# INDENTATION OF SOFT BIOLOGICAL TISSUES

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## Introduction

Tissue biomechanics is an emerging field that can make a significant contribution to the study of human diseases. Elasticity changes have been correlated to several pathological states, such as osteoarthritis, atherosclerosis or cancer. However, there is lack of information regarding the role of tissue mechanics in disease progression [Ebenstein, 2006]. In part, this is due to the complexity of the subject: soft biological tissues exhibit complex mechanical properties characterized by nonlinear anisotropic viscoelastic behaviour. In other part, this is due to the lack of suitable tools. Atomic force microscopy has been successfully used to indent single cells and has shown that cancerous cells may be distinguished from normal ones by their stiffness [Cross, 2007]. Herein we present the first measurements obtained with a newly developed nanoindenter for the characterization of mechanical properties of biological tissues. The measurements were performed on soft polyacrylamide gels and the human cornea.

## Methods

The indentation experiments were performed with the new Bioindenter (CSM Instruments, Switzerland) especially developed for measurements of soft and biological materials. The Bioindenter allows large displacements up to 100 µm with specific loads from 10 µN to 20 mN. Petri dishes were directly mounted on the Biochamber (CSEM SA, Switzerland) to allow testing in liquid. Areas to measure were visualized in the attached optical microscope. Load-displacement curves were acquired with large spherical indenters (Ø 200 µm and Ø 1000 µm). A maximum applied force of 20 µN to 110 µN resulted in a maximal indentation depth of ~60 µm including a hold period of 60 seconds in case of polyacrylamide gels and 180 seconds in case of corneal tissues. In a first approximation, the Young's modulus (*E*) was calculated using the Oliver and Pharr model.

## Results and discussion

The measurements on polyacrylamide gels showed very low degree of viscoelasticity compared to corneal tissue (Fig. 1). Although the approximate values of Young's modulus of the polyacrylamide gels and corneal tissues were similar, the biological samples showed significantly more creep. Therefore, it was necessary to perform the measurements with sufficiently long hold period in order to obtain correct values of Young's modulus. Using a 180 second long hold at the maximal load, we found that the sclera of human eye is softer than the central cornea.

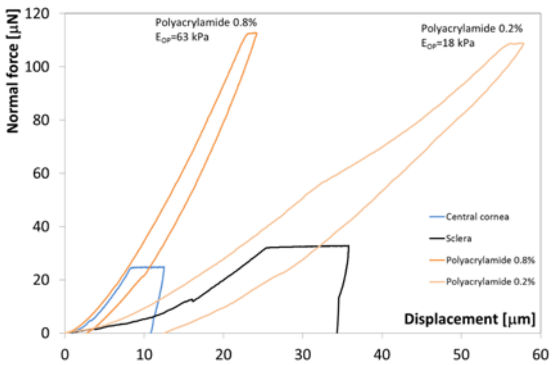


*Fig. 1: Comparison of load-displacements curves on polyacrylamide hydrogels and corneal tissues.*

## Conclusions

A new instrument was developed for indentation of biological tissues. The first measurements of polyacrylamide gels and biological tissues, mainly cornea, revealed reproducible and plausible results in the range of the Young's modulus previously measured by other methods for these samples [Last, 2011]. Our results show that the device is capable of fast local mechanical analysis of various types of soft materials and biological tissues.

## References

Cross *et al*, Nature nanotechnology, 2:780-783, 2007. Ebenstein *et al*, Nanotoday, 1(3):26-33, 2006. Last *et al*, Invest Ophthalmol Vis. Sci, 51(12):6083-6094, 2011.