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Circular Polarizers Enhance Visibility of Endothelium in Specular Reflection Biomicroscopy

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• **A simple and inexpensive technique for enhancing the visibility of corneal endothelial cells in specular reflection biomicroscopy involves the insertion of a circular polarizer in front of the patient's eye, intersecting both the incident and reflected light beams. This filter significantly reduces the glare from the epithelium and enables more comfortable and clearer viewing of the endothelial cells.**

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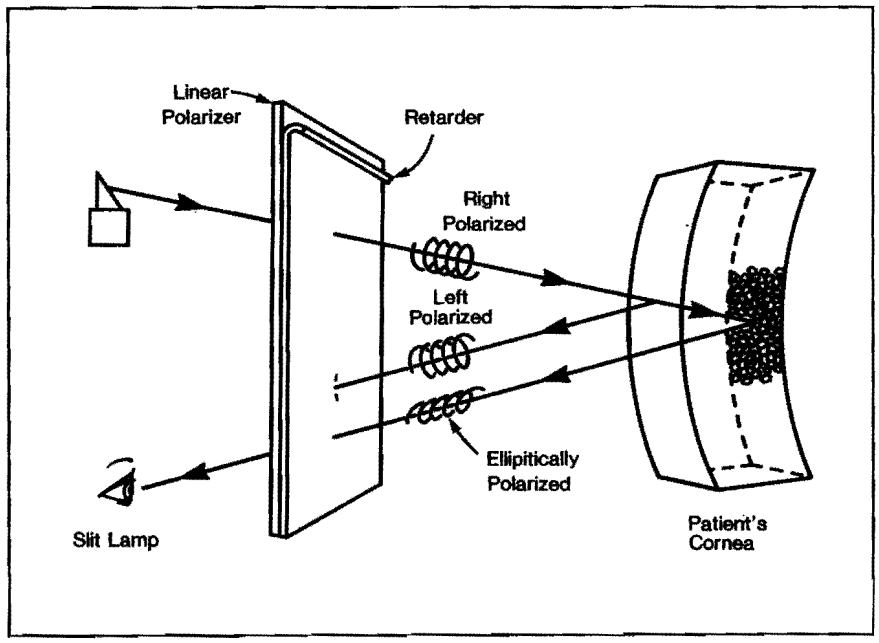
The importance of corneal endothelium in maintaining corneal clarity is well established.[1] The growing need to evaluate endothelial cells suggests future widespread use of specular microscopy. Specular microscopes, however, are quite expensive. Holladay et al[2] recently described a less expensive, semiquantitative technique for endothelial biomicroscopy. Their technique combines the use of a slit lamp and specular reflection and is based on counting endothelial cells along the horizontal diameter of a 0.2-mm circle projected by the spot beam from the slit lamp in the usual specular reflection illumination. This technique allows estimation of cell density with the slit lamp with a mean error of 7%, as compared with specular microscopy. Unfortunately, the dazzle effect of the bright epithelium reflex significantly impairs the observer's ability to study the endothelial cells with specular reflection biomicroscopy. A simple method to reduce this glare source significantly, thereby facilitating observation and evaluation of the endothelium, is described herein. The technique is based on the ability of circular polarizers to trap specularly reflected light, and on the birefringent properties of the cornea.

A circular polarizer commonly consists of two layers: a linear polarizer and a retarder. A retarder is an optical element that, without altering the intensity and polarization of a polarized beam, resolves the beam into two orthogonal components, retards the phase of one relative to the other, and reunites the two components. If the retarder's axis is at 45° to the axis of the linearly polarized light, the two components will be equal in magnitude. If, in addition, the retardance (ie, the relative phase difference between the two components) is 90°, or quarter wavelength, the resulting beam is said to be circularly polar-

Fig 1.—Schematic presentation of specular reflection biomicroscopy of corneal endothelium, using circular polarizer to eliminate glare from epithelium.



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ized.[1] Circularly polarized light can be likened to light that will emerge from a linear polarizer rotating at a very high rate in an incident beam of unpolarized light. The circularly polarized light can be right-handed or left-handed polarized, depending on the angle that the axis of the retarder makes with the axis of the linear polarizer. A light that emerges from a right circular polarizer is blocked by a left circular polarizer. If right circularly polarized light is perpendicularly incident on a smooth surface, the reflected beam is left circularly polarized because the direction of propagation has been reversed. Therefore, the polarizer that produces the right circularly polarized light, when inserted in an unpolarized incident beam, blocks the reflected light in that beam.

If the reflecting surface is a transparent plate, reflections from both the front and the back surfaces will be equally suppressed. When the transparent plate is made of birefringent material (ie, polarizing material), however, the polarization of the light that enters the plate and is reflected from the back surface is altered, and this light can pass through the polarizer and is less suppressed than is the reflection from the front surface. This is the principle applied here to enhance the view of the endothelial

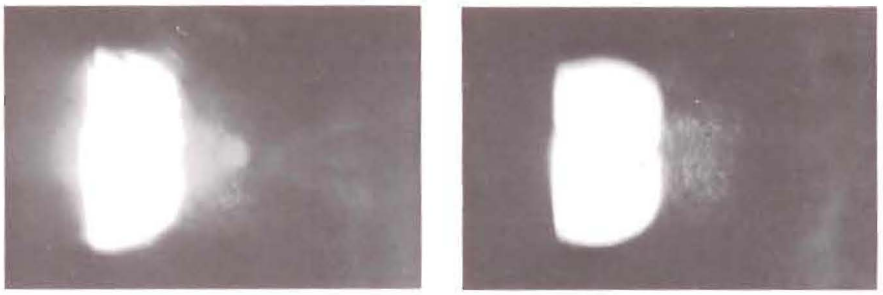
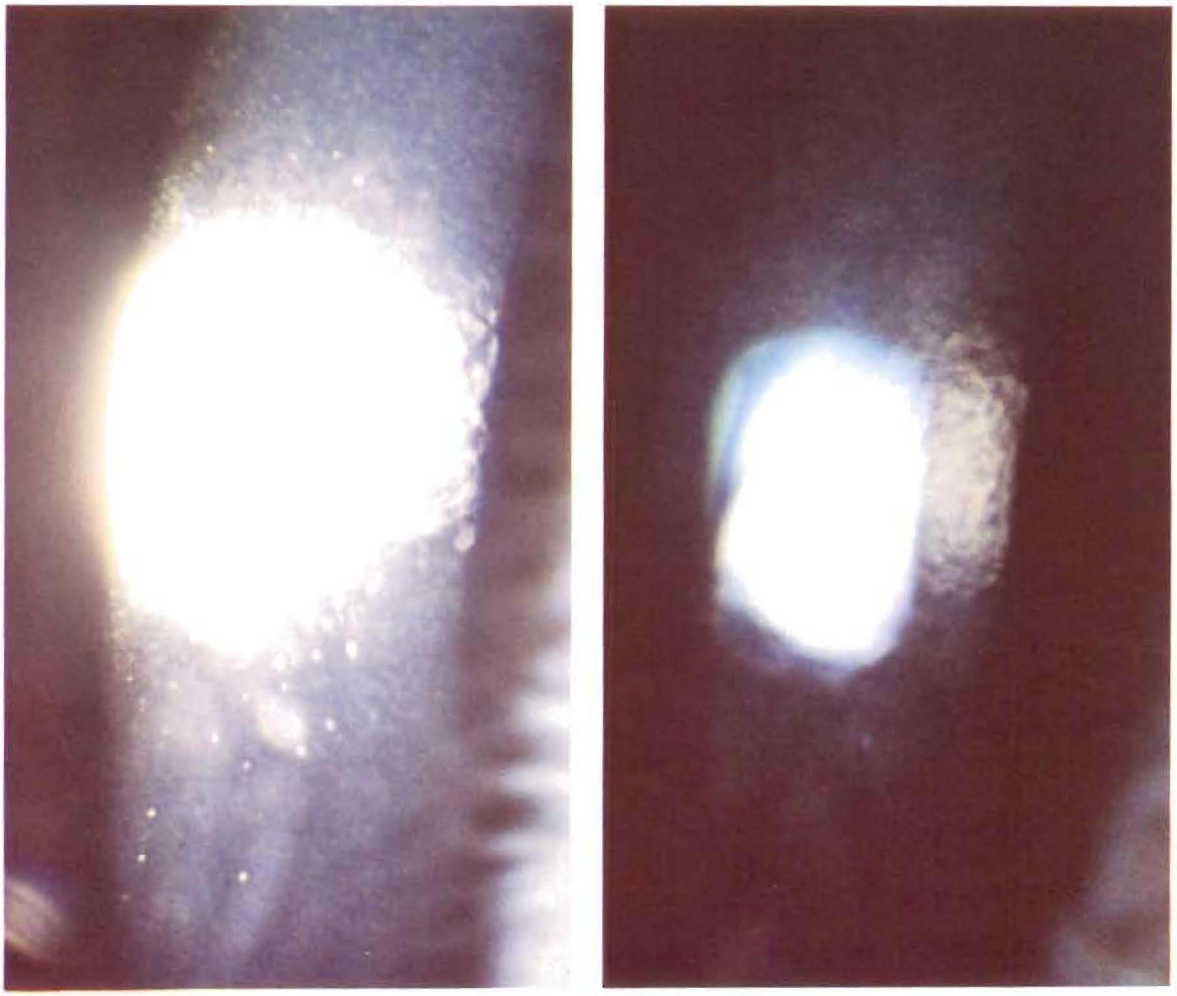


Fig 2.—Specular reflection photography of normal endothelium with regular slit lamp. Left, Specular reflection without filter. Although cells can be seen, glare from epithelial reflex clearly reduces visibility. Right, Specular reflection of same cornea with circular polarizer shows reduced glare, improved visibility of endothelium, and elimination of artifacts resulting from reflections of lashes, as seen in Fig 2, left.

Fig 3.—Specular reflection microscopy of normal endothelium. Left, Without filter. Right, With filter. Note difference in color between endothelial and epithelial reflections with filter.



cells by suppression of the disabling glare from the corneal epithelium.

TECHNIQUE AND RESULTS

The slit lamp is positioned for specular reflection biomicroscopy with the angle between the beam and the oculars between 60° and 80°. Three images are seen on the cornea; two are reflections of the slit beam at its intersection with the anterior and the posterior corneal surfaces, which represent the epithelium and endothelium, respectively. The third image, which is the brightest, is the mirror image of the lamp filament. For observation of the endothelial cells, the bright reflex of the filament is superimposed on the endothelial beam reflex. When proper alignment occurs, a brilliant light is projected into the clinician's eye from the epithelial layer. The endothelial cells are viewed contiguously to this bright reflex.

The circular polarizer, with the retarder layer toward the patient, is then inserted into both the incident and reflected light beams (Fig 1). If the retarder side is directed toward the clinician, the reflections from both corneal surfaces will be affected equally, resulting in an overall reduction of light but no improvement in visibility. The light should pass through the filter twice, which can be easily achieved by placing the filter close to the patient's eye.

With the circular polarizer properly inserted, the reflection from the epithelium is suppressed significantly (Fig 2) and appears deep blue, purplish (Fig 3) because of the spectral characteristics of the Polaroid type H polarizers.[4] Because of the birefringent property of the cornea,[5] the light that passes through the cornea and is specularly reflected from the endothelium changes its polarization character (from circularly to elliptically polarized), and thus is less affected by the polarizers. This endothelial reflection appears greenish orange (Fig 3), and its brightness is reduced less than that of the epithelial reflection, permitting a clear view of the endothelium without the disabling glare. The color difference is helpful in locating the endothelial reflection and focusing the slit lamp on it.

Abnormalities of Descemet's membrane or the endothelium will induce diffused rather than specular reflection. The diffusely reflected light is unpolarized and less suppressed by the circular polarizer, rendering it even more visible. Because the glare from the epithelium is reduced, the clinician can widen the beam and view a larger area of the cornea than is possible without the filter (Fig 2).

In moving toward the center of the cornea in specular biomicroscopy, the distance between the viewed endothelial cells and the epithelial glare becomes smaller because of the change in incident angle and the decreased corneal thickness. Thus, observation of the endothelial cells near the center of the cornea becomes even more difficult. On the other hand, when circular polarizers are used, glare suppression becomes more significant as one approaches perpendicular reflection. Thus, the filter becomes more effective as one approaches the center of the cornea.

COMMENT

The method described herein is inexpensive and is effective in improving the visibility of corneal endothelial cells, on specular reflection biomicroscopy, by differentially suppressing the reflected glare from the epithelium. The technique is simple, and the only modification of the standard slit-lamp technique is the insertion of the circular polarizer. It can improve the clinician's ability to monitor endothelial cell density quantitatively, using the method devised by Holladay et al.[2] The technique enables evaluation of endothelial cells near the center of the cornea. Because the filter differentially enhances the visibility of any lesions or changes in endothelium and Descemet's membrane, it improves the possibility of detecting such changes.

Since the amount of light reflected from the endothelium depends on changes in polarization of the light as it passes through the cornea, this technique might be useful in evaluating changes in properties of the cornea under various conditions, such as contact lens wear and dry eye, and in mechanical stress, such as occurs after radial keratotomy.

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