DEVELOPING THE OPTIMAL ARTIFICIAL TEAR

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ABSTRACT

Development of what has been called "the optimal artificial tear solution" was based on a two-pronged strategy. This strategy was first, to develop a profound understanding of the pathogenesis of dry-eye disease, and second, to develop a comprehensive understanding of why the eye needs a tear film. As an eye becomes dry, through either decreased tear production or increased evaporation, the tear film loses water and tear film osmolarity increases. The increase in osmolarity dehydrates the ocular surface and drives the disease process. TheraTears™, based on clinical studies, has the hypotonicity necessary to rehydrate the tear film, thwarting the disease process and permitting rehydration of the ocular surface.

As a result of a blood-tear barrier, the living cells on the surface of the eye depend upon the tear film for two life-sustaining requirements: oxygen and electrolytes. TheraTears™, based on clinical studies, has an electrolyte balance matching that seen in the normal human tear film; this electrolyte balance has been shown in pre-clinical studies to be crucial for the maintenance of normal goblet-cell density. By providing this electrolyte balance, and lowering elevated tear film osmolarity, TheraTears™, in pre-clinical studies, permits healing to proceed. TheraTears™ has specifically been shown in pre-clinical studies to restore both conjunctival goblet-cell density and corneal glycogen levels in dry-eye disease.

INTRODUCTION

In 1976 I began a research program designed to develop the first therapeutic tear solution. Our research team had a two-pronged strategy: (1) To develop a profound understanding of the pathogenesis of dry-eye disease, and (2) to develop a comprehensive understanding of why the eye needs a tear film.
There are many papers in the literature that carefully describe changes observed in the tear film and ocular surface in dry-eye disease. The limitation of these studies is that they were unable to place these observations in chronological sequence and they were unable to describe the natural history of dry-eye disease. For this reason, in 1986 we began to study rabbit models of dry-eye disease. With these studies, performed over a four-year period, it was demonstrated that elevated tear film osmolarity was the first change measurable in a spectrum of dry-eye diseases. It was found that tear film osmolarity may increase through one of two general mechanisms: decreased tear secretion or increased tear film evaporation. Secretion may decrease through any mechanism that damages lacrimal gland tissue or any mechanism that decreases corneal sensation. Evaporation may increase through either large palpebral fissure width, occurring normally or in the context of thyroid eye disease, or through meibomian gland dysfunction, commonly resulting from chronic posterior blepharitis.

Whether osmolarity increases through decreased tear production or increased tear film evaporation, the surface diseases that unfold share common features. First, increased water transport occurs across the conjunctival epithelium, resulting from the increased osmotic gradient across the conjunctiva; this increase in water transport between conjunctival cells causes increased conjunctival cell desquamation. Occurring simultaneously with these changes is a decrease in conjunctival goblet-cell density and corneal glycogen levels. Since the attachments between corneal cells are stronger than those between conjunctival cells, the cornea is more resistant to the increase in tear film osmolarity. As a re-

![Figure 1. The effect of various hypotonic solutions and an isotonic solution on tear film osmolarity in keratoconjunctivitis sicca patients. Published courtesy of Ophthalmology (1885; 92: 646-650).](image-url)