6136 Age-Related Changes in Human Lens Stiffness Data

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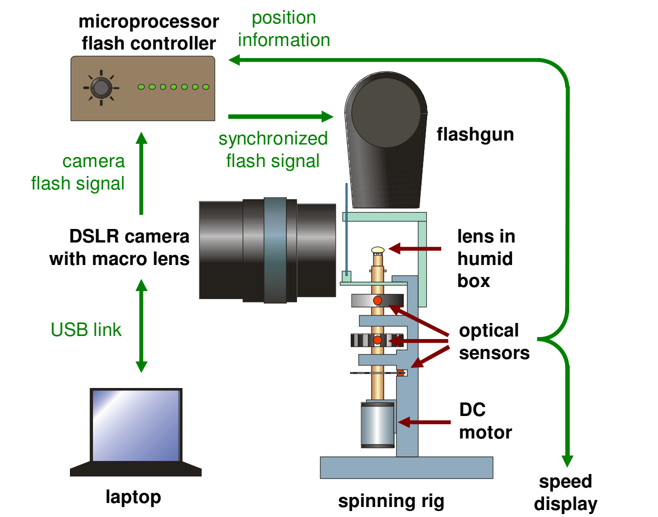
PURPOSE

To present further measurements on the stiffness of human lenses of a range of ages, obtained using an improved form of the spinning lens test devised by Fisher (1971), and to compare these values with those from previous indentation tests (Heys *et al.* 2004; Weeber *et al.* 2007) and a previous bubble-based acoustic method (Hollman *et al.* 2007).

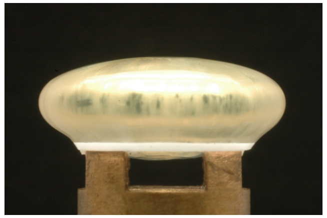
METHODS

- 14 human lenses from the Bristol Eye Bank were tested in the rig illustrated below (Wilde, *et al.*, 2008).
- Each lens was photographed while spinning at 1000 rpm and also at rest. The capsule was carefully removed before testing.
- The lenses were not frozen. Most were tested within three days of death, and all within five days.
- Adult lenses with a diameter less than 2.1 times their thickness were assumed to have swollen post mortem, and were excluded.
- A finite-element model of each test was used to deduce the stiffness parameters of the lenses via an inverse analysis.
- The lenses were modelled with a distinct nucleus and cortex with independent stiffness parameters in each region. The nucleus was ellipsoidal with axial dimensions 70% of those of the whole lens.

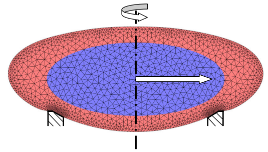
EXPERIMENTAL RIG



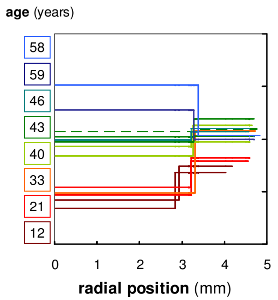
RESULTS



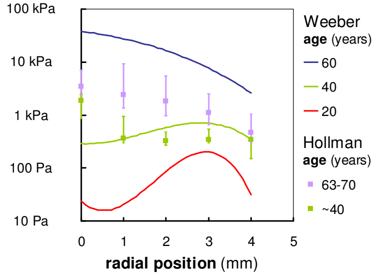
An image from the test of a lens without its capsule. Successive photographs are taken at eight orientations as the lens rotates.



An axisymmetric mesh generated from the eight images as used in the finite-element inverse analysis. The arrow indicates radial position as plotted below.



Shear modulus profiles for 14 lenses deduced from the spinning test, assuming a discrete nucleus and cortex.



Shear modulus profiles from Weeber *et al.* (2007) and Hollman *et al.* (2007). They are similar at 40 years but not at 60 years.

REFERENCES

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Hollman, K., M. O'Donnell, *et al.* (2007). "Mapping elasticity in human lenses using bubble-based acoustic radiation force." Exp. Eye Res.

Weeber, H., G. Eckert, *et al.* (2007). "Stiffness gradient in the crystalline lens." Graefe's Arch Clin Exp. Ophthalmol.

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ACKNOWLEGEMENTS

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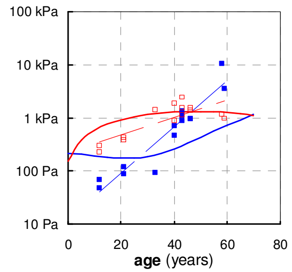
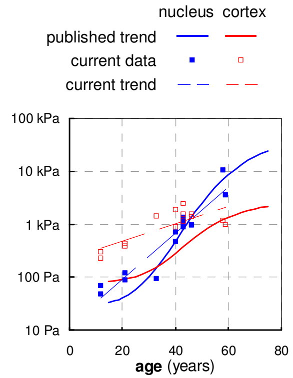
COMPARISONS

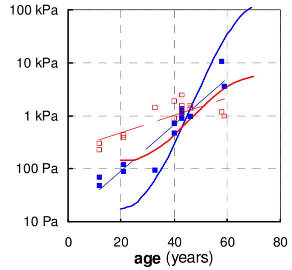
The following graphs compare the current shear modulus data with published trends.



Fisher (1971). The original lens spinning tests.



Heys *et al.* (2004). A large displacement indentation test of sectioned lenses.



Weeber *et al.* (2007). An indentation test of sectioned lenses.

	nucleus	cortex
Fisher	2.5	1.4
Heys	63.3	7.9
Weeber	208.9	9.3
current	20.2	3.1

A 'stiffening index' giving the ratio of stiffness at 50 years to that at 20 years in the trends from each study.

CONCLUSIONS

- Spinning, indentation and bubble-acoustic tests are quite different methods, but all produce a similar picture of substantial increasing lens stiffness as presbyopia develops.
- Despite this there is still a wide range in the actual values and the rate of increase with age, with an order of magnitude difference in the 'stiffening index' between the current results and Weeber *et al.* (2007).
- The relatively small increase in nuclear stiffness obtained by Fisher (1971) is at odds with the more recent measurements including the current data. This is likely due to imaging and modelling difficulties in the original tests.