Contact Lens Update
CLINICAL INSIGHTS BASED IN CURRENT RESEARCH

A review of contact angle techniques

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Wettability refers to how easily a liquid spreads over the surface of a contact lens. Clinically, this can be observed by viewing the interaction between the tears and the lens surface. In a laboratory setting, in vitro wettability can be quantified by measuring the "contact angle."

The contact angle is the angle formed between a drop of liquid and the surface of the lens. Small contact angles are associated with an increased ability of the tears to spread out over the surface of a contact lens and lead to a more stable tear film.[1-3] A completely wettable surface has a contact angle of 0˚,4, 5 greater than 0˚ to 90˚ is considered partially wettable, between 90˚ to 180˚ is partially nonwetting and greater than 180˚ is completely nonwetting.[4]

Campbell D, Carnell SM, Eden RJ. Applicability of contact Angle techniques used in the analysis of contact lenses, Part I: Comparative methodologies. Eye & Cont Lens 2013;39(3):254-262.

The sessile drop technique

The sessile drop technique involves using a syringe to put a drop of liquid on the surface of a contact lens.[4, 5] The contact angle is the angle created between the surface of the contact lens and the droplet (Figure 1). Images or videos of the experiment are recorded and analysed with the instrument's computer software to determine the contact angle.[5]

The sessile drop technique is fast and easy to perform. The sessile drop technique can also measure static and dynamic contact angles, which can help differentiate between various contact lens materials.

The sessile drop technique requires the lens surface to be blotted.[4, 5] Data analysis can be subjective depending on the software analysis model that the instrument uses and some models require the user to estimate the angle, which can be difficult when small angles are analysed. The contact lens and probe liquid are also susceptible to dehydration during the measurement because the lens is exposed to air.[5, 6]

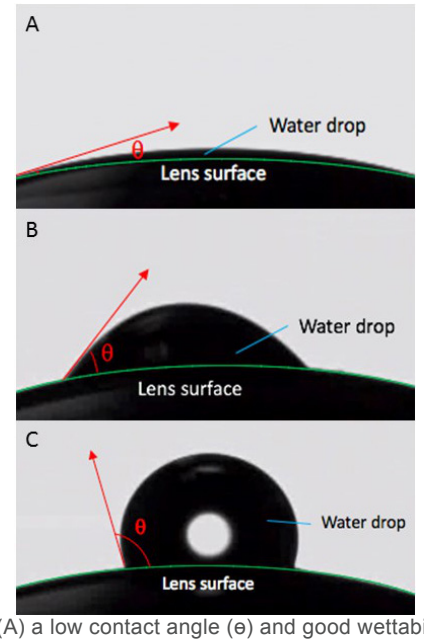

Figure 1. Examples of a contact lens with (A) a low contact angle (ɵ) and good wettability, (B) a higher contact angle and (C) a high contact angle with poor wettability obtained with the sessile drop technique.

The captive bubble technique

In the captive bubble technique, a contact lens is submerged in liquid (usually water). A syringe is used to place either a small air bubble or another liquid with a lower density on the surface of the lens.[4, 5] The contact angle is the angle formed between the surface of the contact lens and the air bubble (Figure 2).

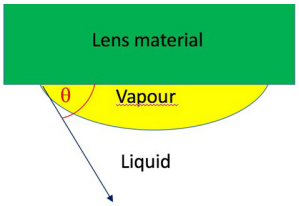

Figure 2. Diagrammatic representation of the captive bubble technique. ɵ is the contact

As with the sessile drop method, the captive bubble technique only requires a small amount of the probe liquid, minimal sample preparation and the data is collected by the instrument's computer software. However, the sample is not prone to dehydration because it is suspended in liquid.6 Performing the captive bubble technique takes longer than the sessile drop technique because aligning the bubble with the lens surface is time consuming.[5] Determining the contact angle is also dependent on the analytical model that the computer software was designed to use.

Wilhelmy Plate

The Wilhelmy plate technique involves inserting and removing a contact lens from a liquid. A rectangular sample of a contact lens is attached to a balance positioned above the liquid.[3] The force of the sample is set to zero at the beginning of the experiment when the lens is almost in contact with the solution. The sample is then immersed into the solution, then withdrawn back to the initial position. This cycle is repeated a few times. The force that the sample undergoes when it is lowered and removed from the liquid is recorded and used to calculate the contact angle.[4, 5]

The advancing contact angle is calculated as the sample is inserted in the solution and the receding contact angle is calculated when the lens is removed from the liquid.[4, 5] The difference between the advancing and receding

contact angle is known as the contact angle hysteresis.[4, 5]

There are two main types of contact angle hysteresis: kinetic and thermodynamic. Kinetic hysteresis is observed with the Wilhelmy plate when the cyclic immersion and emersion curves change with time or frequency. Various reasons are believed to cause this, including sample swelling, deformation of the surface, the probe liquid penetrating the surface of the sample and reorientation of polymer chains at the surface of the lens.[4, 5] Thermodynamic hysteresis is observed when the immersion and emersion curves can be replicated over multiple tests. This is thought to be due to lens surface roughness and heterogeneity.[5]

The Wilhelmy plate technique provides more data about the lens than the sessile drop or captive bubble methods. However, it requires a large volume of the probe liquid and obtaining a sample is difficult as it is easy to contaminate or tear the sample. Acquiring and analysing the data is also time consuming,[5, 7] but the results obtained from this method are accurate and reproducible.[7]

Conclusion

As this review outlines, each technique for measuring contact angle has its own advantages and disadvantages (see Table 1).

Table 1: Summary of contact angle measurement techniques

Technique	Sessile drop	Captive bubble	Wilhelmy plate
Description	A syringe is used to place a drop of liquid on the surface of a contact lens	Contact lens is submerged in liquid; a syringe is used to place small air bubble (or another liquid with a lower density) on the lens surface	A rectangular contact lens sample is Inserted and removed from liquid
Time/ease	Fast, easy to perform	Takes longer	Time-consuming
Advantages	Can measure static and dynamic contact angles, which can help differentiate between lens materials	Not prone to dehydration because suspended in liquid	Provides more data about the lens Larger area is analysed
Disadvantages	(1) Requires blotting of lens surface; (2) lens and probe liquid can dehydrate	Difficult to align the bubble with the lens surface	(1) Easy to contaminate or tear lens sample (2) Sample preparation is complex

This review highlights the difficulty of not having an ISO standard to measure the contact angle of soft contact lenses. The authors suggest that having a standardized method for each technique would be helpful to eliminate inter-laboratory variation, as would the addition of using more than one method to investigate each contact lens material.

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