Uveal damage in secondary glaucoma
A morphometric study

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Abstract. In a morphometric study, we investigated histopathologic changes in the ciliary body and retinal pigment epithelium in eyes with secondary glaucoma. Eyes with malignant melanoma served as controls. The mean thicknesses of the ciliary muscle and inner connective-tissue layer of the pars plicata were significantly lower (P < 0.001) in glaucomatous than in melanomatous eyes, as was the mean width of the stroma of ciliary processes (P < 0.001). With increasing age, the ciliary muscle in melanomatous eyes became significantly thinner (P < 0.001). The width of the stroma at the base of the ciliary process was significantly correlated with the thickness of the inner connective-tissue layer of the pars plicata in both groups of eyes (P < 0.001). The mean number of ciliary processes was significantly lower in glaucomatous than in melanomatous eyes (P < 0.001), as was the mean height of pigment epithelial cells in the midperipheral retina (P < 0.05). The present study revealed quantitative glaucomatous tissue changes in the ciliary body and retinal pigment epithelium.

Introduction
A large number of studies concerning histopathologic changes in the retinal ganglion cell layer and the nerve fiber layer have been carried out in chronic glaucoma patients; however, little attention has been paid to secondary changes in the ciliary body and outer retinal layer at elevated intraocular pressure. Although all intraocular tissues are obviously affected by ocular hypertension [2, 5], to our knowledge, no systematic histopathologic research has yet been done on secondary changes in the ciliary body and outer retinal layer in chronic glaucoma patients. This study deals with morphometric changes in the ciliary body and retinal pigment epithelium in eyes that were surgically enucleated due to secondary glaucoma.

Materials and methods
In the Ophthalmic Pathological Laboratory of the Department of Ophthalmology, University of Erlangen-Nürnberg, more than 500 eyes enucleated due to secondary glaucoma are on file. From this material, eyes were selected whose ciliary body and retinal pigment epithelium had not been affected by primary diseases causing secondary glaucoma.

A total of 200 eyes enucleated due to malignant melanoma of the uvea (without secondary glaucoma) served as controls. The age distribution of the control group was approximately matched with that of the study group.

Ciliary body
In all, 33 eyes with secondary glaucoma and 39 with malignant melanoma were suitable for morphometric evaluation; eyes that had undergone anterior segment surgery were excluded. The mean age was 72.5 years (range 55–84 years; median, 74 years) and 71.4 years (range 58–84 years; median, 72 years), respectively. The following measurements were done in the meridional section of the prepared specimens using a Morphomat 30 light microscope (Zeiss): (a) the thickness of the ciliary muscle, (b) the thickness of the inner connective-tissue layer of the pars plicata as well as the area between the muscle and the valley between ciliary processes (Fig. 1), and (c) the width of the stroma at the base of the ciliary processes. Three to four independent measurements were averaged. The number of ciliary processes was also microscopically counted.

Retinal pigment epithelium
A total of 52 eyes with secondary glaucoma and 38 with malignant melanoma were considered suitable for morphometric evaluation. The mean age was 69.8 years (range, 46–84 years; median, 72 years) and 66.9 years (range 48–82 years; median, 68 years), respectively. The height of pigment epithelial cells in the midperipheral retina (P < 0.05). The present study revealed quantitative glaucomatous tissue changes in the ciliary body and retinal pigment epithelium.

Fig. 1. Diagram of the ciliary body. I, Iris; S, sclera; CM, ciliary muscle; E, ciliary epithelium; a, thickness of the ciliary muscle; b, thickness of the inner connective layer of the pars plicata; c, width of the stroma of a ciliary process.
ment epithelial cells in the midperipheral retina was measured as described above. The number of nuclei in pigment epithelial cells in the midperipheral retina was microscopically counted using high-power magnification. Three measurements were carried out and averaged. Student's two-sided t-test for paired samples was used to determine statistical significance.

Results

The mean thickness of the ciliary muscle in eyes with secondary glaucoma (0.380±0.069 mm) was significantly lower (P<0.001) than that in eyes with malignant melanoma (0.529±0.078 mm). The mean thickness of the inner connective-tissue layer of the pars plicata was 0.059±0.025 mm in eyes with secondary glaucoma and 0.096±0.028 mm in those with malignant melanoma; the difference between the two groups of eyes was significant (P<0.001). The mean width of the stroma at the base of the ciliary process was significantly narrower in glaucomatous than in melanomatous eyes (0.043±0.009 mm and 0.057±0.012 mm, respectively) (Table 1, Figs. 2 and 3).

The thickness of the ciliary muscle in the control group showed a moderate, inverse correlation (P<0.001) with the age of the subjects; this was not statistically significant for eyes with secondary glaucoma. There was no significant correlation in either group between the thickness of the ciliary muscle and that of the inner connective-tissue layer