Age-Related Changes in the Anterior Segment of the Eye

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A. Introduction

In general, the tissues of the anterior segment of the eye undergo the same aging processes which take place in the organism as a whole. However, the special role of the eye as a device for optical function has led to the development of specialized mechanisms which, in some places, may also inhibit or even prevent common aging processes. This inhibition of age-related degeneration in certain constituents of the connective tissue may prevent early dysfunction in this important sensory organ. Such dysfunction may be more critical on the survival of the organism than comparable aging processes in the skin or bones; e.g., the maintenance of corneal transparency and a constant intraocular pressure are of fundamental biologic importance. The corneal transparency depends on a continuous process of dehydration and a certain degree of “nonaging” of the connective tissue found in the corneal stroma (cf. Sect. B.1). With respect to intraocular pressure maintenance, it appears that the age-related increase in outflow resistance is counteracted by a simultaneous decrease in aqueous formation. This may be the means by which the tissues of the ciliary body and the chamber angle maintain a fairly constant intraocular pressure during life. Similar interrelated processes may also develop at other sites of the eye (Fig. 1). Thus, aging in the eye cannot be considered an isolated, uniformly developing degenerative process. Rather, it is a complicated process of structural and biologic changes of interrelated functional systems whereby systems may compensate for changes occurring in a neighboring system and vice versa. We are far from a real pathologic or gerontologic understanding of such interrelations and functional mechanisms.

B. Cornea

The five-layer epithelium of the cornea has a very regular structure with a total thickness of about 50 μm. The surface of the superficial cell layer is covered with microplicae and microvilli which enable the tear film to remain attached to the eyeball. The turnover time of the corneal epithelium has been estimated to be 7–8 days (HANNA et al. 1961). It seems to become longer with increasing age.

The basal lamina and basement membrane of the corneal epithelium can clearly be differentiated from Bowman’s membrane. They demonstrate the typical staining characteristics of subepithelial basement membranes (TENG and KATZIN 1953; CALMETTES et al. 1956; GRAUMANN and ROHEN 1958). In contrast, Bow-
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Fig. 1. Horizontal section through the human eye (schematic drawing). Arrows direction of aqueous flow; rectangle chamber angle region with anterior part of ciliary body and iris root

man’s membrane is not a basement membrane, but rather a modified stroma layer. It is composed almost entirely of collagenous and other fibrils of connective tissue, which form a very tight, but irregularly arranged network. This network is embedded in a ground substance rich in acid glycosaminoglycans and glycoproteins. There are no cells and no elastic fibers within this layer. The border to the stroma layer is not distinct. Histochemically, a gradual change in staining characteristics can be seen.

I. Stroma

The corneal stroma is composed almost entirely of collagenous lamellae containing fibroblasts (keratocytes) and nonfibrillar interstitial substances. The 200–250 lamellae consist of densely packed collagenous fibers revealing a very regular pattern throughout the cornea (SCHWARZ 1972; BASHEY and KERN 1972). The parallel collagenous fibrils bundled within the lamellae are uniform in size and spacing. The interfibrillar spaces are filled with a cementing substance (matrix), which appears especially rich in glycosaminoglycans. The diameter of the collagenous fibrils remains relatively constant throughout life, varying between 210 and 360 Å (KAYES and HOLMBERG 1960; JAKUS 1961; SCHWARZ 1953, 1972; SCHWARZ and KEYSERLINGK 1969; SCHWARZ et al. 1966). Conversely, the collagenous fibers of the sclera gradually thicken with age (SCHWARZ et al. 1966; ROHEN and LÜTJEN-