Precise IOL Position Measurement to Improve Refractive Outcomes in Cataract Surgery

Editorial

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Abbreviations: IOL: Intraocular Lens; ELP: Effective Lens Position; ACD: Anterior Chamber Depth

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Over the last decades cataract surgery techniques have evolved remarkably, culminating in a procedure which aims to restore vision but also to provide spectacle free through the implantation of an Intraocular Lens (IOL). Currently the power of the implanted IOL is calculated with formulas derived by retrospective analysis of a large number of patients who had IOL implantation, and whose data was subjected to regression analysis, resulting in a power calculation formula, characterized by a set of constants which are calculated so that the postoperative refractive error, given by the difference between the target and postoperative refraction, averages zero. These formulas relate several biometric parameters measured preoperatively, such as the corneal power and the axial length of the eye, in order to calculate the power of the IOL. Another parameter taken into consideration when calculating the power is the Effective Lens Position (ELP), which acts as proxy to the physical position of the IOL inside the eye, given by the postoperative anterior chamber depth (ACD).

However, accurately achieving the desired postoperative refraction remains a challenge. According to our data [1] there is strong indication that the main underlying cause for this are the difficulties associated with predicting the postoperative position of the lens inside the eye ACD. This estimate is of a major importance to the refractive error. The predictability of ELP has improved over recent years, attributable to enhancements in the formulae used and the accuracy of the preoperative measurements of ocular biometric variables. However, ray tracing evaluation may contribute more to improve ACD estimation. The fact that eye models define the lens physical position [2] and not a theoretical position such as the ELP, allows comparisons with post-surgical measurements. Also several authors have explored the possibility of using the symmetry of the eye in order to improve the refractive outcome [3-5]. By performing the surgery sequentially the refractive outcome of the first operated eye is assessed and its ACD measured. The power of the IOL to be implanted in the other eye is calculated considering these parameters which results in an improved refractive outcome, compared with calculating the power of each IOL independently. This technique was shown to be more effective when the corneal power of the two eyes was similar (a corneal power difference smaller than 0.6D between the eyes) [6].

Several authors have explored the possibility of measuring ACD in the past. Methods to verify the IOL position in situ have been based on measurements of the Purkinje-Sanson III + IV images reflected from the anterior and posterior surface of the IOL [7,8]. Although such methods have proven highly accurate they are not easy to perform as they require special equipment not within the normal clinical techniques. More recently, the interferometer IOLMaster™ has been used to measure ACD, but Sahin & Hamrah point out that the ACD measuring module of the interferometer IOLMaster™ should not be used to determine the ACD in a pseudophakic eye, as the evaluation software is only designed for phakic eyes. The evaluation algorithms expect scattered light from the crystalline lens, while IOLs essentially produce strong reflections, which will be interpreted erroneously. Pseudophakic ACD will thus give results which are faulty and unreliable [9]. Scheimpflug photography has also been used to take this measurement, but Nemeth et al conclude, from their work, that in pseudophakic eyes, the precise assessment of ACD is dependent on the measuring device, although the exact reason for this difference remains elusive [10]. Optical measurements with reflectometry, such as Lenstar™, are not always possible, since in the majority of cases the light beam does not detect both surfaces of the IOL [11].

For this reason it is crucial to be able to accurately measure this parameter. Currently there is a need to assess the accuracy of ACD measurement techniques. We assessed the accuracy of a measuring device, the Zeiss Visante™ OCT. A pseudophakic eye phantom was built [11], (Figure 1), using laboratory grade optomechanical components, custom designed components and a 22D SA60AT Alcon AcrySof™ single-pice IOL. The IOL is installed in a custom IOL holder, which is glued onto a custom optical post that is in turn connected to off-shelf optical posts mounted on a translation stage. The stage is actuated via a high precision micrometer head (5 µm/div), allowing for precise axial displacements relatively to the front surface. Calibrations were performed and the span shift error was found to be virtually inexistent, (Figure 2). The thickness of an IOL was measured and a 56 error was found, which, considering this to be representative of the zero shift error, is clinically insignificant. Knowing that OCT based devices perform accurate measurements of ACD will certainly contribute to improve ELP estimation methodologies and continue to push forward ray tracing based methodologies, which make a direct use of the ACD.

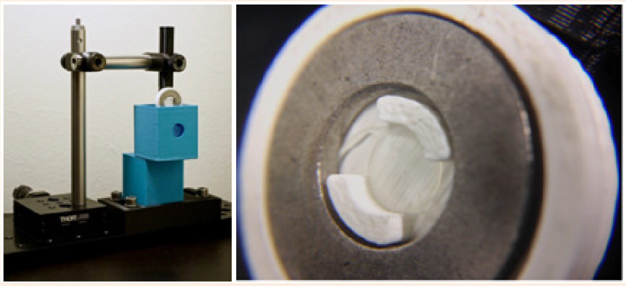

Figure 1: Pseudophakic eye phantom and custom IOL holder.

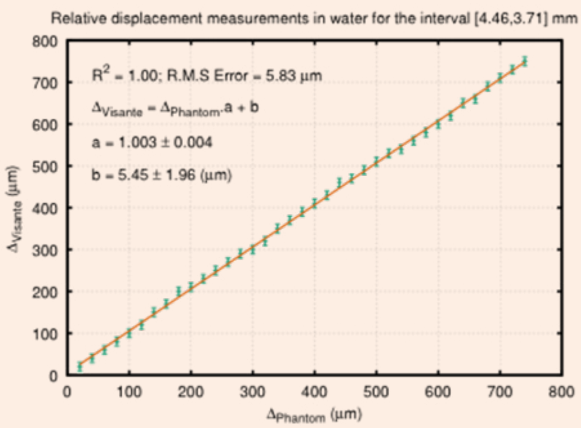

Figure 2: Relation between Visante™ OCT and IOL's Phantom Eye relative displacement measurements in water in the medium range [3.71, 4.46] mm.

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