



# Tears

## An overview and step-by-step guide to their clinical evaluation

By Professors Nizar Hirji and Sudi Patel

**T**his is a handy overview of our current understanding of the tear fluid and its properties. It also provides an in-practice investigative routine that will help primary care practitioners come to terms with describing and quantifying tears with conventional consulting room equipment and materials.

### Anatomy

Tears cannot be considered separately from the lacrimal apparatus which consists of secretory, distribution, and excretory portions. The secretory portion includes all glands, individual cells (conjunctival goblet cells and epithelial cells – mucin secretors), small invaginations (glands of Krause in the fornices, and glands of Wolfring found in and around the upper tarsal border and, to a lesser extent, in the lower tarsal border – aqueous secretors) other glands of the lids (meibomian glands and glands of Zeis – lipid secretors) and the large primary lacrimal gland, located in the fossa for the lacrimal gland, in the frontal bone with ducts that open directly into the upper fornix providing the bulk of the aqueous secretion. Though innervated by both sympathetic and parasympathetic nerves, it's the parasympathetic fibres of the facial nerve (VII) that primarily affect the secretory activity of the lacrimal gland. However, regulation of tear secretions is a very complex process and involves both neuronal and hormonal factors.<sup>1</sup> The distribution portion consists of the lids that mix the secretions (tear components) to form an optically smooth complex film over the cornea which re-forms after every blink. There are slight accumulations of tears at the lid margins – at the apposition of the palpebral and orbital conjunctiva, resulting in a tears strip or meniscus which unites (from the upper and lower lid margins) at the lateral and medial canthi – where there is an accumulation of tears (lake). The excretory portion consists of the superior and inferior lacrimal canaliculi, their puncta, the lacrimal sac and the naso-lacrimal duct. The lacrimal canaliculi are L-shaped

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canals from the puncta to the lacrimal sac. The puncta are small apertures (about 0.1mm in diameter) that dip into the medial tears lake about 5mm lateral to the medial canthus, and can normally only be seen with the lid pulled away from its normal position. The puncta are round in about 60 per cent of eyes and gradually become more oval and slit-like in older patients.<sup>2</sup>

The lacrimal sac is a bag about 12mm in height and 4-8mm wide lying in the lacrimal fossa of the medial orbital wall. It consists of a thin mucous membrane surrounded by fibrous tissue continuous with the medial palpebral ligament and Horner's muscle. The naso-lacrimal duct is about 15mm long from the lacrimal sac to the inferior meatus of the nose and at that juncture there is a fold of the mucous membrane – the valve of Hasner. Tears ultimately drain into the nose via the valve of Hasner. Blinking not only distributes the tears over the cornea but it also has an important role in their drainage. Tears may enter the canaliculi by gravity (lower puncta) and capillary action from the tears lake, but it is the blinking action that results in a contraction of Horner's muscle which pulls the anterior wall of the lacrimal sac, thus dilating it, and pulling the tear fluid along the canaliculi into the sac and on relaxation of the muscle the sac recoils and the fluid is passed down the naso-lacrimal duct to the nose. The vast majority of tears drain into the nose in this way, the remainder tend to evaporate.<sup>3</sup>

### Tear structure

A classic view of the structure of tears is of a trilaminar thin film with an innermost mucin layer in contact with microvilli of the corneal epithelium (to wet the epithelium and aid the spreading of the tears over the otherwise hydrophobic corneal surface), a middle aqueous layer and a surface layer of lipids (sebum consisting

of polar lipids spread over the aqueous surface and apolar lipids spread over the polar lipids).<sup>4</sup> A revised contemporary view (Figure 1, see over) is that it is an aqueous-mucin gel with glycoalyx (sulphated glycoaminoglycans) on the microvilli of the corneal epithelium, while gel-forming mucins and soluble mucins are distributed in a concentration gradient that decreases towards the surface lipid layer.<sup>5</sup>

Physical characteristics of the tear fluid are that it is 7-10µm thick (most widely quoted from older studies), secreted unstimulated at the rate of about 1-2µl/min,<sup>6</sup> has a pH of about 7.5+/-0.1,<sup>7</sup> an osmolarity of 310-334 mOsm/kg,<sup>8</sup> an undisturbed resident volume of about 6-8µl<sup>9</sup> and a surface tension of 42-46dyn/cm.<sup>10</sup> Tears behave like non-Newtonian fluids in that their viscosity changes (it reduces) as a sheer force is applied.

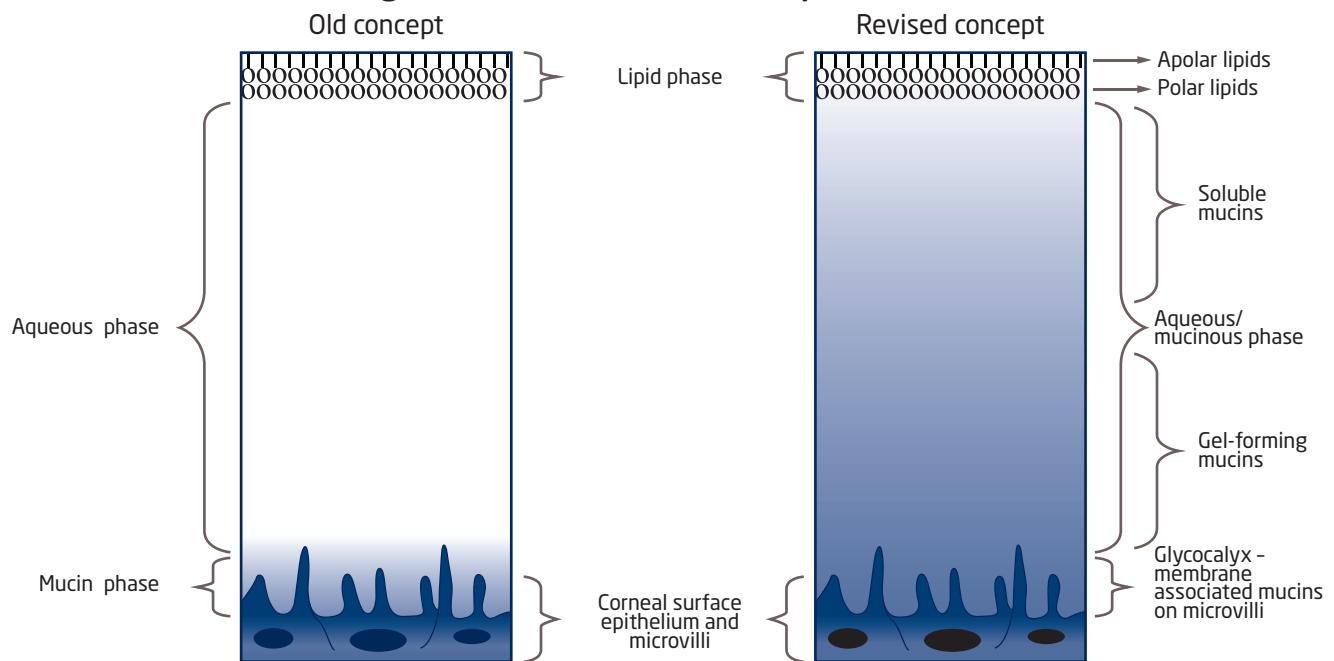
Tears provide both nourishment and protection for the cornea and conjunctiva. They do this by protecting against desiccation, microbial infection, and damage from external particulate matter. Tears facilitate the transport of atmospheric oxygen into the avascular cornea, supply it with essential ions and remove metabolic waste and cellular debris while maintaining a fairly constant pH and an optically smooth and transparent surface for optimum refraction through the cornea.

About 2 per cent of tear fluid is a complex cocktail of material other than water. This includes electrolytes (Na<sup>+</sup>, Cl<sup>-</sup>, HCO<sub>3</sub><sup>-</sup>, Mg<sup>++</sup>, K<sup>+</sup>, Ca<sup>++</sup>), organic solutes (glucose, urea, lactate, pyruvate, ascorbate, all-trans-retinol), major tear proteins (lysozyme, lactoferrin, lipocalin, tear-specific albumin), other proteins (albumin, enzymes, glycoproteins, immunoglobulins) and lipids (wax esters, sterol esters, polar lipids, hydrocarbons, diesters, triglycerides, free sterols, free fatty acids).<sup>11</sup>

In evaluating the tears, clinicians should bear in mind that anything that affects or alters the secretory, distribution or the excretion of the lacrimal fluid will have an impact on the quality and quantity of tears and their effectiveness on the eye.



**Figure 1 Tears - a schematic representation**



**A STEP-BY-STEP EVALUATION PROCEDURE FOR PRIMARY CARE PRACTITIONERS**

- Evaluate subjective symptoms: Are symptoms persistent or occurring in certain environments or times of day? Use a standardised questionnaire or analogue scale to score severity of symptoms
- Observe nature of blinking: Note, is the blink complete, harsh, frequent?
- Slit-lamp examination
  - a) Magnification X10 or less. General view
    - Tear film: Check for debris? Is it oily?
    - Tear meniscus: Is it regular without breaks along its length?
    - Conjunctiva (bulbar): Any redness, inflammation, folds?
    - Lid margins: Are margins smooth? Meibomian gland openings blocked? Are lashes pointing away from ocular surface? Are they very oily?
  - b) Magnification X30 or above. Specific view
    - Measure tear meniscus height\*
    - Check lipid layer with TearScope\*
  - c) Conjunctiva (palpebral)
    - Depress lower lid:
      - Is the punctum open?

- Conjunctiva: Look for any folds, signs of oedema, papillae, follicles. Grade positive findings using standardised scale\*  
Evert upper lid, repeat.

**WAIT A FEW MOMENTS**

- Tear stability: Note the time taken for first Purkinje image to destabilise after a blink.\* Use keratoscope, videokeratoscope or TearScope with appropriate grid
- Tear volume: Phenol red thread or Schirmer strip (optional invasive tests)
- Ocular surface staining: Lissamine green, rose bengal or fluorescein. Note location and severity of any staining. If preferred, measure tear break-up time with fluorescein
- Examine the conjunctiva for presence of lid parallel conjunctival folds (LIPCOP) and grade as appropriate.\*

\*Recommended tests for numerical evaluation of tear properties/ocular surface

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