal condition of the ligamentum pectinatum.

I may summarise the above observations as follows:

1. In mammals eyes the ligamentum pectinatum is generally a more extensive structure than in the human eye. In them it consists of what may be described as an external laminated zone with slit-like spaces and an inner cavernous zone with large irregular spaces. In man's eye there is practically no cavernous zone, the whole of it having apparently been thrown into the angle of the anterior chamber, which is prolonged further outwards than in animals' eyes.

2. This alteration in the ligamentum pectinatum is associated with an alteration in the relative size of the cornea and globe. The decrease in the relative size of the cornea to the globe in man's eye being accompanied by a simplification in the structure of the ligamentum pectinatum and a prolongation of the angle of the anterior chamber outwards.

3. In the process of development the human eye passes through stages in which the relation of parts about the angle of the anterior chamber and the relative size of the cornea to the globe is the same as in animals.

4. In some congenitally defective human eyes in which the globe has failed to reach its normal dimensions, the condition of parts about the angle of the anterior chamber, and the relation in size of the cornea to globe, which exists before birth, and which is found in animals' eyes, persists.

5. In some human eyes in which the intraocular tension has been increased since birth, and in which consequently the elastic tissues of the globe have become much expanded, the condition of the ligamentum pectinatum resembles that met with in animals eyes, some of the cavernous zone persisting.

With these facts before us it seems to me fair to assume: That the simplification of the ligamentum pectinatum and prolongation outwards of the angle of the anterior chamber in man's eye facilitates the exit of the intraocular fluid. A more easy exit of which is rendered necessary by the diminished area which the ligamentum pectinatum occupies in proportion to the size of the eyeball.

That if the prenatal or prehuman condition of the ligamentum pectinatum persists in an eye which is congenitally small, no delay in the exit of fluid from the eye results and the tension remains normal; but if it is present in an eyeball of average size then delayed exit of fluid takes place and increase of tension with enlargement of the globe results.

Fig. I.

Angle of anterior chamber in a pig.
C = Canal of Schlemm
F = Process of fibrous tissue at angle of chamber.
B = Large circular artery at root of iris.

Fig. II.

The ligamentum pectinatum from the eye of an ox.
L = Laminated portion of ligament.
C = Cavernous portion of ligament.
F = Process of fibrous tissue at angle of anterior chamber.

Fig. III.

Angle of anterior chamber in a cat.
C = Canal of Schlemm.

Fig. IV.

Angle of the anterior chamber in a chimpanzee.

Fig. V.

Ligamentum pectinatum in a foetal eye of the 4th and 5th month under higher power; $^1/_6$th of an inch.
A = Angle of chamber.
C = Canal of Schlemm.
B = Large circular artery at root of iris.

Fig. VI.

Angle of anterior chamber in a human foetus at birth.

Fig. VII.

Microphthalmic eye (no. 4) showing angle of the anterior chamber with congenital defects.

Fig. VIII.

Microphthalmic eye (no. 5) showing angle of anterior chamber with congenital defect.

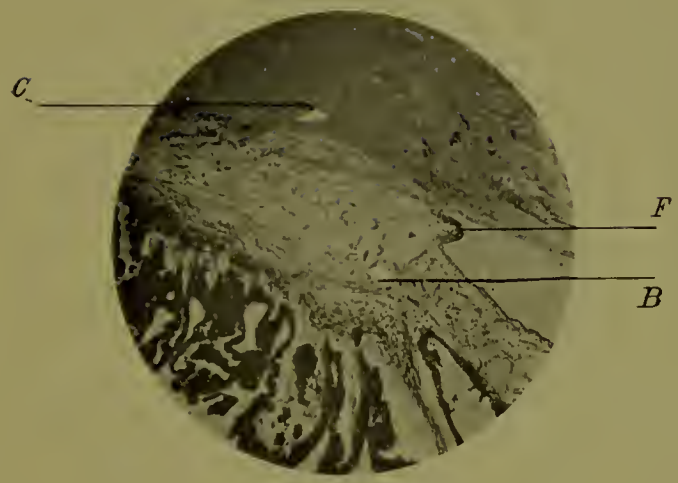

Fig. I.

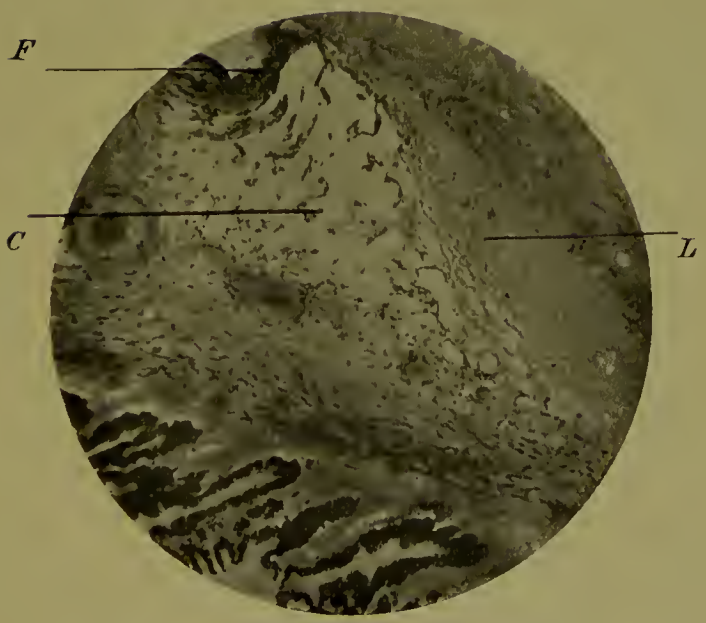

Fig. II.

E. TREACHER COLLINS *Anatomy and congenital defects of the ligamentum pectinatum.*

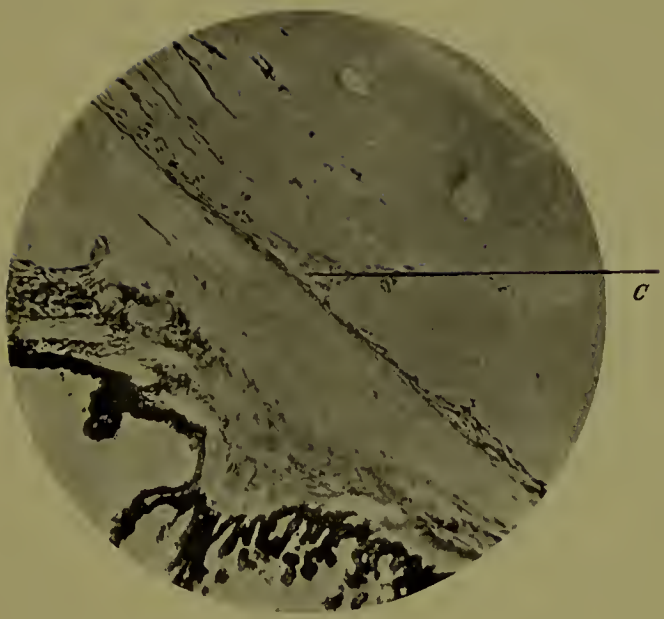

Fig. III.

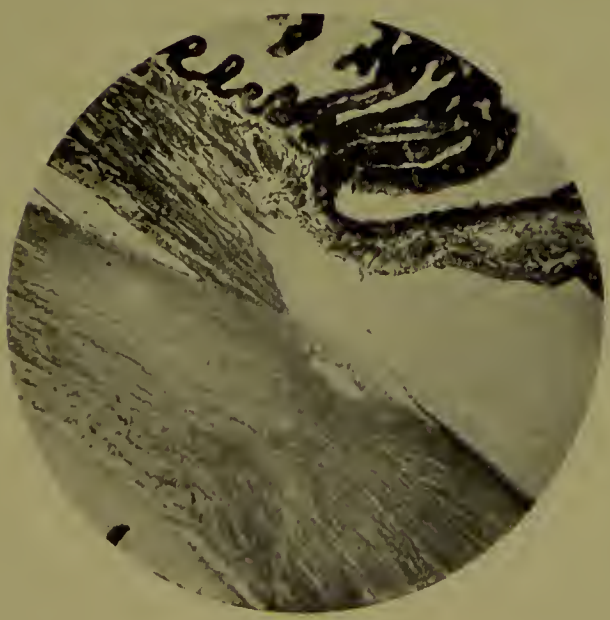

Fig. IV.

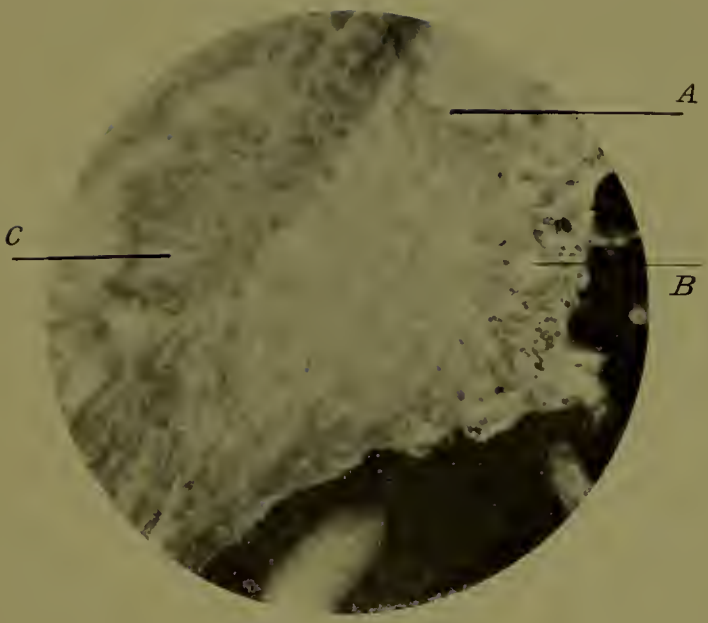

Fig. V.

Fig. VI.

E. TREACHER COLLINS. *Anatomy and congenital defects of the ligamentum pectinatum.*

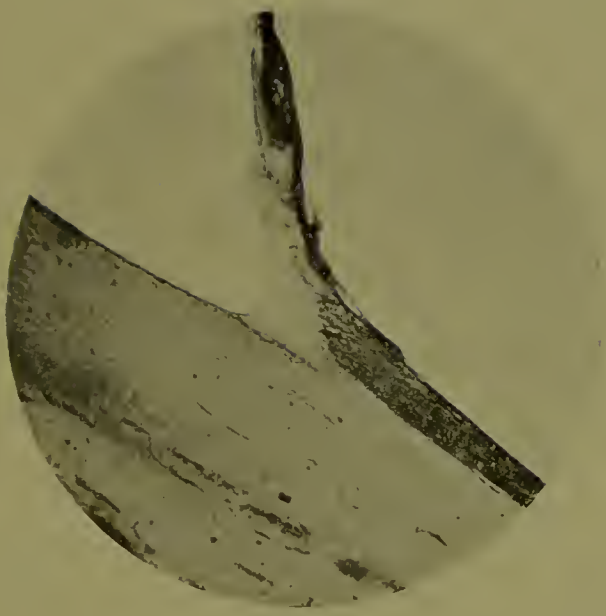

Fig. VII.

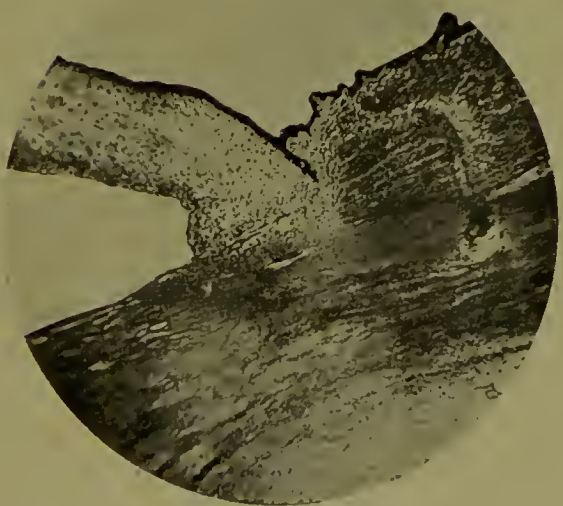

Fig. VIII.

E. TREACHER COLLINS. *Anatomy and congenital defects of the ligamentum pectinatum.*