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Physical Properties of Hydrophilic Gel Contact Lenses

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Recent development of hydrophilic synthetic polymers to compete with conventional methyl methacrylate (Perspex, Lucite, Plexiglas) in the manufacture of contact lenses has created the need to evaluate the physiologically important properties of these two materials. Some unpublished (or published only in the public press) clinical investigations in Czechoslovakia, where the hydrophilic lens originated, claim that contact lenses made of this material may be tolerated on the eye longer than the conventional methyl methacrylate lens. High oxygen transmissibility and high water permeability are the physical properties which would lead to this important advantage of the hydrophilic polymer over the conventional polymer. We have measured these properties of hydrophilic and conventional methyl methacrylate lenses and report them here.

It is generally recognized that the oxygen necessary to maintain the metabolism of the cornea is brought to the epithelial surface under a corneal contact lens by air-saturated tear fluid flowing under the lens. Each blink rocks the lens slightly and thereby pumps fresh tear fluid to the corneal surface. The hydrophilic lens is much softer and more pliable than conventional methyl methacrylate and is observed clinically to mould itself to the cornea. For the hydrophilic lens, therefore, high oxygen transmissibility or high water permeability is essential if the hydrophilic lens is to allow passage of oxygen from the air to the cornea. Our measurements, described below, indicate that oxygen transmissibility and water permeability of the hydrophilic material are not appreciably greater than those of conventional methyl methacrylate.

Methods

Oxygen transmissibility was measured by passing nitrogen gas over a lens, sealed by heavy grease to a small air-filled chamber, about 3.7 c.mm., which was in turn sealed to the surface of a Clark-type membrane-covered oxygen electrode. The rate of decrease of oxygen tension in the chamber, together with the dimensions of the chamber and lens, was used to calculate transmissibility. No attempt was made to obtain

precise data; instead, emphasis was put on the comparison of hydrophilic and conventional methyl methacrylate lenses.

Water permeability was measured by noting the rate at which water flowed through a water-submerged lens when it was held by vacuum against the end of a clear plastic rod with an axial hole 1 mm. in diameter. The end of the rod had a curved surface of 5 mm. radius so that the lens would hold against the surface and allow no water-passage except through the lens material itself.

Results

The oxygen transmissibility of both hydrophilic and conventional methyl methacrylate is no higher than 4×10^{-12} sq. cm. O₂ (S.T.P.)/sec./mm. Hg. The water permeability of both materials is no higher than 1.4×10^{-14} cm.⁴ sec./dyne.

Discussion

The corneal epithelium requires about 6 μ l. of oxygen per hour per square centimetre of surface. This oxygen must be provided by the air, through the tear layer. Oxygen in the aqueous humour cannot supply the epithelium because of the resistance to oxygen transport offered by the stroma. If it is assumed that the epithelium can create the maximum oxygen tension gradient across the contact lens, 155 mm. Hg, then only about 0.05 μ l. of oxygen per sq. cm. per hour will be obtained. This is about 1/100 of the necessary oxygen. It is apparent, then, that neither the hydrophilic nor the conventional methyl methacrylate lens can supply oxygen to the cornea by oxygen passage through the lens material.

The water permeability of both lens materials is no greater than that of the epithelium. But, since a lens is usually ten times thicker than the epithelium, resistance to water-flow across the lens will be ten times that across the epithelium. No process can be visualized that would deliver a useful amount of tear fluid through either the hydrophilic or the conventional lens material.

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