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Age Changes of the Human Optic Nerve Head

A Neurohistologic Study

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Summary. Eleven human optic nerves from subjects in different decades ranging from the fifth to the ninth were investigated with the silver carbonate method to establish the pattern and frequency of age changes within the optic nerve head and their relationship with the glaucomatous excavation. It has been found that despite the occurrence of age degeneration at the same level of the cribriform lamina, there are definite anatomical differences as compared with glaucoma changes, especially regarding the distribution of axonal damage.

Introduction

In a recent article on the glaucomatous cupping of the optic disk (Vrabec, 1976) we have described a narrow band of degenerative changes of the retinal axons in glaucoma cases. This sharply delimited band of degeneration extends across the optic nerve at the level of the proximal portion of the cribriform lamina and immediately behind it. On this occasion an optic nerve head of an aged person without eye disease was examined: a narrow layer of axonal degeneration was found there, situated at the same level, but of a different pattern. We therefore decided to reexamine axonal changes in several optic nerve heads of aged people without any known eye disease.

Material and Methods

Ten optic nerves from normal human eyes ranging in age from the fifth to the ninth decade were obtained by autopsy. They were fixed in 10 % formalin for at least three weeks and then sectioned using a freezing microtome at 40 to 60 microns. Most of them were cut sagittally; in cases where we could obtain both optic nerve heads of the same eye, the other disk was cut transversally. All sections were stained with the

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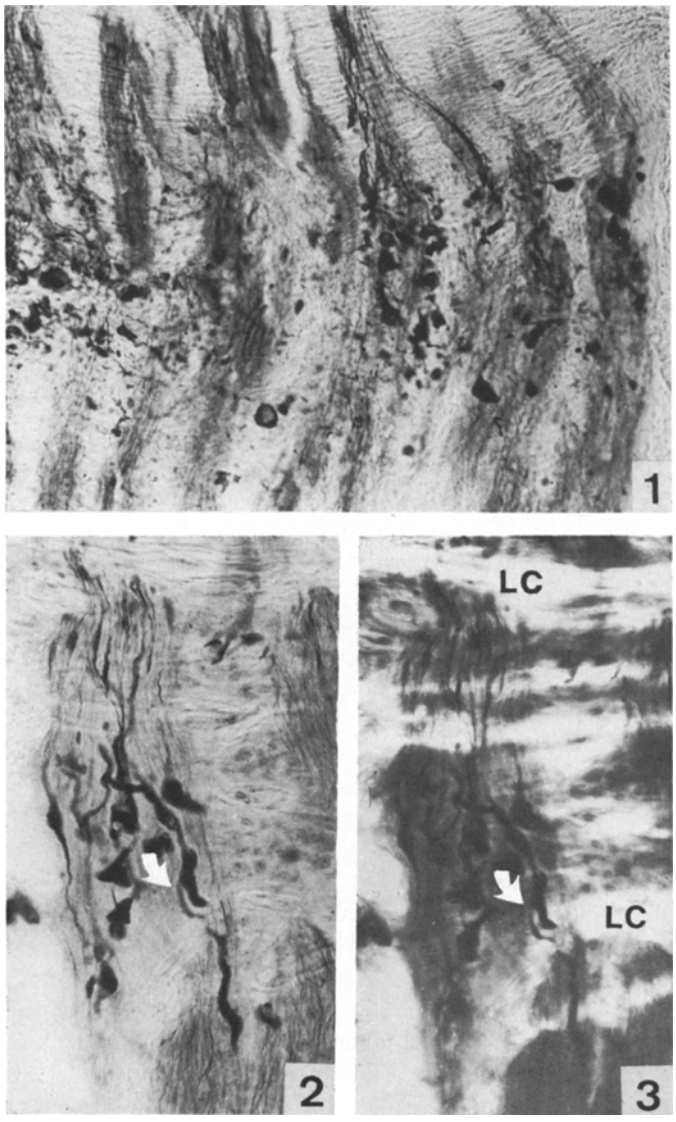

Fig. 1. Laminar portion of the optic nerve head of a person aged 80. Fully developed degenerating changes across the whole optic nerve at the level of the lamina cribrosa. Silver carbonate method of Jabonero, x 160

Figs. 2 and 3. The same detail of a bundle of degenerating retinal axons in the optic nerve of a person aged 76. Figure 2 was taken in normal light, Figure 3 in polarized light to show collagen bundles of the lamina (= *LC*). White arrows in both pictures indicate the same group of degenerating axons. Jabonero method, x 270

silver carbonate method of Jabonero (1953). One more optic nerve from a case of a melanoma of the anterior segment was fixed immediately after enucleation in formol and impregnated following Agduhr's (1930) modification of the Bielschowsky method *en bloc*. Our material includes the following ages: 46, 51, 60, 64, 64, 68, 70, 76, 80,

and 80 years. A polarization microscope was found useful for the exact localization of the connective tissue portion of the cribriform lamina.

Findings

In the optic nerve of a 46-year-old man we have already found several degenerating axons at the above-mentioned level. The man was otherwise healthy and died in a traffic accident. On the other hand, in cases of 51 and 60 years of age, degenerating axons were very rare; this finding proves a great individual diversity of age changes of ocular tissues (Vrabec, 1965 a and b; 1974). In 64 and 68-year-old persons axonal degeneration was more pronounced and in both 80-year-old persons axonal alterations were fully developed (Fig. 1); retraction clubs, cones of growth, and some collateral sprouts – the latter much less numerous than in glaucoma cases. If the degeneration began in a more distal portion of the cribriform lamina, i.e., immediately behind the prelaminar portion of the disk, the cones of growth sprouted mostly horizontally – across the optic nerve. In cases where the changes appeared within a more proximal portion of the lamina, their cones of growth advanced at random in both directions – across the nerve as well as longitudinally toward the intraorbital portion of the optic nerve. The width of the band of changes was less than in glaucoma changes (Figs. 1 and 2); this also shows that "frustrated regenerative acts" (Cajal, 1959) are less pronounced in the aged than in glaucoma cases.

Compared with glaucoma changes, age changes do not prefer the vertical meridian of the optic disk, but are dispersed diffusely throughout the whole diameter of the optic nerve head with, sometimes, a slight prevalence at the periphery (Fig. 4). A slight flat excavation of the optic disk was seen only in one of the oldest cases.

The cones of growth often penetrated into the connective tissue septa of the lamina and joined some adjacent axon fascicle (Fig. 5). Many of them were flattened and displayed a fibrillar structure. Some of them contained a denser round or oval core similar to the so-called "cytoid bodies" seen in some pathologic retina. In almost all sections examined we have seen spherical swellings of retinal axons (Vrabec, 1965a) randomly dispersed within the retina or the prelaminar and laminar portion of the optic nerve head. They were not related to the axonal changes described above. Spherical swellings were rather rare and reflected the senile condition of the retina (Fig. 6).

Comment

This finding can be considered a supplementary detail concerning the question of the glaucomatous excavation of the optic disk. It confirms the existence of a spot of minor resistance of the retinal axons at the level of the cribriform lamina. It also shows a fundamental difference in distribution of changes as compared with glaucoma; there, most changes start at the vertical meridian of the papilla and the last dying axons lie at the periphery. In age changes, degeneration is diffuse with some prevalence exactly at the periphery. This is also the answer to a question put forward by Sachsenweger (1971) as to whether there is a definite difference between senile and glaucomatous changes of the optic nerve. It

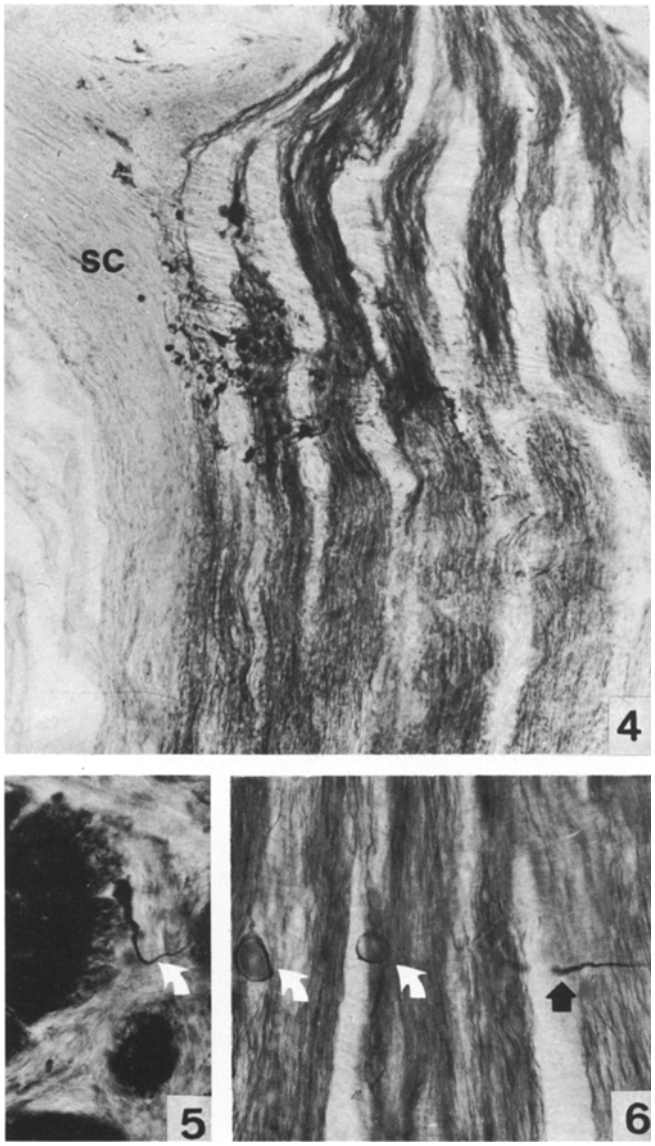

Fig. 4. Sagittal section of the optic nerve head of a person aged 64. Degenerating axons are more pronounced at the periphery. *SC* = sclera. Jabonero method, x 160

Fig. 5. Cross section of the laminar portion of the optic nerve of a person aged 70. An axon, indicated by arrow, penetrates the connective tissue septum and invades the periphery of an adjacent nerve fascicle. Jabonero method, x 270

Fig. 6. Prelaminar portion of the optic nerve head of a person aged 68. Two spherical swellings of otherwise smooth retinal axons are indicated by white arrows. An axon growing across the prelaminar portion is indicated by a black arrow. Jabonero method, x 270

seems likely that in glaucoma cases the axons penetrating into the optic nerve at the vertical meridian are threatened by some cooperating mechanisms, i.e., a diminished resistance of axons at the level of the cribriform lamina and perhaps, their piling up within the paramacular arcuate retinal bundles of axons (Vrabec, 1966). Clinically, age changes of the optic disk appear as some discoloring of the optic nerve head and a flat excavation reaching the periphery. They are reflected in inconspicuous loss of peripheral visual fields (Hollwich, 1963).

Our results are confirmed by many recent experimental reports about a damming of the axonal flow and mitochondria at the above-mentioned level (Minckler et al., 1976a and b; Levy, 1974a and b; and others). This question also revives the problem of the blood supply to the optic nerve head, some new views having appeared recently (Anderson et al., 1976). Also we should like to mention Goder's hypothesis about the influences of anatomical relationships of blood contribution to the papilla (Goder, 1966). On the other hand, our recent work (Vrabec, 1976) showed that degenerative changes in cases of secondary glaucoma in young people with a permanently normal other eye are identical with the changes in bilateral primary glaucoma.

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