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COMMUNICATIONS

CERTAIN CLINICAL FEATURES OF THE NORMAL LIMBUS

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The Vascular Plexus of the Limbus

A few points concerning the limbus-plexus of Fig. 16 may now be considered. Mention may be made of the large centrifugal vessel M; it lies stereoscopically mid-way between the surface of the conjunctiva and the surface of the sclera. Some of the deeper basal vessels of the limbus-plexus, and also some of the episcleral vessels into which they lead, are drawn in hatched lines. The tributaries N and O to the vessel M are worth noting; they are an example of a feature commonly seen.* Two vessels run side by side as one, having a common binding "coat." When the blood is not circulating in them, or when it is absent temporarily in one, the double nature of the channel is apparent. It is not uncommon to find fused conjunctival vessels which for a part—sometimes a very long one—of their course are treble or quadruple in bore, the whole appearing as one large expanded vessel when the circulation is abundant. A similar principle may be seen in the case of the ring s'-sd-d' which measures 0.1 mm. across its longest diameter. The two channels, s and d—s being

*An error of omission occurred in printing this part of the block; a note of correction will appear in the August issue.

the superficial and d slightly deeper—together form the segment sd, and for this short distance (sd) they run in a common union, the blood here going in opposite relative directions in the two; and they reunite to leave the opposite side of the ring in similar close association along sd', the blood here going in the same relative direction in each. It is quite easy to appreciate this relationship stereoscopically, the one component here lying precisely over the other. In other similar instances of concomitant association of vessels of the limbus-plexus, they may be side by side in the same plane instead of being superimposed one on the other.

The case of Fig. 16 affords a good example of a not uncommon type of limbus-plexus, *i.e.*, one in which a single relatively large vessel along the corneal border of the plexus conveys blood in one direction concentric with the limbus. Such a vessel in the course of embryonic development is probably in part formed by successive linking of the transilient summits of conterminous loops; it is at first insignificant and sinuous, but with establishment of the dominant continuity of its individualized circulation its successive angular salients tend to become more and more obtuse in aiming at a direct alignment. (The details in Fig. 16 were correctly depicted in nearly all their proportions and angular relations). Under normal conditions only this concentric marginal vessel conveys blood, and the channels of the net lying on the conjunctival side of it are usually empty; but they fill up readily under any circumstances increasing the superficial vascularity of the eye.

This condition is imitated by certain types of pathological superficial corneal invasion from the limbus above, the final state settling down with a major transverse corneal vessel running concentrically with the limbus and being formed by a serial anastomosis between the distal apical constituents of the feeding loops whose basal or proximal portions eventually play a minor rôle.

On the corneal side of this main marginal channel, in the normal example here drawn, some very fine loops are seen at U V W X Y and Z. They were nearly always empty in this particular person, but under rare circumstances they conveyed blood, especially the loops at Z and U. The very fine deep anterior ciliary afferent vessels ("a" 1, 2, 3 and 4) to these loops are evident. At the summit of Z is a very minute and all but invisible blind extension. This was at no time seen to convey blood. By analogy with pathological invasions, it represents a characteristic stage in the development of an immigrating vascular tube where it has just stopped short of full functioning encroachment. A similar feature is seen at W.

Another normal type of the limbus-plexus is seen in Fig. 20. Here the principle on which the final end-loops are built is noticeable. It will readily be seen how the blood, brought by the two

fine deep afferent vessels, a and a1, can readily discharge itself into the penultimate plexus-system without of necessity having to flow through the most remote (corneal) terminal loops. Fig. 21 shows other examples of normal terminal (corneal) capillary loops in the same subject.

(Figs. 20 and 21 were recorded in 1924 from a man, aged 45 years; I re-examined him in 1933 and although the tracks of the terminal end-loops were still discoverable, the blood had ceased to flow in many of them. It is my impression that a clinical opinion on the tendency to general arterio-sclerosis of any individual cannot be gained by an isolated inspection of the conjunctival and limbal capillaries; but some accurate information may perhaps be deduced concerning any one individual if minute records of the vessels, such as those here shown, can be made and remade from time to time as years go by—a procedure obviously too tedious for general adoption at present).

In some persons these loops have a dominantly elongated character and are so uniformly spaced as to convey the appearance of a delicate marginal alphabetical frieze. As will be seen, the terminal loops display the general principle (applicable to normal and pathological systems) that as soon as the arterial capillary has turned back on its course, the diameter of the vessel at once increases. The flow of blood is so rapid in these small calibrated arterial vessels that it is seldom visible; but once the blood has entered the larger loops its relatively leisurely and purposeful flow is very easily seen. The blood having entered the plexus, the direction of its flow in any of the constituent parts is subject to whimsical variations according to local pressure-influences. It is by no means uncommon for the bulk even of these larger plexus-vessels to contain no circulating blood under average conditions. In one or more constituents of the network the blood may flow at one time in one direction, at another in the opposite; it may remain stationary or it may oscillate. These instances of hesitating, alternating, and reversing flow in many of the components of this normal network suggest the conclusion that the blood, once it is delivered by the invisibly rapid flow in the small calibrated arterial capillaries, pursues its leisurely flow in the plexus with adequate time to serve the metabolic purposes for which it has been brought rapidly to the particular region. On this account it might seem appropriate to name the coarser constituents of such a plexus, *i.e.*, all exclusive of the fine afferent arterial channels which are apt to be overlooked unless the observation is carefully made, the "metabolic vessels." The adoption of this nomenclature is further supported by the evidence of pathological corneal vascular invasions, whose principle is commonly much the same—save that they may at times reach out

to distances far in advance of their normal initial base—*viz.*, a dilatatory system served with rapid delivery (sometimes mainly terminally or apically, sometimes in all its parts) by very fine arterial channels whence transition of calibre is relatively abrupt. It is, perhaps, reasonable to assume that the architecture of a pathological vascular invasion may be adapted in anticipation of the metabolic functions which it will be called upon to serve. If this conception is acceptable, there is reason for refraining from the use of the word "venous" in speaking of the larger components of a capillary system before they have materially converged to form main conducting channels of departure (such, *e.g.*, as the large vessel M, Fig. 16). If the trabecular loops serve a purpose—and are not some sort of vestigial remnants no longer useful—then the larger (usually centripetal) component of each might be included with the "metabolic system."

At first sight the functional and morphological appearance of this plexus at the limbus conveys an impression that it is "venous" in character, *i.e.*, excluding the fine arterial afferent channels which are inconspicuous, it consists of a net-work of relatively coarse capillaries leading, peripherally, direct into larger episcleral vessels whose blood is flowing mainly centrifugally away from the net. In further suggestion of the seemingly "venous" character of this plexus, it is joined here and there by the numerous apparently "venous" (*i.e.*, large calibred) efferent components of the various afferent-efferent conjunctival loops described, and the rate of blood flow is leisurely in these components when compared with the rate in the corresponding afferent arterial components. It is true that most of these conjunctival loops, save some of the isolated intratrabecular loops, receive minute accessory tributaries from the conjunctiva, but often in a manner suggestive of the access being contingent and incidental, rather than fundamental. I would like to suggest that the efferent components of these conjunctival loops, though perhaps phylogenetically belonging to the "venous" side of a capillary system, have become specialized in the conjunctiva to facilitate oxygenation of the blood as it passes through them on its way to the limbus-plexus. Moreover, considered in relation to a time-factor, the rate of blood flow is relatively slower if the course is elongated by a loop-formation even if no part of that course undergo any increase in diameter, *i.e.*, a given unit of blood will stay longer near the surface in proportion with the mere length of the surface-loop which it traverses. The epithelium of the conjunctiva is very thin—only three cells deep. I have hesitated to make this suggestion in print without seeking further opinions, *e.g.*, that of Dr. F. G. Chandler, on the question of the absorption of gases through the pleura. From what I can gather by analogy with other parts of

the body there is not, *prima facie*, any apparent objection to this suggestion in principle which I will not discuss at length, save to add that Sir Stewart Duke-Elder, whose opinion I have sought, sees no fundamental objection to it. He adds that it has been shown that the corneal epithelium has the property of actively absorbing oxygen and that there is no apparent reason why the thinner conjunctival epithelium should not do so. The colour of the blood in all the efferent components of afferent-efferent conjunctival loops tends to be red and not purple; and the lasting redness of a spontaneous subconjunctival haemorrhage, when it is not very gross and extensive, is a matter of common knowledge. I do not suggest that the conjunctival vascular architecture is ideally specialized to facilitate direct oxygenation of its blood to the fullest capacity that could be devised if this were the main aim in its design, but rather that, among the factors which have contributed to the evolutionary specialization of the design, a partial subservience to this particular function may have contributed its quota in moulding the phylogenetic material available. The fact that trabeculae are not found in all individuals, and that, when they are found, not all of them contain vascular loops (see, *e.g.*, Fig. 12) suggests that their vascular function is possibly vestigial; but the long conjunctival loop-system is practically a constant characteristic. It may be conjectured that the blinking movements of the lids, by compressing and decompressing both the vessels and the lax mobile areolar tissue in which they lie, influence the gaseous interchange in this primitive superficial "respiratory" function. It is worth considering the possibility of treating certain surgical and pathological conditions of the eye on the basis of these conjectures.

There is a recurrent acute affection of the conjunctiva—as far as I know not clinically recognized except that it gets labelled "conjunctivitis"—which is characterised by great dilatation of the "metabolic" constituents of the conjunctival vascular system in the absence of any surface discharge or other apparent surface trouble. When, in inflammation of the eye, these long, fairly straight metabolic conjunctival vessels dilate, they also tend to become flexuous suggesting that they perhaps undergo an intrinsic longitudinal expansion as well as transverse dilatation.

In making this rather lengthy approach to this subject I have succumbed to the temptation to present a selection of simple clinical observations somewhat in the order in which they chanced to unfold themselves when I made them with no particular pre-formed ideas in view. I would like to add one final example from records of a type which seemed to support this view after those already given had afforded inferential evidence leading up to its suggestion. In Fig. 22 an episcleral anterior ciliary artery A' is seen dividing

into branches A, AA. (There were no trabeculae here in this subject.) The branch A loops forward and is quite superficial, *i.e.*, it is immediately under the conjunctival epithelium in its course A, B, C, CC. The portion ABC of this vessel, which is arterial in origin, increases to a diameter suggestive of a "metabolic" function. The movement of its blood could not be seen in this portion ABC, but from the origin of the vessel a southward flow could be inferred. Now the flow in the portion C - CC was southward and was usually very slow and "dilute"—*i.e.*, the corpuscles were not close packed—progressing usually in very short cardio-vascular periodic steps. The blood went rapidly southward in the portion C - CC only when the local vascular activity was more excitable than normal, *e.g.*, on one occasion when there was a small foreign body on the eye. Opposite B and C respectively two very tiny (only just visible) quite superficial vessels D and G branch off from this dilated "arterial" channel and if their course is followed it will be seen that they lead by way of vessels still superficial, *which receive no other tributaries*, to R and J, which empty into the limbus-plexus. The vessel GHJ undergoes an appreciable increase in diameter in its portion HJ. The flow of blood was rapid, and always in the direction shown, in the minute superficial connecting vessels G and D. Thus it can be inferred that the flow of arterial blood is relatively slow through the dilated portion ABC because of the mechanically restricted outlet, through the tiny vessels D and G, and of its functionally counterbalanced restriction through the southward outlet C - CC; the portion of this blood which passes on through G will again flow through another superficial channel of larger diameter H before it enters the limbus-plexus. Although peripheral connection is established with the purely conjunctival circulation at CC, it is quite clear that the arterial blood of the vessel A is mainly destined for the limbus-plexus and that its main purpose is seemingly not to give blood to, or receive it from, the conjunctiva through which it travels by a circuitous excursion. (Space need not be given to further description of this figure other than to add that AB is obviously of arterial origin; AD and VA form an afferent-efferent loop based on the limbus and not absolutely superficial in the conjunctiva until it is approaching the region of VC (but its fine arterial branch, AE, is very superficial) more peripheral to which, in the region of P, it spreads out into connections with the ordinary conjunctival circulation; it is evident how some of the arterial blood of AF can pass down to the region of VD which is directed towards the fornix. T is from a portion of the temporal marginal region of a limbus at about "3.15 o'clock"; AK and VG are an arterio-"venous" superficial conjunctival loop, AK becoming superficial in a curve from the episcleral artery Z; the

fine arterial branch LMN, from Z, will be noticed. The vessel W - X unites with VG at X whence in common union they plunge deep, perpendicular to the surface, to join the episcleral plexus vessel, OP. Fig. 23 is added as an additional example showing an *arterial* anterior ciliary episcleral connection at the limbus;

FIG. 23.

these are often not so easily seen as most of the other features described; A is the episcleral artery which curves forward to take a conjunctival course down to and beyond D; in part of its course it accompanies the conjunctival efferent vessel E; a branch, B, goes up to the marginal region of the plexus, and another branch, C, passes down to join the conjunctival efferent vessel E.

In concluding these remarks on the possible use made by local oxygenation of the blood I do not suggest that it be stressed too

much. The conjunctival loops are relatively not very numerous, and the suggestion is not one which is altogether compatible with the fact that the metabolic constituents of the conjunctival loops tend to join the basal or peripheral parts of the limbus-plexus rather than the final marginal or apical constituents; in fact, many of the larger conjunctival "veins," (*i.e.*, efferent constituents of long loops) join the limbus-plexus at a level where it merges with episcleral vessels which most probably have a function which is little more than that of veins conducting blood away from the plexus; this is seen in the case of E, E1, E2, E3, Figs. 2 and 3, and of other figures reproduced in this article. Even so, it might not unreasonably be asked whether these coarser episcleral vessels—which, visibly conducting blood not quite so red as that in the conjunctival vessels, tend to form an intercommunicating spread-out plexus of sorts, on the surface of the sclera over a considerable distance peripheral to the corneo-scleral junction—may possibly be thus disposed so as to unload in this plane the oxygen brought to them from the conjunctival vessels "round the corner;" in other words, these visible coarse episcleral vessels may possibly to some extent serve a metabolic function rather than merely that of efferent conductors of entirely deoxygenated blood from a metabolic region strictly limited to the corneo-scleral junction. In this connection it is also reasonable to suppose that the blood leaving the conjunctiva by way of efferent channels at the fornices to enter the episcleral veins near the equator of the globe, is probably not as yet so deprived of its oxygen as venous blood normally might be. This raises a question on which I have no knowledge, *viz.*, as to how far back from the periphery, along the homeward path, vessels gradually increasing in calibre are still capable of permitting transfusion of what oxygen may still be in them. It may be added, finally, that, except quite close to the limbus, the episcleral vessels have, for the sake of clearness, generally been omitted from the figures here reproduced, with the possible exception of Fig. 16 in which, in hatched lines, some, but by no means all, have been inserted.

As the vessels of the limbus-region furnish conjunctival and also sessile loops, it might be convenient to classify, as an "offshoot" from them, *i.e.*, one central to the region of the sessile loops, the finest, and often empty, corneal loops already referred to, terminating immediately beneath the marginal epithelium of the cornea. It would seem reasonable to regard these final corneal loops as not being essential for the nutrition of the cornea. It is expedient to look upon them as the final relics of the "leaders" of the advancing vascular invasion in the embryo which, having served their purpose, pass thereafter a dormant, and in the case of some, almost extinct rôle, ready to lead the way once more if

FIG. 18.

Mainly to show the destination of three anterior ciliary arterial vessels: B at its upper curved end leaves the episclera and arches forward to take a conjunctival course BC (giving off the branch G); the episcleral origin of W is not shown before it has come forward to run down superficially in the conjunctiva, this vessel being depicted here chiefly to show its recurrent branch R; V is shown in its episcleral position where it bifurcates into two branches which arch forward to take a downward course in the conjunctiva, one of them, at U, contributing the afferent component of the loop T-t'. A further feature shown in this figure is the transitional alteration of calibre of the vessels RR and Q.

This figure is described on pages 336 and 337.

FIG. 20.

FIG. 21.

Terminal Marginal Corneal Loops.

Linear magnification : approximately $\times 135$.

(The afferent channels in these two figures, particularly in Fig. 20, have not, in reproduction, come out as fine as they should be in relation to the thickness of the efferent ("metabolic") vessels. This is not due to lack of skill or care on the part of the publishers, but is unavoidable unless, rather unnecessarily, a more costly method of reproduction be employed.)

FIG. 22.

FIG. 29.

Peripheral refractile post-corneal rim in optical section

Linear magnification : approximately $\times 28$.

by chance later in life a pathological invasion in the homologous anatomical plane should claim their initiation in a further vascular advance. (This statement requires amplification and certain reservations for which there is not space here. It must be borne in mind that, under the elementary conditions of clinical observation, the proof that fluid is circulating in small vessels is afforded by no other means than seeing the blood corpuscles in movement. I have seen corpuscles held up at parts of developing capillaries by their impaction at sites transiently just too narrow to permit their passage. I think it not at all impossible that some of these finest end-loops—which under ordinary “quiet” circumstances may be too small in bore to transmit corpuscles—may sometimes have blood serum slowly percolating in them; indeed, this would be a reasonable supposition in keeping with the fact that such tiny vessels, both normal and pathological, may under circumstances of local vascular engorgement suddenly transmit visible corpuscular circulation after having failed to do so for a very long time—even after years in the case of some pathological capillaries. Vogt apparently refers to Koeppe having “no doubt in error” referred to a “blood-free lymph-vessel net at the limbus.” It would be interesting to enquire if Koeppe—as a pioneer working at a time when terminological pitfalls were unpremeditated—might have had in mind this possibility concerning the terminal vessels when they are not dilated enough to transmit the largest solid elements to the blood.)

The Superficial Limbal Spur

The exact plane of the visible limbal network remains to be described. If the focused wide slit beam is cast on the limbus region, the superficial face of the block of light appears to be approximately as in Fig. 24. If the thin optical section is employed (Fig. 25) the relucant line (B) of the cornea, which represents

FIG. 24.

FIG. 25.

Bowman's membrane, can be traced to the tip of what may appropriately be termed the "relucent superficial limbal spur," S. This spur can occasionally be seen indicated in a vague way in many slit-lamp pictures, but it is seldom delineated with the precision and clearness that accurate work merits. It corresponds with the area so familiar in histological sections of the limbus region—in shape like a tall "wedge," having its apex where Bowman's membrane stops short, lying beneath the epithelium anteriorly, while posteriorly it accommodates itself on the face of the lamellated fibrous coat of the eye by causing a shallow indentation which narrows the total thickness of the fibrous coat here. On, and just in, the anterior face of this spur lies the visible limbal vascular plexus whose corneal and finest loops—those more usually empty than not—normally reach a level which corresponds with its tip. So the superficial spur represents in section an optically heterogeneous zone of tissue at the superficial part of the edge of the cornea. The extent to which the superficial edge of this spur in optical section is convexo-concave is variable in different individuals, being scarcely curved in some; but it will be noted that the epithelial surface "impact line" of light E continued towards the bulbar conjunctiva does not, in the case here drawn, bend much, but follows an even course in a manner corresponding with the interposition, between it and the face of the spur, (a) of a greater thickness of the epithelium and, as the line comes more in front of the sclera, (b) of sub-epithelial areolar tissue. The contour of the epithelial surface is slightly concave for a short distance below. The shape of the face of the focused "block" of light of Fig. 24 displays the contour of the face of the spur; this is also seen in Fig. 1. The average position, in the section, of a trabecula T, and of a basal epithelial crypt C, is also indicated in the section, Fig. 25, as well as the peripheral part of one form of the arcus senilis. It is the thin final part of this "spur" when seen by retro-illumination that contributes the main constituent of what is often spoken of as the "bedewing of the normal epithelium at the limbus." The physical properties of the normal surface-epithelium at the limbus justifying the term "bedewing" are so very slight that they can only just be detected by a critical and experienced observer, though with pathological bedewing it is otherwise. The "bedewing" of the limbus, *i.e.*, the appearance of imperfect transparency so easily seen by casual retro-illumination is commonly due to the optical properties of the not quite transparent thin part of the superficial limbal spur.

Sometimes over this spur, and also more peripherally on the conjunctiva, thin, sharp superficial lines are seen more or less concentric with the limbus. They look like cracks in the epithelial surface, but they are only narrow linear invaginations of the surface. They are more apt to occur in the elderly.

Deep Vessels visible at the Limbus

Two more vascular elements, deeper and not to be included with the superficial plexus, are sometimes seen at the normal limbus. Figs. 26 and 27 represent portions (L,L) of the temporal region of the limbus of the right and left eyes respectively of an

FIG. 26.

Medullary sheaths of the corneal nerve-fibres. The efferent component of a vascular loop is seen in both A and B. The tip of an afferent-efferent loop, X, is seen in D.

adolescent girl. They depict the peripheral medullated portions of nerve fibres so often noticeable about mid-way between front and back surfaces of the cornea at the limbus. If these "short medullated sheaths" are looked at carefully it will often be seen that each may contain one afferent-efferent fine vascular loop

FIG. 27.

Nerve fibres (three, E, K and M, being medullated) and their associated vascular loops. V and W are deep, coarse vascular loops seen hazily in the depth of the limbus.

(shown by dotted lines). Usually, the afferent component is invisible and only the single efferent component is seen, as in A and B. (The medullated trunk C, in which no vessel is seen, overlies the trunk B. It may be remarked in passing that the asymmetrical manner in which the nerve, n, is seen leaving the end of its medullated sheath is accurately depicted.) D recalls a not uncommon feature; often, in respect of very small afferent-efferent loops anywhere in the living eye, the blood cannot be seen circulating in them save just at their sharp apex (X) where it shoots round the corner in interrupted spurts which render its existence, its movement and its direction evident. These spurts may be in phase with the cardio-vascular pulse or may sometimes be separated by irregularly attenuated successive intervals having apparently no such relationship.

(I often formed the impression that the perception of the *existence* of quick motion, when it was accessible to view in no more than very small areas, could be formed readily enough by direct inspection with the retinal fixation point; but that conception of the *direction* of the movement could be determined with more ease by deliberately viewing the feature with fixation displaced just enough to be perimacular. In recording rapid movement occurring simultaneously in different relative directions in minute closely crowded features only just resolvable—as in close-set developing pathological endothelial tubes—I used to encounter a fallacy of apparent simultaneous similarity, when looking long and intently at a very minute vessel in order to determine whether it served an afferent or efferent function, with nothing more to go by than a just perceptible occasional transient pulsatile spurt of a few corpuscles in very rapid movement through it. If by chance such a vessel had near it—so as just to fall in the perimacular field—another in which (perhaps from its being bigger, perhaps from its circulation being fuller or more regular) the movement of the circulation was more visible, then the view of this latter in the perimacular field dominated, often erroneously, in the conception of the *direction* of the movement in the smaller vessel perceived with the fixation point. It was a fallacy soon overcome by education; but it was prone to mislead me at first. I found it particularly noticeable when fatigued by prolonged visual and mental straining to see features only just within the limits of resolution, or by adverse conditions. I mention it—in the personal sense in case an idiosyncrasy may have played some part—only as a matter of passing interest; it plays little or no part in the instances quoted here.)

In the case of Fig. 27 it was not clear whether the efferent vessel F was inside or outside the medullated sheath E. In the case of G an efferent vessel was seen only for a short part of its course. In H an efferent vessel crossed from one side of the nerve to the other in the short distance in which the vessel was visible; as to whether or not there was a medullated sheath was not apparent. In K (which overlay another medullated nerve sheath M) the circulation was visible throughout the whole length of the loop and the afferent component was larger and had more leisurely circulation than the efferent component; this condition is presumably explained on the principles already discussed in relation to a similar structural anomaly formed in the conjunctival circulation. It may be remarked that, owing to the rather similar simple optical properties of the tissue of medullated sheaths and empty blood

vessels, the latter, when within a medullated sheath, can scarcely be distinguished when it contains no blood. But it will be noticed that in the two examples of vascular loops here quoted whose circulation renders their apices evident, the apex falls short of the end of the sheath. This is common, as also, if I remember correctly, is the numerical proportion of not more than one loop in one sheath. Speaking from memory, without searching my records, I do not recall having seen vascular loops accompanying fibres that are, as is more usual in the cornea, non-medullated.*

The second additional vascular feature referred to above is diagrammatically illustrated in Fig. 27, V and W. Its occurrence in this particular case is a chance one and does not indicate a relationship with the presence of medullated nerve fibres. It is in the form of one or two pink vascular loops, rather large both in calibre and extent, such as are sometimes seen hazily in the limbus jutting out from within the sclera and lying mid-way between the front and back surfaces of the corneal periphery. They are thus deep and have nothing to do with the vessels of the superficial limbus-plexus, compared with which they are much coarser. They are probably derived from perforating branches of the anterior ciliary vessels. They are by no means uncommon. I have not searched my notes for the records of them which are scattered here and there among stored-up records of other conditions, but as far as I recollect these loops were found more or less in the region of "3 o'clock" and "9 o'clock"; I do not recall seeing them above or below, but it may be added that the lids render these parts less accessible to casual inspection. However, I seem to recollect making a note of an anterior ciliary vessel which ran up to the limbus from below and then sank into the sclera to continue as a buried and only just visible loop from about "6.30 to 7.30 o'clock" deep in the limbus. It seems curious that such features do not occasionally reach into the cornea as a developmental aberration.

The Peripheral Post-Corneal Rim

Mention may be made of an ill-defined textural non-vascular zone of faintly increased relucency at the extreme periphery of the posterior part of the cornea depicted diagrammatically in the lower end of the deep face (P) of the corneal "block" (Fig. 1). It is not a constant feature and its visibility is faint. It commonly has some antero-posterior depth, especially at the extreme

* Meesmann in his "Spaltlampen-Atlas" says that I have found that the superficial part of the vascular corneal invasion, in interstitial keratitis, follows the paths of the nerves. I mentioned this in the *Brit. Jl. of Ophthalm.*, October, 1924, p. 470, as being a possibility, but I did not then add that I had seen it in only two cases of interstitial keratitis.

FIG. 28.

Peripheral refractile post-corneal rim.

periphery, but it is thin centrally, so that it is often somewhat wedge-shaped in section.

Attention may be drawn, in concluding, to a structural feature by no means uncommon which, schematically represented in Figs. 28 and 29, I have suggested might be named the "*peripheral refractile post-corneal rim*."* Many years ago I collected numerous records of variations of this feature which was so common as to

*The visibility of the rim is exaggerated in the reproduction of both these figures owing to its having been drawn (as well as the initials in the corner of Fig. 28) with process-white. It may here be added that in Fig. 1 the stippled bedewing at the limbus has for the same reason come out unintentionally bright; in the coarseness suggested by this error it might be more reminiscent, in a purely diagrammatic sense, of a pathological bedewing. I did not foresee this when drawing these figures.

be within the limits of the normal. In many instances its form was very inconspicuous; when well marked it was, in the cases I saw, usually more in evidence on the temporal than the nasal side; its edge usually receded gradually from view behind the limbus above and below and it was seldom seen in the upper or lower limbus arcs. When present it was often, but not always, bilateral and its development was seldom symmetrical in the two eyes. Diagrammatic examples from two persons—for access to whom I am indebted to Sir Richard Cruise—are shown in Fig. 30. Quite rarely minute fragments of tissue, having a strong semblance to

FIG. 30.

the tissue forming the stroma of the iris, were seen attached to, or close to, the edge of this rim. In Fig. 31, which shows the condition in a left eye, it was more pronounced on the nasal side N. (It was not present in the right eye of the same subject.) The gap G between the slightly spread ends, B and C, was very nearly 1 mm. wide; D represents the rim on the temporal side T, where the dotted line F represents the relative position, in this particular case, of a prominent normal circumferential fold of the iris.

Fig. 32 is another example. P depicts a small fragment of brown tissue on the back of the "rim" of the same colour (dark brown) as the stroma of the iris.

Fig. 29 is intentionally given as being schematic. It was recorded from the same subject as was Fig. 28 in whom the rim (at the edge M) was very conspicuously developed, but its representation in Fig. 29 as running in the form of an appreciable and

FIG. 31.

Linear magnification : approximately $\times 6$.

FIG. 32.

thick relucant and transparent membrane right into the periphery of the chamber is rather in response to the temptation to forsake visible fact for fiction. The optical appearances anywhere peripheral to the definitely marked edge M are too indistinct, both in themselves and in access of view to them, to allow of definite

FIG. 33.

Linear magnification : approximately $\times 118$.

interpretation. But it can be affirmed that in well marked cases the *edge M* is definite in its thickness (variable), its configuration (sometimes regular, often variously irregular, as in Figs. 31 and 32) and in its having optical properties indicating that it is a contour elevation towards the anterior chamber of higher refractive index than the aqueous fluid. In both Figs. 31 and 32 it is the conspicuous "thick edge" that has been drawn. Sometimes this edge was found to be just in line with the demarcation between

the main flat region of the iris and the small peripheral part of the iris-face which slopes back in the chamber angle to unite with the anterior end of the ciliary body; but neither this spatial alignment, nor one relative to the circumferential iris folds, seemed constant.

Less often, grotesquely-shaped and much smaller features of a like kind were recorded; Fig. 33 depicts one; from a to b was about 0.75 mm.; the portion X was approximately 0.6 mm. from the limbus L (though this raises a point, which cannot be discussed here in a short space, on where and whence to take measurements at the limbus region—apt to be so vague when magnified; various possible “starting points” are open to consideration). P indicates on the translucent adventitious tissue, a small fragment of material of the same colour (light brown) as the face of the iris.

These observations were made some 10 years ago under disappointing circumstances; but at that time I had a tangible hope of being able to find means to pursue the subject of the slit-lamp in detail for many years and, not then foreseeing that I should soon have to abandon it altogether, I tried to include detailed records of the normal in a preliminary to the anticipated continuance of the work. This communication is only an abstract from various records that were made then in the course of general observations on a very limited number of cases not particularly selected on this account. It is by no means exhaustive. The type of records chosen for reproduction are not difficult to make but some of the generalizations may, indeed, be digressive or untenable, and I would by choice have preferred to investigate much further the subjects discussed before writing on them. Nor has this report the accessory aid of any histological or physiological investigation and it touches on the fringe of interesting speculations merely from one view-point.

Turning back now to the discarded records of an abortive attempt, I would be cautious, in reviewing any condition included in them, to say it is a rare one; but the “peripheral post-corneal rim” was noted relatively so frequently that it may safely be called a common feature. It would seem possible that the “congenital hyaline membranes” on the posterior surface of the cornea described by Miss Mann in the *Brit. Jl. of Ophthalm.*, August, 1933, may be an aberrant exaggeration related to this inconspicuous variable feature.