ACCURACY OF INTRAOCULAR LENS POWER CALCULATIONS USING THE ZEISS IOL MASTER. A PROSPECTIVE STUDY

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ABSTRACT

Purpose

Partial Coherence Interferometry (PCI) is a fast, non-contact method to calculate lens implant power for cataract surgery. It has been reported as a potentially more accurate method than ultrasound biometry.

Prospective study of the refractive outcomes of a consecutive series of patients undergoing phacoemulsification surgery with preoperative biometry by both ultrasound A-scan and PCI.

Methods

A series of 50 eyes of 35 patients underwent small-incision phacoemulsification cataract surgery and lens implantation by one single surgeon. All patients had preoperative biometry performed by both ultrasound using the Sonomed and IOL Master optical biometry. The IOL Master results were included in the SRK II formula to calculate the lens implant power. Postoperative refractive assessment was performed 4 weeks after surgery.

Results

The mean difference in axial length between ultrasound and optical biometry was 0.2 mm. The IOL Master measures a longer axial length. The mean keratometric power using the Javal instrument was 43.4D and for the Zeiss IOL Master it was 42.9D. At the week 4 postsurgery assessment, the overall refractive outcome was in the range of ±1D. Five patients were unable to undergo PCI biometry due to the density of cataract.

Conclusions

Intraocular lens power calculations using the Zeiss IOL Master are easy to perform and result in excellent refractive outcomes. A-scan biometry is still needed in case of mature cataract.

RÉSUMÉ

Objet

Partial Coherence Interferometry (PCI) est une méthode rapide, non-contact, pour calculer la dioptrie de l'implant lors de la chirurgie de la cataracte. Cette méthode serait plus fiable que la biométrie aux ultrasons.

Etude prospective des résultats réfractifs d'une série consécutive de patients qui subissent une chirurgie de la cataracte. La biométrie pré-opératoire a été faite aux ultrasons A-scan et au PCI.

Méthodes

50 yeux de 35 patients ont subi la chirurgie de la cataracte par phaco-émulsification avec implantation de lentille intra-oculaire. Les interventions ont été exécutées par un seul chirurgien. Chez tous les patients la biométrie pré-opératoire a été faite aux ultrasons en utilisant le Sonomed et à l'interférométrie en utilisant le IOL Master. Les résultats du IOL Master ont été incorporés dans la formule SRK II afin de calculer la valeur dioptrique de l'implant. La réfraction postopératoire a été déterminée après 4 semaines.

Résultats

La différence moyenne de la longueur axiale entre la biométrie aux ultrasons et au PCI était de 0.2 mm. Le IOL Master mesure une longueur axiale plus longue. La valeur kératometrique moyenne du Javal était de 43.4D comparée à une valeur moyenne du IOL master de 42.9D. La réfraction postopératoire après 4 semaines chez tous les patients se situait entre ±1D. La biométrie au PCI était impossible chez 5 patients à cause de la densité de la cataracte.

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Conclusion
Le calcul de la valeur dioptrique de l'implant par le Zeiss IOL Master est facile à faire et donne des résultats réfractifs excellents. A-scan biométrie reste nécessaire en cas de cataracte mature.

SAMENVATTING

Onderwerp
Partial Coherence Interferometry (PCI) is een snelle, non-contact methode om de dioptrie van het lensimplant bij cataract chirurgie te bepalen. Deze methode is mogelijks nauwkeuriger dan echografische biometrie.
Prospectieve studie van de refractieve resultaten na phacoemulsificatie bij een serie opeenvolgende patienten waarbij de preoperatieve biometrie gebeurde met A-scan echografie en met PCI.

Methode
Bij 50 ogen van 35 patienten werd phacoemulsificatie met lensimplant uitgevoerd door één chirurg. Bij alle patienten werd de pre-operatieve biometrie bepaald door middel van de Sonomed echograaf én de IOL Master interferometer. De waarden van de IOL Master werden gebruikt in de SRK II formule om de dioptrie van het lensimplant te bepalen. De postoperatieve refractie werd bepaald 4 weken na de ingreep.

Resultaten
Het gemiddelde verschil in aslengte tussen A-scan echografie en optische biometrie bedroeg 0.2 mm. De IOL Master meet een langere aslengte. De gemiddelde keratometrie waarde bedroeg 43.4D bij de Javal en 42.9D bij de Zeiss IOL Master. De postoperatieve refractie na 4 weken lag voor alle patienten tussen ±1D. Bij 5 patienten was het onmogelijk om PCI biometrie uit te voeren wegens de densiteit van de cataract.

Conclusie
Bepaling van de intraoculaire lens sterkte door middel van de Zeiss IOL Master is eenvoudig uit te voeren en geeft uitstekende refractieve resultaten. A-scan biometrie blijft nodig in geval van matuur cataract.

KEY-WORDS

Partial coherence interferometry, ultrasound biometry

MOTS-CLÉS

Partial coherence interferometry, biométrie aux ultrasons.

INTRODUCTION: EMMETROPIA IS THE GOAL

Cataract extraction and artificial intraocular lens (IOL) implantation is one of the most frequently and successfully ophthalmic surgical procedures carried out today. One of the remaining problems, however, is accurate calculation of IOL power, in order to obtain the desired postoperative refraction.
While techniques in cataract surgery are constantly improving, the demand of patients and surgeons for a high predictability in the refractive result increases dramatically.
At a time where multifocal foldable lenses could be the future, a precise calculation of the power of intraocular lenses becomes even more critical.
The data required for accurate intraocular lens calculations include axial length, corneal curvature and anterior chamber depth. These data are integrated in calculation formula's. The most commonly used are the SRK II, SRK-T and Holladay formula.

In **ultrasound biometry** (1) measurements of axial length can be obtained either by an applanation or an immersion technique. With the applanation technique, the sterile probe is directly placed on the locally anaesthetized eye. With the immersion technique, the probe is coupled to the eye using a medium of methylcellulose or water. The resolution in axial length measurements is about 0.1 mm, corresponding to a mean postoperative error of 0.25 D.
When considering the **SRK II formula**: $P = (A+C) - 2.5AL - 0.9K$ it is obvious that axial length is the biggest source of error in IOL power calculations (4). Immersion scans are more precise because there is no corneal indentation. Furthermore, ultrasound does not always measure the optical axis. Keratometry is the second most important parameter leading to possible errors due to calibration and patient fixation.
Recently, **optical biometry** (2,3) techniques offer new possibilities. The technology of an instrument like the Zeiss IOL Master is based on laser interferometry with partial coherent light, often termed as partial coherence interfero-

metry (PCI). Some important features of the IOL Master are the fact that it is a non-contact measurement with higher speed and higher accuracy with a resolution going up to 0.01 mm. The measurement results are operator independent: the reproducibility is high. Axial length can be measured in phakic, pseudophakic and aphakic eyes. The IOL Master still gives reliable results in pseudophakic eyes, in eyes with silicone in the vitreous and in eyes with asteroid hyalosis.

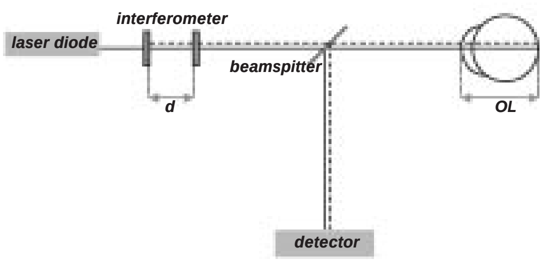

Fig. 1 Diagram of the laser interferometer for measuring the axial length of the eye.
d: plate spacing of the interferometer
OL: optical length of the eye

Light from a laser diode (Fig. 1) passes an interferometer that splits the beams into two parallel beams: a direct beam and a second beam that is reflected once at both interferometer plates and hence is retarded by a path difference of twice the plate spacing d. Both beams illuminate the eye through a beamsplitter. They serve as measuring beams as well as a fixation target. The two coaxial beams are reflected at both the cornea and the retina yielding four reflected beams. This introduces an additional path difference of twice the optical length (OL) of the eye between the two beams reflected at the cornea and the two beams reflected at the retina, respectively. If the coherence length of the laser is shorter than 2 OL, the wave fronts from the retina and the cornea do not interfere. However, if the two path differences 2d and 2 OL equal each other, two of the four reflected beams will interfere. The interference pattern that results will be seen with a detector. In principle, the eye length can be measured by a shift of the interferometer plates.
The diode laser emits infrared light with a wave length of 780 ηm. The time needed for measurements is about 0.5 sec. The IOL Master provides a measuring range of 14 to 39 mm.

SUBJECTS AND METHODS

The purpose of the study was to compare IOL power calculations using the IOL Master versus ultrasound biometry and standard keratometry.
In a prospective study, optical and applanation ultrasound biometry were preoperatively performed on 50 cataractous eyes. We used the optical biometry data given by the Zeiss IOL Master to calculate the desired IOL power with the SRK II formula in order to obtain an emmetropia or slight myopia.
In all patients the Allergan SI40 NB silicone foldable intraocular lens (A-cte 118.0) was implanted through a self-sealing 2,5 mm temporal incision after phacoemulsification. All interventions were performed by the same surgeon

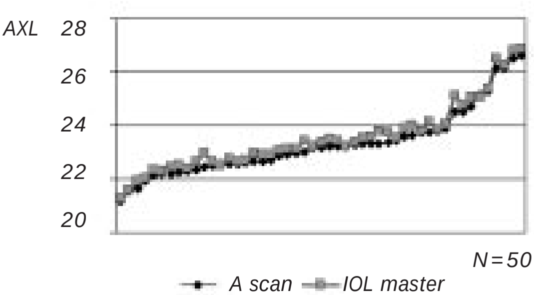

Fig. 2 The mean difference in axial length between ultrasound and optical biometry was 0.2 mm. The IOL Master measures a longer axial length.

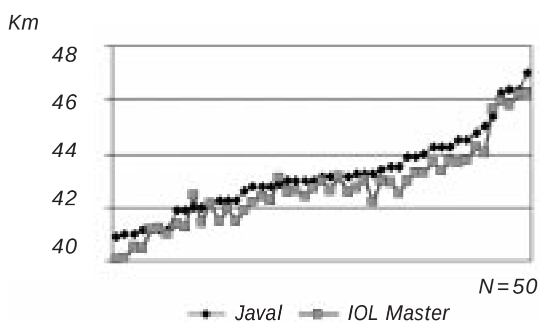

Fig. 3: The mean keratometric power using the Javal instrument was 43.4 D and for the Zeiss IOL Master it was 42.9 D.

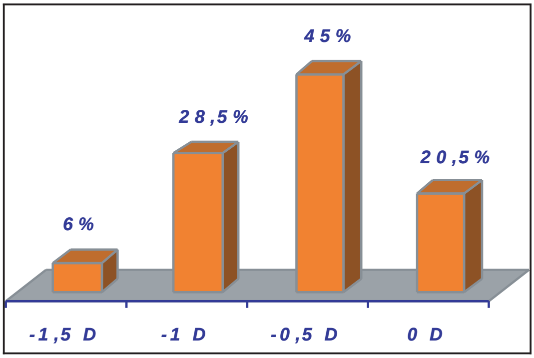

Fig. 4 The IOL power according to optical biometry minus the IOL power according to ultrasound biometry

(Dr. J.C.V.). Patients were operated on using topical anesthesia.
Four weeks after surgery, the refractive outcome was determined. The preop ultrasound biometry data were retrospectively integrated in the SRK II formula to determine the refractive outcome.

RESULTS

Ultrasonic instruments measure the distance between the anterior surface of the cornea and the internal limiting membrane, whereas the IOL Master measures the distance between the anterior corneal surface and the pigment epithelium. Due to the thickness of the cell layer, the resulting differences of the measured axial length are between 150 - 350 µm. Measurements using the ultrasonic contact technique cause additionally an applanation of the eye. In our study, we had a mean difference in axial length of 0.2 mm (Fig. 2).

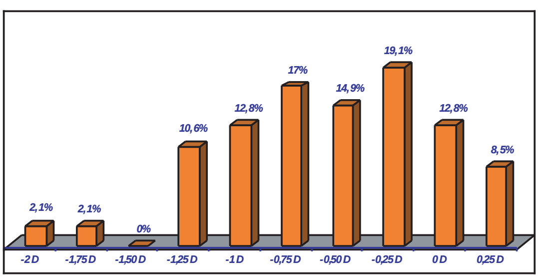

Fig. 6: The refractive outcome, retrospectively calculated, that would have resulted when using the data given by US biometry

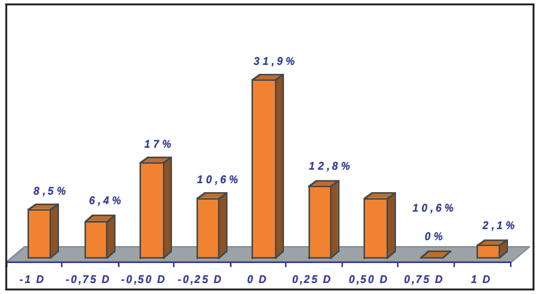

Fig. 5 An excellent refractive outcome was obtained at week 4 using the data given by the IOL Master to calculate the IOL

When using Javal keratometry, the mean corneal curvature was 43.4 D while mean IOL Master measurement was 42.9 D (Fig. 3).

The difference of the IOL power according to optical biometry and according to US biometry is shown in Fig. 4. The IOL Master calculates an IOL that is 1.5 D or 1D less in about 30% of cases, an IOL that is 0.5 D less in 45% of cases and the same IOL as compared to ultrasound biometry in 20% of cases.

Using the data given by the IOL Master to calculate the IOL, we obtained an excellent refractive outcome (Fig. 5). About 30% of patients had a spherical equivalent of 0 D, and the overall refractive outcome was in the range of ±1 D.

Retrospectively, we determined the power of the IOL that we would have chosen using the US biometry for a target emmetropia of 0 D. Then we calculated the refractive outcome of this IOL power, using the real postoperative refraction and the implanted IOL power (Fig. 6). We considered - by approximation - a 1 D difference in IOL power to result in a 0.7 D difference in refractive outcome. In 4% of cases, the refractive outcome was higher than 1.5 D in myopia. In these 2 patients, there was an absolute difference in axial length measurement of ≥0.45 mm.

In Fig. 7 we compare the refractive outcome achieved with ultrasound versus optical or PCI biometry. For each biometric technique, the percentages of patients with refractive errors less than 0.5 D, 1 D, 1.5 D, etc. are shown.

	<0.5 D	<1.0 D	<1.5 D	<2.0 D	<2.5 D
US	40.4 %	72.3 %	95.8 %	97.9 %	100 %
PCI	55.3 %	89.3 %	100 %	.....	.....

Fig. 7 Comparison between the refractive outcome achieved with ultrasound and PCI biometry.

In 90% of patients tested with the IOL Master we obtained a refractive result of less than 1 D of the spherical target. We obtained the same good result in only 72% of patients tested with the standard US measurements.

CONCLUSION

We evaluated the ease of use of the Zeiss IOL Master. It scored high as to its user-friendliness and reproducibility, making it an instrument which can be manipulated by paramedicals. The measurement itself takes less than a minute.

In patients with a very dense cataract however, the signal reflected at the retina is so small that it cannot be used for exact axial length measurement. In these circumstances ultrasound biometry is still needed: in our small series this represents 5 patients out of 50 (10%).

We may conclude that IOL measurements performed with the Zeiss IOL Master, using partial coherence interferometry, are easy to perform.

The measurement requires minimal cooperativeness and fixation capability of the patient.

The refractive outcome obtained was excellent.

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