Clues to the manners…

…of soft contact lenses during measurements

Recent developments in material and production technology have led to higher and higher comfort for the soft contact lens wearer. Many products do not only model and improve the optical properties of the cornea but also the biological properties. So the soft contact lens wearer barely feels any difference between the situation with and without lens in the eye – except for much better vision. Key properties that have been improved over the years are higher water content, smoother contour, thinner center thickness, higher gas permeability, and so on.

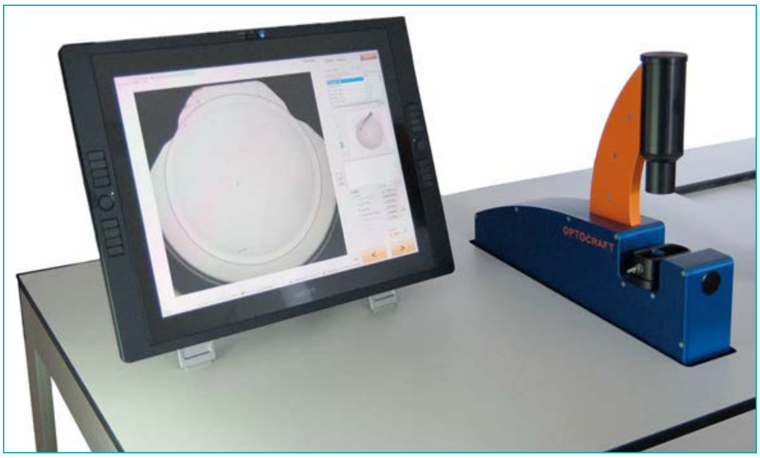
By Jürgen Lamprecht and Johannes Pfund

However, the same properties lead to challenges in the daily quality control process. The price of better wearing comfort is a higher sensitivity to ambient conditions. Temperature, chemical content of the surrounding liquids, mechanical handling etc. have all to be controlled within extremely small tolerances in order to achieve stable and reproducible lens properties.

Lens qualification according to ISO 18369 already sets various demands on the preparation of the measurement process. For individual soft lens designs it should be considered whether the stated preparation parameters are sufficient, or should be enlarged, or even whether they could be optimized. Understanding how and in particular how much external or internal properties affect the measurement of soft lens parameters is fundamental for QC, R&D, validation of new measurement equipment and comparison of different measurement procedures.

A CLOSE EYE ON LENS STABILITY

Here, we focus more on intrinsic stability issues rather than direct external mechanical effects caused by tweezers, tissues and so on. However, this brings up a very important problem: how can we measure the lenses with a minimum of mechanical interaction? In current measurement processes nearly each parameter is measured on a different instrument and thus, the lens has to be moved from one instrument to another and is handled within different procedures.



Here, we use our new metrology tool SHSOphthalmic omniSpect SCL which has already been introduced in GlobalCONTACT 3-12. This multifunctional measurement system has been designed to improve both the measurement process and the over-all performance in daily work of contact lens industry. It measures the refractive data and the geometric properties in an integrated measurement process and overcomes the shortcomings of the traditional manual, time-consuming multi-stepped measurement sequence. Besides measurement speed and ease of use, the system provides the capability to collect data continuously and simultaneously. So, physical effects of the lenses can be quantified and visualized in a way it has not been possible before.

In this article we present some results that have been collected recently. Here, we concentrate on the major parameters like lens back vertex power (BVP), diameter and sag of the lens. Other refractive parameters like cylinder and prism, and also BC are affected in a similar manner. All of them are measured simultaneously in the SHSOphthalmic omniSpect SCL.

SYSTEM RESOLUTION

In a first step the intrinsic stability of the measurement instrument was investigated. In other words: what resolution of the measured parameters can be expected under ideal conditions. Initially, this is done with well-known and stable glass lenses that help to separate between intrinsic effects of the measurement system and lens related behaviour.

The optical and geometrical parameters of these lenses are not subject to substantial changes due to temperature or whatsoever effects. In the current study glass meniscus lenses with stable refractive data and geometric dimensions have been used. The lenses were measured 50 times in the same process as soft lenses in a temperature stabilized saline solution, but have not been manipulated between the measurements. Thus, the data shows the repeatability of the system without lens movement. The plots in figure 1 exemplarily show a test run of a glass lens with a nominal diameter of 14.3mm made of BK7.

The same experiment has been performed with soft contact lenses. The red curves in figure 1 show a test run of a daily disposable hydrogel lens with a nominal diameter of 14.5mm. The lens has been already sufficiently stabilized.

The steadiness of the results for both lens types shows that:

- the electro-optical process control of the system is sufficiently stable
- the conditions inside the cuvette with respect to saline temperature, water flow and homogeneity of the refractive index (=”Schlieren”) are excellent.

So it can be expected that the current measurement device is suitable to demonstrate even small changes in the lens parameters.

AGILITY OF THE LENSES IN THE MEASUREMENT PROCESS

The agility of the lenses in the measurement process differs in:

- Contribution of changing temperature
- Changing surrounding media
- Suffer from dehydration

CONTRIBUTION OF CHANGING TEMPERATURE

A well-known phenomenon is the influence of temperature on lens parameters. To illustrate the dependency of the measured values on the saline temperature a series of measurements has been taken where the temperature has deliberately been changed (figure 2).

One can clearly see the correlation between the temperature and the measured parameters. In the following, the lens BVP and the diameter of the lens are plotted (figure 3). Please note that there is a heating time of about 5min between the different temperature steps, which is not displayed in the diagrams.

To some degree, such effects can be detected in conventional standard equipment, e.g. projector systems, however image processing based analysis using a high resolution digital camera allow a deeper insight into the “lens activities”. As expected, also the refractive data parameters are affected significantly. Here, only modern wavefront technology using a wet cell can track these effects. Obviously focimeter measurements at air cannot capture such effects as a matter of its principle.

CHANGING SURROUNDINGS

ISO 18369-3 demands that hydrogel lenses are equilibrated in standard saline solution for at least 30 min at 20 °C+/-0.5 °C before a measurement. Furthermore, in this context it is stated in places: “… unless otherwise specified by manufacturer.”

The interesting question is: Does the manufacturer really know the appropriate time to wait and the most suitable preprocessing? To raise efficiency and accurateness in QC and R&D, it is surely helpful to know the influencing factors and the time duration until a lens is in the state of equilibrium!

For example, one of the main topics is: What is the behavior in the current workflow, e.g., after unpacking a lens from its blister, where the chemical mixture of the liquid is typically different form the standard saline solution. Here, modern wet cell based wavefront measurement systems can give precise and reliable answers:

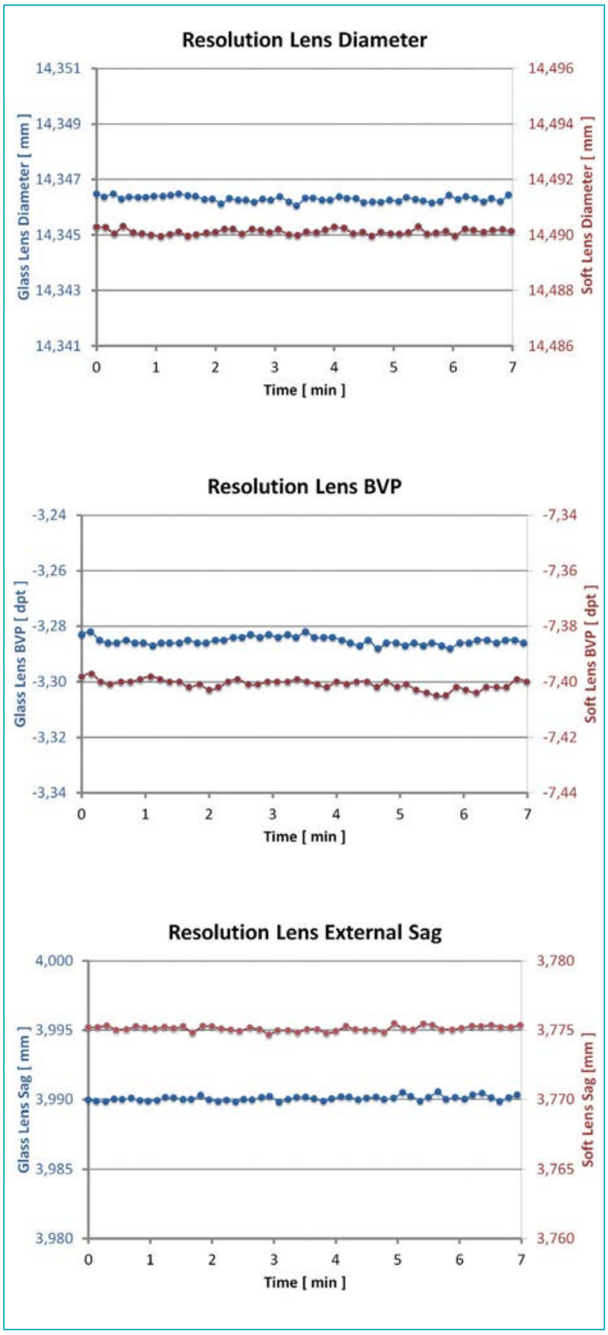


Fig.1: Glass lens (focal length 30mm) shows stable parameters during serial measurement (blue curve). Soft contact lens (7.5 dpt) shows comparable stability in stable environment (red curve).

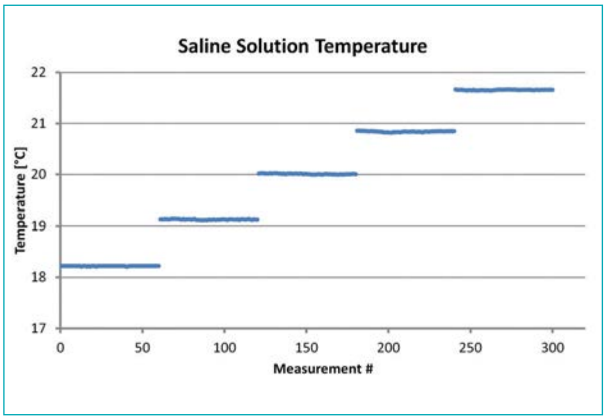


Fig.2: Temperature profile plot

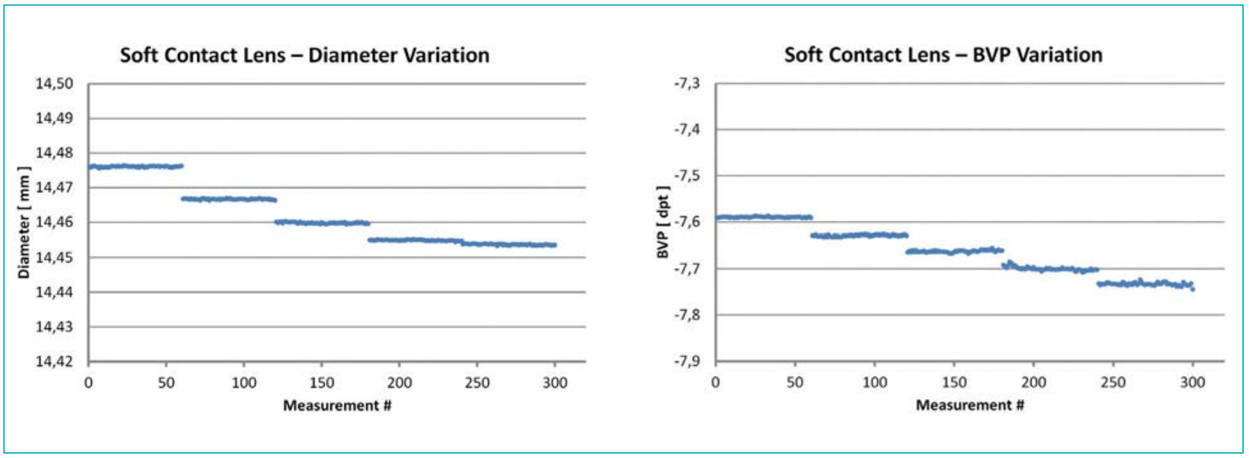


Fig.3: Dependency of diameter and BVP of a daily disposable hydrogel lens for an intentionally introduced temperature profile

For this example lens, the diameter stabilizes continuously and relatively fast, and shows only slight changes after 30 minutes (figure 4 left). In contrast, the BVP shows a much stronger up and down within the same initial time frame. Only after eight hours the BVP reached a stable state (figure 4 right). Here, obviously long-term diffusion processes occur. Comparable to the preceding topic is the situation where the lens has to be purified with conventional cleaning liquid. After a short-term cleaning process of 10 minutes, the external sag stabilizes after 30 minutes (figure 5).

SUFFER FROM DEHYDRATION

Still widely-used in industry is the measurement of contacts in air with a focimeter. The fundamental advantage of that method is that it is a direct measurement of the lens BVP without the need for recalculation from "saline-power" to "power in air". However, in that measurement procedure the contact lens is faced with quite a number of inconveniences: not only the mechanical load of the blotting process, and the change of the surrounding temperature to the room temperature, but also the dehydration of the lens material during the actual measurement process. All this together will leave a mark on the measured refractive data of a soft lens. This effect can be displayed performing the following type of experiment:

A lens is placed in the temperature stabilized cuvette until it is in a steady state, then it is removed and the focimeter measurement is performed. Afterwards it is placed back into the cuvette immediately and the BVP values are recorded. Here, it can be clearly seen in figure 6 that within just a few seconds the dehydration of the lens has an effect on the BVP. Of course, the magnitude of this effect for a specific lens type will depend on the skill of the operator performing the focimeter measurement (pressure, time duration, etc.), but the lens parameter will change considerably for many combinations of lens types and performed measurement procedures.

A detailed knowledge on this topic will also be helpful if the measurement process should be transferred from in-air-measurements to in-saline measurements with up-to-date measurement devices.

TRANSFERRING THE KNOWLEDGE

The effects discussed herein strongly depend on lens material and geometric lens design and thus should be examined

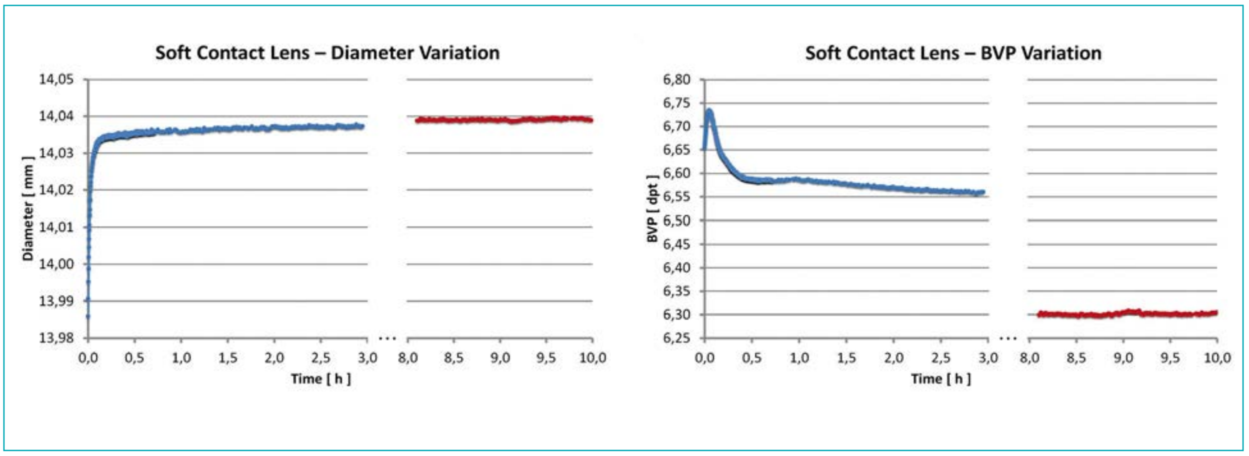


Fig.4: Temporal behavior of a silicone hydrogel daily disposable lens after placing it in the wet cell immediately after unpacking from blister

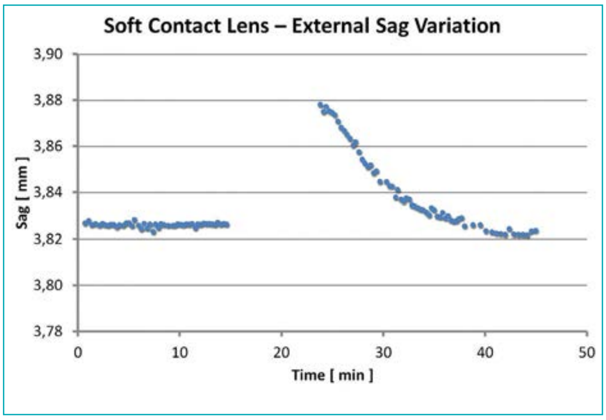


Fig.5: Temporal behavior of the external sag of a silicone hydrogel daily disposable lens after cleaning the lens with cleaning solution

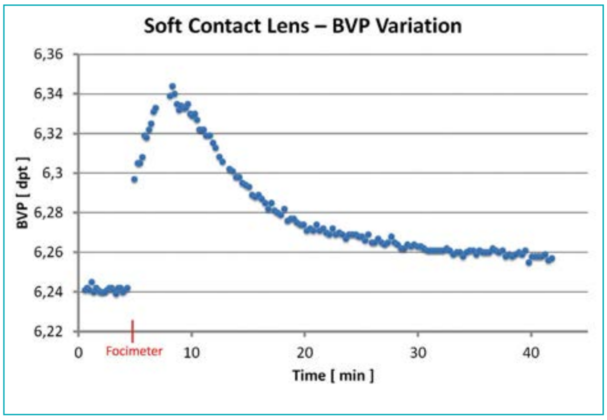


Fig.6: Behavior of a silicone hydrogel daily disposable lens after focimeter measurement in air

individually. We observed that in particular for extraordinary materials and lens designs, these effects can be even more severe.

The data presented in this article shall trigger a general discussion about current metrology processes used in QC and R&D for present and upcoming contact lens products.

If a well-adapted preprocessing is applied that allows the lens to calm down, the achieved stability and high resolution of the integrated metrology approach of the SHSOphthalmic omniSpect brings up knowledge about the lens with much higher consistency than ever possible before. Consequently, this can be transferred to an equivalent quality of the lens product itself.

Obviously, lens stability is half way there. Another topic of the complete metrology process is lens handling which will be treated in a following article. ■

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