The Application of the Indentation Test on the Measurement of Modulus of Soft Contact Lens Materials

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Introduction:

Material parameters have a direct impact on the comfort(1) of soft contact lenses. The measurement of material properties such as the modulus is being under discussion and is not yet a standardized procedure.

Methods:

Instrumented hardness testing according to DIN EN ISO 14577-1:
- This procedure uses a diamond vickers pyramid to apply a defined force (F [mN]) to the contact lens material with the simultaneous measuring of the indentation depth (h [µm]). device: Fischerscope® HM 2000, Helmut Fischer GmbH, Germany
- The measurement of all soft contact lens materials can be carried out under full hydrated conditions without any drying out
- A full calotte and a pin hole calotte out of aluminium (fig. 1) was used

(1) Loading: The force rises until the maximum force is reached. The increase of the indentation depth is not linear (fig. 2)

(2) Unloading: When the force is removed, the test peak is pushed back by the elasticity of the material → calculation of the modulus (EIT)(2)

Results:

Influence factors of measurement setup:
- For the evaluation of the different fluids (measured on Narafilcon A, +3.0D), a significantly lower modulus for saline solution was found in comparison to conditioned solution (OptiFree, Alcon) (p<0.001; t-Test) and to blister solution (p=0.03; t-Test), any other differences are not significant (fig. 3)
- The variation of the thickness of the lens material, realized by different powers of the contact lens, shows that the stage surface of full calotte leads to higher modulus values in comparison to a stage surface of calotte with pin hole (rmax=0.78 p=0.24; rmax=0.99 p=0.03) (fig. 4)

![Comparison of the measured modulus for different soaking fluids](image1)

![Correlation between the measured modulus [MPa] and the material thickness [µm]](image2)

- To get a higher material thickness the use of soaking (different numbers of lenses above each other) is possible
- The measured values of modulus (Lotrafilcon B) are lower (r=0.938 p=0.755, t-test) and the standard deviation rises (r=0.878 p=0.769, t-test) if several stacked lenses are tested (fig. 5)

![Measured modulus for different numbers of lenses above each other (stacking)](image3)

Discussion:

The evaluation of several confounding factors shows that the measured modulus is on the lowest level when using saline solution and a material which is as thick as possible. The influence of the thickness is caused on the material of the calotte. In this context, a pin hole calotte was used. The higher standard deviation when using more contact lenses (stacking) is caused by the inaccurate superimposition of the contact lenses. In this case, the use of a single lens with an aluminum full calotte and saline solution as fluid is indicated. For the maximum material thickness a high-power contact lens(e.g. +6.0D) is recommended.

Conclusion:

The novel indentation test was applicable for all market-leading soft contact lens materials. The measurement of the modulus of elasticity was performed under full hydrated conditions for the first time. Several confounding factors were described. The comparison of the modulus of soft contact lenses was difficult. The reasons are the various, non standardized measurement procedures. This novel method gives the contact lens specialists comparable values for the modulus of all market-leading soft contact lens materials.

References:


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