The elastic tissue of primate trabecular meshwork
A histologic and electron microscopic study

Tsuyoshi Yamashita and David A. Rosen

Granules of variable diameter considered to be elastic tissue have been found surrounding and within the central collagen core of trabecular beams and in the endothelial meshwork of primate trabecular meshwork with histologic and electron microscopic methods. This material could be distinguished from 1,000 Å "curly" collagen.

Elastic fibers were originally demonstrated in the human trabecular meshwork by Salzmann,1 who used a histologic staining technique. Garron and Feeney2 were unable, in their electron microscopic study, to identify elastic tissue in the trabecular beams. Leeson and Speakman3 and Spelsberg and Chapman4 detected an amorphous material "probably not collagen" within the beams but they were uncertain about its nature. The present investigation is a correlated study of adjacent sections of plastic-embedded tissue examined by light and electron microscopy. In it we were able to demonstrate material which we believe to be elastic tissue in the trabecular meshwork.

Material and methods

Three adult eyes enucleated for choroidal melanoma, one eye from a patient with orbital tumor, two normal adult eyes removed at autopsy, and one eye with glaucoma secondary to hyphema were included in this study. The tissues were fixed in osmic acid immediately after enucleation or after a period of fixation in buffered 2 per cent trioxymethylene solution and were stained with phosphotungstic acid prior to embedding in epoxy resin A (Araldite 6005, Ciba) or epon resin 812, Shell. One micron sections were prepared and stained with Weigert’s elastic tissue stain or toluidine blue. After localization of the portion of the meshwork to be studied, the blocks were further trimmed and sectioned for electron microscopy. The sections were stained with uranyl acetate before microscopy to increase contrast in the photographs.

Toluidine blue has been found to stain elastic tissue in plastic-embedded tissue a dark blue color5 (Figs. 2 and 3). Because of its simplicity, it was used, in part, as a substitute for the Weigert’s stain.

To aid in the identification of elastic tissue in the human meshwork, a parallel study was made of the trabecular meshwork of 4 eyes removed from monkeys varying in age from 1.5 to 4 years and of the choroid of adult human eyes. In addi-
tion to the techniques used on the human eyes, thin sections on grids were placed in Weigert’s iron hematoxylin solution for 2 hours and resorcin fuchs in solution for 4 hours prior to electron microscopic examination.

The electron micrographs were prepared with an R.C.A.-EMU-III microscope and were compared with light microscopic preparations of corresponding areas.

**Results**

Sharply defined granules are noted in the sclerocorneal, uveal, and endothelial

![Image](https://iovs.arvojournals.org/pdfaccess.ashx?url=data/journals/iovs/933629/

Fig. 1. Weigert-positive granules (EI) in the trabecular meshwork of a normal eye obtained from a 51-year-old patient.

Fig. 2. Higher magnification of the sclerocorneal meshwork shown in Fig. 1. Granules of elastic tissue (EI) located surrounding and within the central collagen cores.
Elaborated tissue of primate trabecular meshwork

Meshwork in sections stained with Weigert's technique (Fig. 1). Adjacent sections stained with Weigert's and with toluidine blue demonstrate an identical distribution of granules (Figs. 2 and 3). In the sclerocorneal and uveal meshwork, they are present in greatest abundance around the central collagen core of the trabecular beams but granules are noted within the core as well (Fig. 4). Low-power electron micrographs made of adjacent sections demonstrate an amorphous substance in the zone surrounding the collagen core (Fig. 5). This, in higher magnification, appears to be composed of electron-transparent, sharply outlined granules of varying diameter which are in places aggregated into clumps of varying density (Figs. 6 and 7). A similar material is noted in the endothelial meshwork between endothelial cells (Figs. 8 and 9).

The trabecular beams of monkey eyes contain numerous Weigert-positive granules which also appear pale in the electron micrographs. These beams have a more scanty collagen content than those of the adult human eyes, and there are gaps in the endothelial covering (Figs. 10 and 11).

When stained with phosphotungstic acid, the elastic lamella of Bruch's membrane contains granules which are electron transparent and appear similar to those found in the human trabecular meshwork (Fig. 12). When Weigert's technique is applied to the sections before electron microscopy, these granules have a dark appearance (Fig. 13). The granules in the monkey meshwork also turned dark when this stain was used (Fig. 14). It seems likely that the electron-transparent granules noted in the human trabecular meshwork are similar in nature to those in Bruch's membrane and that they represent elastic fibers.

In the light microscopic study of the meshwork, we noted, in addition to the granules which stain darkly with Weigert's, some in the clear zone which stain faintly. In electron micrographs of adjacent sections these were found to correspond to collagen of 1,000 Å periodicity, the so-called "curly collagen" (Figs. 15, 16). Granules of elastic tissue in the meshwork could be clearly distinguished from this collagen (Fig. 17).

Fig. 3. Section adjacent to that in Fig. 2 stained with toluidine blue demonstrating identical distribution of granules (El).
Fig. 4. Zone of granules of elastic tissue (El) surrounding the central collagen core (CCC) in the eye of a 69-year-old patient.

Fig. 5. Low-power electron micrograph of the same trabecular beam shown in Fig. 4. El, elastic tissue; CCC, central collagen core; CZ, clear zone; End, endothelium.
Fig. 6. Higher magnification of the same beam demonstrating zone of granules of elastic tissue and the central collagen fibers.

Fig. 7. Elastic tissue granules (El) and their aggregates (El) in high-power electron micrograph.
Fig. 8. Weigert-positive granules of elastic tissue (El) in the endothelial meshwork of a 51-year-old patient.

Fig. 9. Electron micrograph of the same meshwork shown in Fig. 8. Clumps of electron transparent granules (El) are present between endothelial cells.
Fig. 10. Clumps of granular material (El) in the sclerocorneal meshwork of monkey eye.

Fig. 11. Higher magnification of Fig. 10. Aggregates of granules of elastic tissue adjacent to collagen fibers (CF).
Fig. 12. Pale granules in the elastic lamella of Bruch's membrane (El). PE, pigment epithelium; BM, basement membrane; Ch, choroid.

Fig. 13. Adjacent section to Fig. 12 treated with Weigert's. Granules of elastic tissue stain darkly (El).
Fig. 14. Granules of elastic tissue of the monkey trabecular meshwork appearing dark with Weigert's (El).

Fig. 15. Faintly stained granules (CC) in the clear zone and dark granules (El) surrounding the collagen core. Trabecular meshwork of an eye with secondary open-angle glaucoma from a 55-year-old patient.
Fig. 16. Electron micrograph of a section adjacent to that shown in Fig. 15. The 1,000 Å collagen fibers (CC) and elastic tissue (EI) correspond, respectively, to granules which stain faintly and darkly in Fig. 15.

Fig. 17. The 1,000 Å collagen fibers (CC) in the clear zone (CZ) of trabecular meshwork of monkey.
Discussion

We have attempted in this study to bridge the gap between histologic and electron microscopic observations of an elastic fiber component in the primate trabecular meshwork. Elastic tissue in some structures is known to appear as electron-transparent granules in electron micrographs when treated with phosphotungstic acid. We can conclude from our studies that granules which stain with Weigert’s and toluidine blue in histologic preparations are identical to pale granules found in the electron micrographs and that they are composed of elastic tissue. The results of application of Weigert’s stain to the elastic lamella of human Bruch’s membrane and to monkey trabecular meshworks support this conclusion. Furthermore, the material which we believe to be elastic tissue differs from 1,000 Å collagen in both histologic sections and in the electron micrographs.

The application of Weigert’s stain to specimens studied by electron microscopy may be useful for the demonstration of elastic tissue.

REFERENCES