·Letter to the Editor·

Preoperative evaluation of human crystalline lens hardness using A-scan ultrasound biometry: a pilot study

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Dear Editor,

I write to present the results of a study on the correlation between the ultrasound energy consumed during phacoemulsification with various preoperative parameters, including best corrected distance visual acuity (BCDVA), the signal to noise ratio (SNR) obtained by partial coherence laser interferometry and primarily, lens spikes measurements derived by A-scan ultrasound biometry.

Quantification of crystalline lens hardness before cataract removal has been attempted by several researchers in the past. These have been in humans and in animals, *in vivo* and *in vitro*, and have used a variety of imaging modalities[1-6]. To date, none of these methods has found general acceptance, and most cataract surgeons evaluate the crystalline lens hardness by means of visual acuity measurements and direct visual evaluation using standardized classification systems[5]. Slit-lamp examination gives important information about lens hardness, but it remains a subjective and empiric method, and cannot provide the information required to predict how much energy can be used safely during phacoemulsification before the corneal endothelium will be affected [6]. Such predictions would be useful in preoperative planning of cataract operations to reduce the risk of adverse effects, particularly in patients with defective corneal endothelium [7]. Moreover, the recently introduced femtosecond laser-assisted cataract surgery technique requires such information in order to fine-tune the settings of the laser platform [8].

We have previously reported the findings of investigations designed to assess the feasibility of using ultrasound technology to quantify lens hardness. Here, we report the culmination of this investigative programme, exploring the possibility of applying ultrasound in clinical practice [9]. This was an observational case control pilot study investigating the correlations between the total ultrasound energy consumed during phacoemulsification with various preoperative parameters, including the BCDVA, and quantified metrics taken from modalities as A-scan ultrasound biometry and partial coherence laser interferometry (SNR and height of spikes).

The study was performed in the cataract service of the 2nd Department of Ophthalmology of the Aristotle University at the Papageorgiou Hospital of Thessaloniki, Greece. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board. Patient anonymity and confidentiality were guaranteed. Patients for whom cataract surgery was planned were eligible to participate and informed consent was obtained from all subjects.

The following inclusion criteria were used: a diagnosis of nuclear cataract (NC) or NCs, graded (NC4 or NC5) according to the Lens Opacities Classification System III, an absence of cortical or sub-capsular lens lesions, and the ability of the patient to understand the nature of the study and give informed consent. Patients with any significant eye disorder resulting in reduction of BCDVA, other than cataracts, were excluded. Standard phacoemulsification in all cases recruited into this study was performed by a single experienced high volume cataract surgeon using topical anaesthesia, and a standard divide and conquer technique through a 2.2 mm clear corneal incision. The primary outcome measures were the correlations between the ultrasound energy used with the BCDVA, the SNR and the ratio of the spike height of the anterior lens surface (L1) to the spike height of the posterior lens surface (L2) after five successful consecutive measurements of the axial length determined by manual immersion ultrasound biometry. The ultrasound system used was the Infiniti ® Vision System (Alcon, Laboratories Inc., Fort Worth, TX, USA), with the energy used being expressed as the cumulative dissipated energy (CDE). The SNR was determined by non-contact partial coherence laser IOL using the Master® (Zeiss, Jena, Germany). The axial length and the L1 to L2 ratio was measured using the Ultrascan ® Imaging System with a 10-MHz biometry probe (Alcon Surgical, Fort Worth, TX, USA). We considered the L1 to L2 ratio to be a potential energy attenuation coefficient as it is directly correlated with the density and therefore the hardness of the crystalline lens. Previous studies have used the height of the ultrasound spikes as an indicator of lens hardness [10]. The ratio may be a measure of the ultrasound energy which is absorbed within the crystalline lens. Immersion A-scan ultrasound was performed using time-gain compensation of 50 dB. This was chosen in order to obtain the maximum possible heights of L1 and L2. We have previously demonstrated the repeatability and reproducibility of our method of measuring A-scan spikes[9] (Figure 1).

Visual acuity was determined using the recently developed Early Treatment Diabetic Retinopathy Study (EDTRS) for letter recognition by non-English speakers. The luminance level used was 160 cd/m^2 as recommended for standardisation purposes [11]. Data were collected prospectively, and analysed using Microsoft Excel 2007 for Windows (Microsoft Corporation, Redmond, WA, USA) and SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA).

A total of 20 eyes from 20 patients (11 women) were enrolled. Their mean age was 71.85±9.58y (range 53-87y). Firstly, we looked for correlations between the preoperative parameters. There was a significant correlation between the BCDVA and the SNR (P=0.005) (Figure 2). There were no other significant correlations. We then looked for correlations between the energy used during phacoemulsification and the preoperative parameters. There was a significant correlation between the CDE and the BCDVA (P=0.038) but not between the CDE and either of the other parameters, although the SNR showed a tendency towards a correlation with the CDE, but this was not significant at the 0.05 level (Table 1; Figure 3).

It is reasonable to assume that visual acuity is affected by cataract changes proportionally to alterations in the optical properties of the lens with increased scattering [12]. This appears to be more important than the changes in the acoustic behaviour of the cataract lens. We can assume that equivalent changes in the lens proteins induce non-directly comparable optical and linear acoustic changes. There are, reports demonstrating reasonable correlation between lens hardness and ultrasound findings using more sophisticated techniques than standard biometry [13]. These findings may only apply to certain types of cataract. In our study all the patients had nuclear cataracts without cortical or sub-capsular involvement.

With regards to the predictive value of lens hardness, neither optical changes detected by the IOL Master nor changes in the acoustic properties identified by our method correlated with the ultrasound energy required intraoperatively. The relationship between lens clarity and hardness is uncertain. Indeed they may be independent of each other. Similarly,

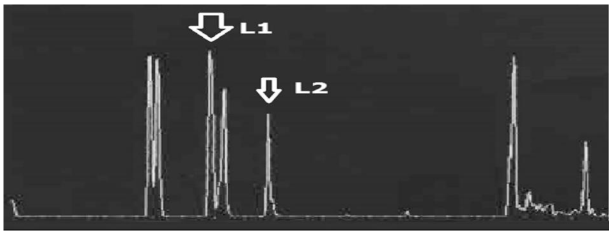

Figure 1 Ultrasound A –scan biometry report showing the spike L1 corresponding to the crystalline lens anterior surface (thick arrow) and L2 spike corresponding to the posterior surface (thin arrow) The ratio of their heights (L2/L1) was used as one of the main parameters of our study.

Table 1 Statistical comparison results (correlations) between preoperative parameters (BCDVR, optical biometry SNR, L2/L1 ultrasound biometry ratio) and intraoperative ultrasonic energy (CDE)

Pre-/Intra-operative parameters	BCDVA	SNR	L2/L1 ratio
SNR			
Pearson correlation	-0.599		
Sig. (2-tailed)	0.005[a]		
n	20		
L2/L1 ratio			
Pearson correlation	0.033	-0.271	
Sig. (2-tailed)	0.892	0.248	
n	20	20	
CDE			
Pearson correlation	0.466	-0.405	-0.189
Sig. (2-tailed)	0.038[b]	0.077	0.425
n	20	20	20

CDE: Cumulative dissipated energy; BCDVA: Best corrected distance visual acuity; SNR: Signal to noise ratio. [a]Correlation is significant at the 0.01 level; [b]Correlation is significant at the 0.05 level.

alterations in the acoustic properties of lenses may occur by mechanisms which do not affect the hardness of the lens. We found that the SNR obtained using optical biometry appeared to correlate with CDE, though this failed to reach statistical significance. This suggests that lens hardness may be more related to the optical properties than the acoustic properties of lenses. Novel techniques such as the measurement of ocular light scattering as suggested by Cabot *et al* [14] or Scheimpflug imaging may be worth exploring [15].

There is a natural tendency in science to quantify experience. However, our findings suggest that the preoperative quantification of crystalline lens hardness using the existing modalities is not a reliable method for determining the energy used during phacoemulsification; other unidentified factors must be involved. Given our present understanding and the technologies available to us, a pressing priority should be the development of methods to precisely measure the hardness of crystalline lens. Further large scale studies should be undertaken to address this important clinical issue which will

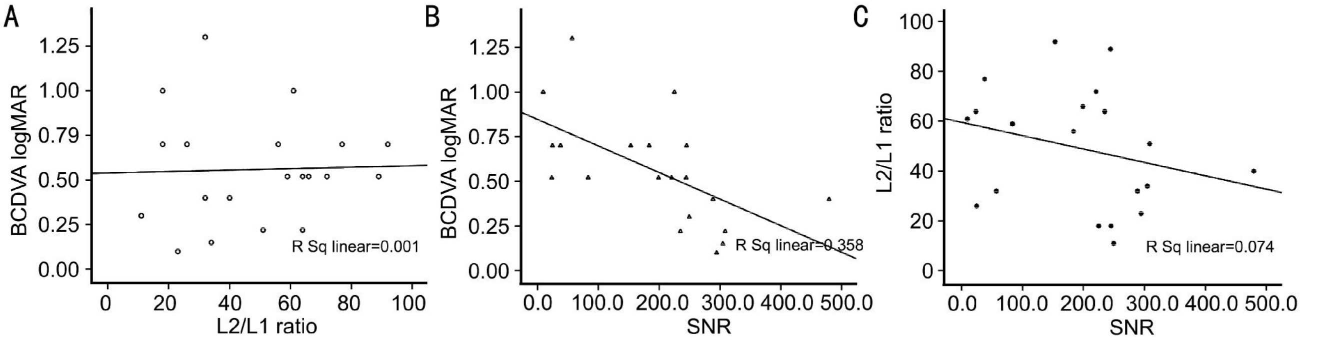

Figure 2 Correlations among preoperative parameters The only statistically significant showed in B section between BCDVA (logMAR) and signal to noise ratio as retrieved from the partial coherence laser interferometry.

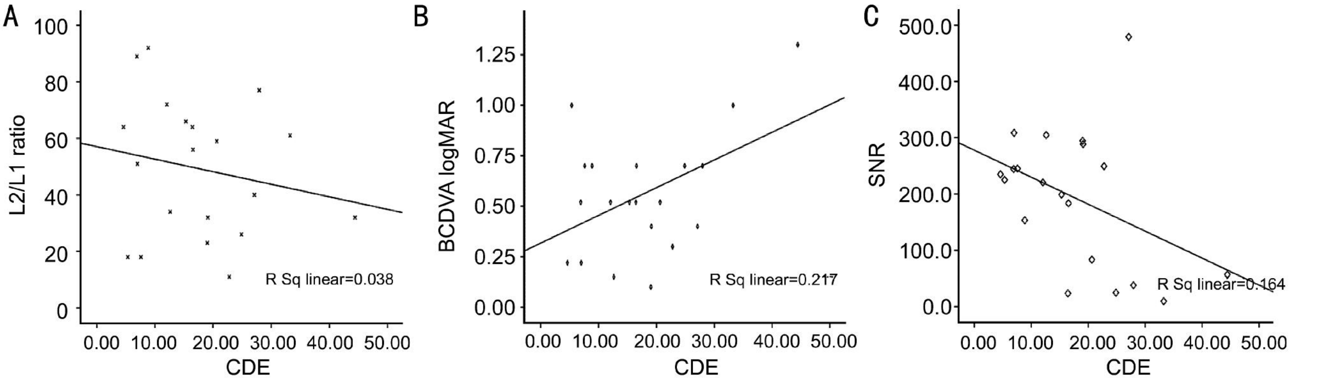

Figure 3 Correlations between preoperative metrics and ultrasound energy (CDE) Although SNR ratio of IOL Master showed a tendency it failed to reach statistical significance (P=0.077), BCDVA showed significant correlation with the CDE at 0.05 level of significance (P =0.038) while finally the proposed ultrasound metric totally failed to provide any correlation with the consumed intraoperative energy.

undoubtedly help in preoperative planning for cataract surgery.

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