

MECHANICAL, ELECTRONIC AND VISCOELASTIC TONOMETRY

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Abstract

Lymphoedema is an outcome of a failure of the lymphatic system to clear the load of fluids and their contents from the tissues. While in the initial stages fluid predominates, as lymphoedema progresses the epifascial tissues shows increasing deposits of fat and later an increasing level of fibrotic induration. Over time the affected limb thus varies in size, composition and compliance. Appropriate targeted treatment requires an accurate diagnosis of the tissue changes particularly of the epifascial compartment.

Traditionally lymphoedema and its progression through the stages have been monitored with mechanical tonometry. Tonometry measures the epifascial tissues' level of fibrotic induration by measuring the resistance of these tissues to compression. In a basic sense, mechanical Tonometry measures tissue elasticity. However these tissues are viscoelastic which require special measurement conditions to quantify the changes accurately. The mechanical tonometer cannot measure viscoelastic properties and its performance can be misleading, arbitrary and susceptible to user error through application technique especially in the hands of in-experienced users. Also the mechanical tonometer is limited to use on flat surfaces, in vertical operation and can be influenced by patient and user's movement.

Hence two new tonometers were designed. The first was the electronic tonometer. It is an electronic version of the mechanical tonometer but designed to be used in any plane, at any angle, on uneven surfaces and can remove user and patient movement and positioning artifact. The second new tonometer, the viscoelastic tonometer (VE), provides a means to measure and research the value of the viscoelastic properties of lymphoedema tissue, that is how the reaction of the tissues over a short time frame changes in response to an applied pressure.

This study examines and compares the performance of the two new tonometers to the mechanical tonometer. A pilot study on normal subjects and tests on phantoms were performed to measure the tonometers' repeatability and user influence. The results show that the electronic tonometer has similar repeatability to the mechanical, has less variation between users and can be used equally well by new and experienced users. The VE tonometer was shown to have a higher repeatability than the mechanical tonometer, less variation between users and capable of quantifying and differentiating the phantoms viscoelastic properties.

This pilot study indicates that the electronic tonometer will be a good replacement of the mechanical tonometer making the measurements easier and more reliable and indicates that the VE tonometer is easily able to measure and differentiate viscoelastic properties of a range of materials approximating human tissues and their changes and should be investigated further on patients with lymphoedema.



Figure 1: (A) Mechanical Tonometer (B) Electronic Tonometer and (C) Viscoelastic Tonometer.

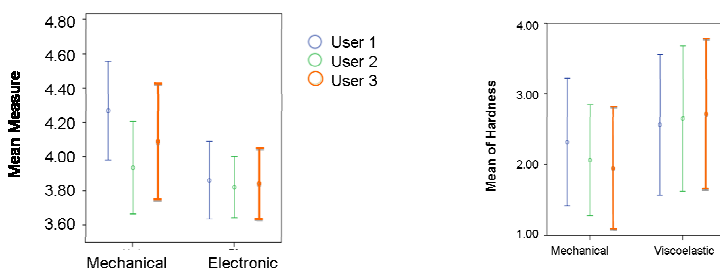


Figure 2: Mean measure plus 95% confidence interval for mechanical and electronic tonometers, and for mechanical and VE tonometers.

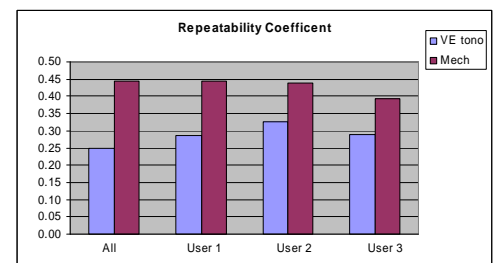


Figure 4: Repeatability Coefficient for the mechanical and VE tonometer.