Superficial fibrillary lines

A feature of the normal cornea

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A biomicroscopical study of keratoconus patients has demonstrated the presence of bundles of fine fibrillar structures, sub-epithelially, internal to Fleischer's ring (Bron and Tripathi, 1974; Bron, Lobascher, Dixon, Das, and Ruben, 1975). A search for similar structures in the normal cornea has revealed identical fibrils, differing only in their visibility and arrangement at the corneal surface. These structures have been called fibrillary lines and the present paper reports their arrangement in the normal cornea and discusses their possible nature.

Methods

Patients were examined with the Haag-Streit 900 slit lamp, using the $\times 16$ ocular, and the highest intensity of illumination. The fibrils were best identified with a broad oblique focal illumination. Forty-seven asymptomatic subjects (94 eyes) were examined and the corneal appearances were documented by drawings. Macrophotographs were taken in a few selected corneae where the features were well marked. The corneal appearances in relation to the fibrils were classified as follows:

- (A) The presence or absence of fibrils was noted.
- (B) If the fibrils were equally numerous about the sagittal plane of the cornea, the pattern was designated symmetrical.
- (C) If the fibrils were predominantly to the nasal or temporal side of the sagittal plane, the pattern was designated asymmetrical.
- (D) The presence or absence of the Hudson-Staehli line and its relationship to the fibrils was noted.

Clinical observations

Using the fine beam of the slit lamp, fibrillary lines appear to lie at the level of the subepithelium. They run a predominantly vertical, slightly oblique, or gently curving course at the surface of the cornea. Individual fibrils are much like one another in appearance. In the broad focal beam of the slit lamp, they appear greyish-white and shiny, like twisted silk thread. They show a slightly wavy contour. They are usually invisible on retroillumination, but occasionally they may show a weakly refractile property with a

reversed effect (Brown, 1971). Visibility by this means of examination implies a difference in refractive index, between the fibrils and surrounding tissue, the fibrils having a higher refractive index. The biomicroscopical appearance of the fibrils is much like that of stromal nerve fibres.

Measurements from macrophotographs in keratoconus patients gave a fibril diameter of $8.0\ \mu$ (Bron and others, 1975). The fibrils of normal cornea are similar. The interval between adjacent fibrils is variable but is in the region of 50 to $150\ \mu$. As subsequent descriptions will show, this distance is partly dependent on the horizontal level in the cornea at which the measurement is made since there is a tendency for fibrils to converge from above, downwards. The fine movements of the eye make it difficult to be certain that individual fibrils are continuous over long distances, but the impression of continuity is given over 5 to 8 mm. Intermittent communications occur between adjacent fibrils as a result of branching. Occasionally a pair of adjacent fibrils can be observed to arise from a stromal nerve filament. The stromal filament may be seen to branch dichotomously at the point where it reaches the level of the epithelium, and the resulting fibrils pursue a nearly parallel downward course. It has not been possible to record these features photographically because of the fine nature of the structures, but similar features have been recorded in keratoconus (Bron and others, 1975).

Some fibrils exhibit nodular swellings similar to those seen on stromal corneal nerves at branching points. The number of fibrils seen in an individual cornea varies from subject to subject. This does not appear to be dependent on age, sex, or racial origin. Fibrils were identified in English Caucasians and subjects from Ghana, South Africa, the Phillipines, Guyana, Jamaica, Italy, and Mauritius. Age range was from 6 to 72 years.

To some extent the variation in numbers of fibrils seen from subject to subject may be purely a matter of visibility. This depends on the background against which the fibrils are seen, colour of iris, degree of pupil dilatation, and zone of cornea viewed, and also on factors such as the steadiness of fixation. Poor fixation makes these fine fibrils very difficult to observe.

In some corneae no fibrils are observed, and in others only one or two. In others still, a well-developed pattern is demonstrable. Though one cornea may show only a few fibrils when they are undemonstrable in the fellow eye, a symmetrical arrangement between the two eyes is more usual and is seen in about half (47 per cent.).

When fibrils are numerous, a well-developed V-shaped pattern may be present (Figs 1 and 2), the fibrils converging to an apex at the junction of the middle and lower third of the cornea. This apex may be narrow (Figs 1*a* and 1*b*) or broad (Fig. 1*c*) and may be symmetrically or asymmetrically disposed in relation to the sagittal plane of the cornea. A symmetrical arrangement was found in 47 eyes (50 per cent.), and the asymmetrical arrangement in 38 eyes (40 per cent.). Of the asymmetrical patterns, the displacement was to the nasal side of the sagittal plane in 33 eyes (35 per cent.), and to the temporal side in five eyes (5 per cent.). Fibrils were visible in 85 of the eyes examined. Other arrangements of fibrils are seen. In some cases the fibrils appear to lie in parallel bundles which, though showing a gentle curving course, do not form a V-shaped pattern. In one patient a ring-shaped pattern was noticed at the apex

of the V. Fibrils were absent in nine eyes (10 per cent.).

A significant feature of the topographical anatomy of the corneal fibrils is their relationship with the Hudson-Staehli line. When the fibrils form a V-shaped pattern, they appear to converge on a point, or over a more extended zone, onto the Hudson-Staehli line. The fibrils can rarely be traced below the level of this line. Where the Hudson-Staehli line shows a dip or inflection point (Bron, 1973), the fibrils appear to converge towards this point. This is a common but not universal finding. When the Hudson-Staehli line is well developed, then a branching pattern may be identified with the slit lamp (Bron, 1973). In some eyes it may be seen that the fibrils lie in register over the major horizontal component of the Hudson-Staehli line or with its branches.

FIG. 1 Diagram to show different arrangements of fibrils in the normal eye. Right eye depicted
(a) Asymmetrically disposed fibrils lying nasally. No Hudson-Staehli line present
(b) Asymmetrical nasal fibrils converging to a narrow point on the Hudson-Staehli line. No inflection point on the Hudson-Staehli line
(c) Symmetrically disposed fibrils converging to a broad point about the inflection point on the Hudson-Staehli line
(d) Symmetrically disposed fibrils converging to a narrow apex at the inflection point on the Hudson-Staehli line

FIG. 2 Fibrillary lines. Macrophotograph of fibrils (arrows)

Discussion

The fibrils described in this paper do not appear to have been reported previously. They were identified in normal corneae only as a result of a special search stimulated by the observation of more prominent but similar fibrils in patients with keratoconus. The nature of the fibrils is uncertain but their apparent origin at times from the superficial terminal ramifications of the stromal corneal nerves makes it likely that they are neural in origin. Their subepithelial situation corresponds to the level of the subepithelial nerve plexus, so that it may be supposed that the fibrillar arrangement described here is the biomicroscopical counterpart of this plexus. The intercommunications between the fibrils are in keeping with neural inosculation. Similarly, the occasional presence of nodules along their course is reminiscent of nodules seen on stromal nerves. However, the arrangement of the fibrils in a converging pattern is not readily explicable in these terms, since a more homogeneous distribution of the nerve fibres to the epithelium might be reasonably expected. Although this may in part be related to the biomicroscopical visibility of the fibrils, so that not all of the fibrils within the epithelium are visible, it is not clear why fibrils are seen only above the level of the Hudson–Staehli line. This peculiar relationship of the fibrils to the Hudson–Staehli line must also be explained.

In a recent report (Bron, 1973), attention was drawn to the resemblance between a number of vortex patterns in the corneal epithelium. It was pointed out that the epithelial whorl patterns in Fabry's disease, in the toxic epithelial keratopathies (e.g. chloroquine keratopathy), and the vortex pattern of diffuse melanin pigment slide (epithelial melanokeratosis) had many features in common. Their

relationship to the Hudson–Staehli line was discussed and it was suggested that the Hudson–Staehli line itself with its branching processes was another form of vortex pattern of similar origin. The hypothesis was advanced that these patterns were the result of a centripetal slide of epithelial cells from the limbus to a point somewhere below the corneal centre. This point corresponded to the convergence point of the vortex disorders or the inflection point of the Hudson–Staehli line.

It is proposed that a fibrillar system described in this paper owes its arrangement to the same topographical system. It is envisaged that the nerve filaments participating in the subepithelial nerve plexus owe their linear disposition to an alignment of epithelial cells in columns passing inwards from the limbus. Such an arrangement might be dictated by the demands of an epithelium in which the cells are innervated and which is yet undergoing constant turnover (Hanna and O'Brien, 1960; Hanna, Bicknell, and O'Brien, 1961). It is feasible that the epithelial cells and the terminal twigs of the epithelial nerve plexus are involved in a continuous readjustment of their relationships. Morphological instability of the nerve twigs in the cornea has been noted previously (Weddell and Zander, 1951). This instability is probably a feature of nerve terminals all over the body. Although the diameter of the fibrils measured in this study makes it unlikely that they represent terminal twigs, it appears acceptable that any overall patterning of the epithelium dictated by the movement of its constituent cells might be reflected in the topographical organization of its innervation.

Further histological and ultrastructural studies in the human eye are in progress which seek to test this hypothesis.

References

- BRON, A. J. (1973) *Trans. ophthalm. Soc. U.K.*, **93**, 455
 ———, LOBASCHER, D. J., DIXON, W. S., DAS, S. N., and RUBEN, C. M. (1975) *Brit. J. Ophthalm.*, **59**, 136
 ——— and TRIPATHI, R. C. (1974) "Corneal disorders" in "Genetic and Metabolic Eye Disease", ed. M. Goldberg. Little, Brown, Boston
 BROWN, N. A. P. (1971) *Brit. J. Ophthalm.*, **55**, 517
 HANNA, C., BICKNELL, D. S., and O'BRIEN, J. E. (1961) *A.M.A. Arch. Ophthalm.*, **65**, 695
 ——— and O'BRIEN, J. E. (1960) *Ibid.*, **64**, 536
 WEDDELL, G., and ZANDER, E. (1951) *J. Anat.*, **85**, 242