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Behaviour of the phakic iris-claw intraocular lens (Artisan®/Verisyse®) during accommodation: An optical coherence biometry study

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PURPOSE. *To evaluate variations in the position of the phakic iris claw lens (Artisan®, Verisyse®) and the natural crystalline lens during the accommodation process.*
METHODS. *We measured changes in position of the iris claw lens and the crystalline lens during the accommodation using optical coherence biometry (AC Master®/Carl Zeiss Meditec, Germany) in 17 patients (28 eyes) with a phakic iris claw lens implanted for high myopia and/or myopic astigmatism. Accommodative effort was obtained using an internal optical target within the measuring device.*
RESULTS. *There was a forward shift of the phakic iris claw lens with a mean of 70 µm (8-178 µm) of the optical path length (OPL). At the same time the anterior pole of the natural lens showed a forward mean movement of 85 µm (4- 260 µm).*
CONCLUSIONS. *An anterior displacement of the iris-claw phakic lens was shown in a series of eyes during the accommodation process. As this displacement goes along with the forward displacement of the anterior pole of the crystalline lens, the preoperative measurement of the latter might provide some additional information about the position of the iris claw lens in the accommodative state after implantation. (Eur J Ophthalmol 2007; 17: 904-8)*

KEY WORDS. *Accomodation, Intraocular, Lens, Movement*

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INTRODUCTION

The phakic iris claw intraocular lens (Artisan®, Verisyse®) is currently one of the most popular IOLs for the correction of high ametropia. The foldable version of this implant (Artiflex®, Veriflex®) appears to partially replace the rigid model in Europe. However, the rigid polymethyl-metacrylate (PMMA) model received an FDA approval in the United States just a few years ago. Despite a long history of safe use related to this particular implant, surgeons naturally have some long-term concerns, when operating on virgin eyes.

Indeed, the original type of the iris claw phakic intraocular lens was introduced as a so called Worst-Fechner Biconcave Lens in 1986. However, the first large trial on the 125 eyes implanted between 1986 and 1990 resulted in a considerable endothelial damage in 10 eyes within the follow-up period (1). Thereafter, in 1991, the design of the lens has been altered to the convex-concave form (Artisan®) without a high optical rim. Therefore, a greater distance between the phakic implant and the endothelium was obtained (2). In the European multi-center prospective study the mean endothelial cell loss was 7.1% after the first year. It stabilized to a mean physiological loss of 0.7% per

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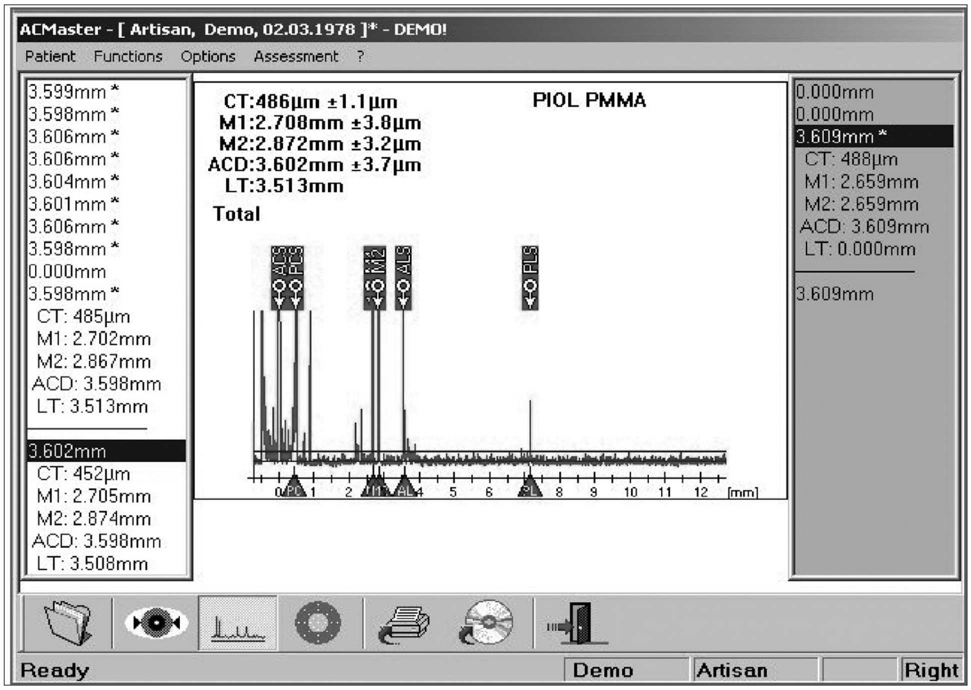

Fig. 1 - *An example of a measurement of the phakic intraocular lens and the crystalline lens position using AC-Master®.*
ACS = Anterior corneal surface, PCS = Posterior corneal surface, M1 = Anterior surface of the iris-claw lens, M2 = Posterior surface of the iris-claw lens, ALS = Anterior crystalline lens surface, PLS = Posterior crystalline lens surface.

year between the 2^{nd} and third year after implantation (3). However, while the mean numbers are very good, occasional "drop outs" with endothelial counts of 1400 cells/mm^2 after 4 years have been described (4). It is a common knowledge, that a deep anterior chamber and a flat iris are prerequisites for a long-term successful endothelial cells survival after iris claw lens implantation. Currently, an anterior chamber depth of at least 3 mm is recommended (Artisan®, Training Manual, Ophtec, Netherlands). Such a measurement is taken using either an A-scan or optical devices (e.g. IOL-Master®, Carl Zeiss Meditec, Germany) in a static state. According to the Helmholtz´ theory of accommodation the anterior surface of the crystalline lens moves forward (9). At the same time the iris claw IOL is "anchored" to the iris. Thus, the aim of the present study was to evaluate in a series of eyes implanted with the iris-claw IOL, the changes of position of this lens implant *during accommodation*.

PATIENTS AND METHODS

Twenty-eight eyes of 17 patients who have had an implantation of the iris claw intraocular phakic lens for myopia were examined in the present study. Preoperative examination included manifest and cycloplegic refraction, intraocular pressure (IOP) measurement, slit-lamp biomicroscopy, central AC-depth measurements from the epithelium to the anterior crystalline lens surface (IOL Master®, Carl Zeiss Meditec AG, Germany), corneal topography (TMS 3® or TMS2N®, Tomey, Japan), dilated fundus exam and the endothelial cell count (SP 2000®, Tomey, Japan). All implantations were performed by the same experienced surgeon (W.S.). Five implants had a 5 mm optic, the others had a 6 mm optic. The site of the main incision was chosen in accordance to the preoperative astigmatism and – if needed – enhanced by an additional limbal relaxing incision as previously described (6). The mean preoperative spherical equivalent was -12.25 +/- 2.7 D (-8 to –20.5 D). At the time of the follow up examination for this particular study, the mean patient's age was 30.7 years (30 to 57 years). The mean follow up period after the implantation was 2.5 years ranging from 0.5 to 4 years. In addition to the usual ophthalmic exam such as biomicroscopy, specular microscopy (SP 2000®, Tomey, Japan) and IOP, following specific examinations were carried out: A subjective accommodation was measured using a "push" method. Here, after the best manifest distant refraction and the best corrected visual acuity (BCVA) was established using phoropter (Moeller-Wedel AG/Switzerland), minus-lenses of 0.25 D

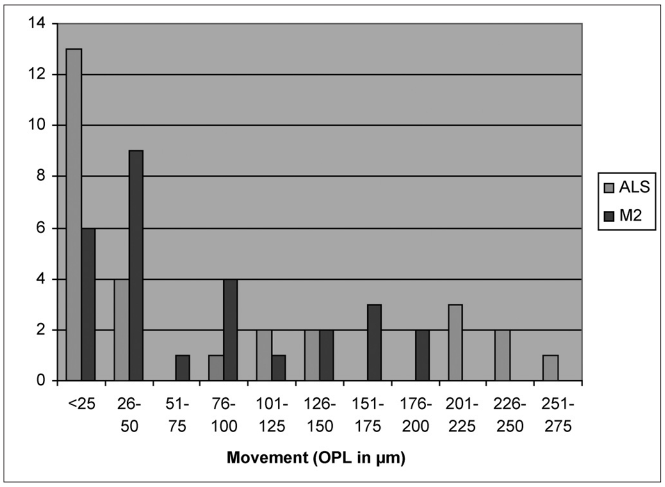

Fig. 2 - *Accommodation induced position changes of the iris claw lens: Movement of anterior surface of the natural lens (ALS) and the posterior iris-claw lens surface (M2) under accommodation.*

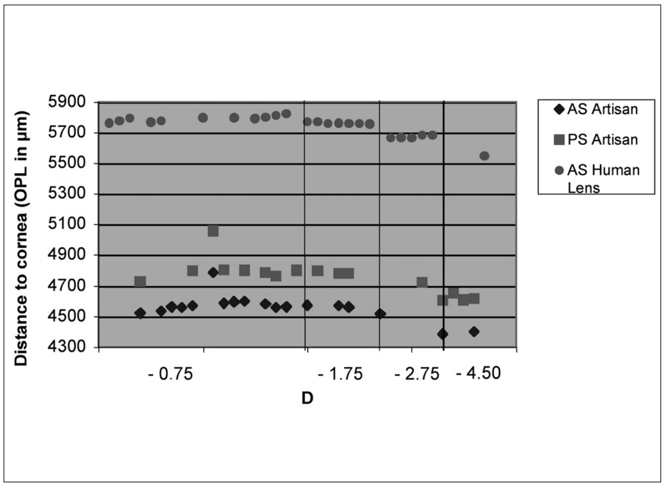

Fig. 3 - *Anterior shift of the iris-claw lens of 132 µm accompanied by a forward shift of the crystalline lens of 193 µm. Distance target fixation is obtained at –0.75 D, the near point is reached at –4.5 D. AS = Anterior surface; PS = Posterior surface: OPL= Optical path length.*

steps were flipped into the visual pathway until the patient could not any longer read the BCVA Snellen line.

Measurements were performed using optical coherence biometry for the anterior segment (AC Master®, Carl Zeiss Meditec AG, Germany). The AC Master® device enables a precise measurement of the optical path length from the corneal epithelium (plane of reference) and the following structures: posterior surface of the cornea, the anterior and the posterior surface of the iris claw lens and the anterior and the posterior position of the crystalline lens. The measurements delivered by the AC Master® have a standard deviation as low as one µm according to the manufacturer (AC Master®,operation manual, Carl Zeiss Meditec AG, Germany). Initially, measurements of the above mentioned structures were taken with a distant gaze target using the spherical equivalent of the refraction obtained at the phoropter. The AC Master® also possesses an internal target that can be moved in 0.25 dioptre steps. Fig. 1 shows a measurement with appropriate parameters. A state of accommodation was induced by moving the internal target, and continuously measuring the changes in the position of the pseudophacos and the crystalline lens. At least 15 measurements were performed per eye. A senior physicist (W.B.) performed all scans, analysed and calculated the means. All clinical examinations were performed by an experienced medical ophthalmologist who is also a qualified optician (A.T).

RESULTS

The preoperative mean best spectacle corrected visual acuity (BSCVA) was 0.82 with a range between 0.5 and 1.2. At the time of the study the mean BSCVA was 0.96 +/- 0.16 with a range of 0.7 to 1.4. The uncorrected visual acuity has improved from 1/35 to 0.78 +/- 0.21 (range 0.4 to 1.2). The mean preoperative spherical equivalent was –12.25 +/- 2.7 D, the postoperative mean spherical equivalent was –0.7 +/- 0.27 D. The mean subjective accommodation was 2.08 +/- 1.28 D with a range between 0.5 and 5.5 D.

Figure 2 shows accommodation induced position changes of the iris claw IOL for each eye examined. Taken the entire group of 28 myopic eyes, the mean forward shift of the iris claw lens was 70 +/- 59 µm. At the same time, the main shift of the anterior crystalline lens surface was 85 +/- 81 µm. An important observation was also a large range of accommodation seen: Depending upon the accommodative effort, the iris claw lens shifted forward from 8 µm in the most ‘static’ case going up to 178 µm in the other extreme case. The natural lens also had a large scale of movement ranging from 4 to 260 µm. We then subdivided the eyes examined in 3 groups: those where the iris claw lens shifted forward less than 50 µm (low motility group), those being in the intermediate range and those whose forward shift measured more than 100 µm (high motility group). Indeed, 54 % of the eyes showed a modest shift of fewer than 50 microns whereas 29 %

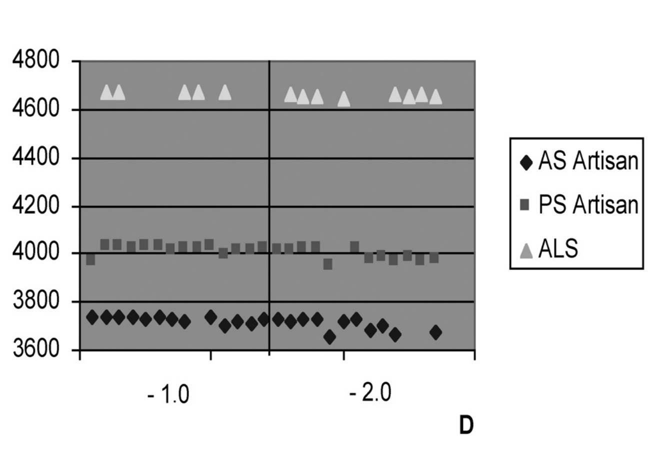

Fig. 4 - *Anterior shift of the iris-claw lens of 25 µm accompanied by a forward shift of the crystalline lens of 15 µm. Distance target fixation is obtained at –1 D, the near point is reached at –2 D. AS = Anterior surface, PS = Posterior surface of the iris-claw lens; ALS = Anterior surface of the crystalline lens; OPL= Optical path length.*

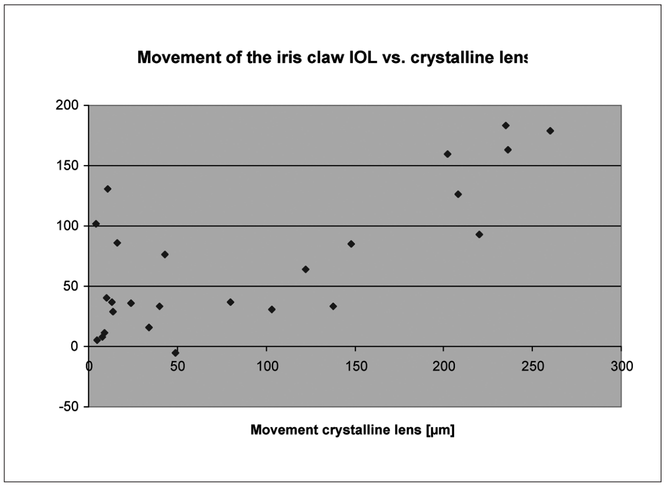

Fig. 5 - *Forward movement of the crystalline lens plotted versus movement of the iris claw IOL. A correlation is seen in eyes where the crystalline lens moved more than 50 µm.*

moved forward more than 100 µm. Only 17 % of the eyes examined were in the intermediate group. In the low motility group example (Fig. 3) the forward shift of the iris claw lens of 25 µm is reflected by a modest shift of the natural lens of 15 µm. In the high motility example (Fig. 4) of a younger patient with almost 4 D of accommodation, the iris claw lens moves forward 132 µm whereas the anterior pole of the crystalline lens has a forward shift of 193 µm. When the anterior movement of the iris-claw lens was plotted against the movement of the anterior crystalline lens surface a visible coupling between the two was seen only in eyes with at least 50 µm of the anterior displacement of the crystalline lens (Fig. 5). Unexpectedly, no clear correlation was found between patients' age and the anterior movement of the crystalline and/or iris-claw lens.

DISCUSSION

There is an increasing awareness that safety criteria for the anterior chamber intraocular lenses based on the assumption that the position of the IOL is static are not sufficient (11). This concern is mainly related to the forward displacement of the IOL influenced by the annual forward progression of the anterior pole of the crystalline lens (6, 7, 11). The latter can be as high as 18 to 20 µm per year according to a recent study by Baikoff et al. (8). Our study demonstrates in a series of 28 eyes a constant position change of the iris supported phakic implant within the anterior chamber, depending on the state and the accommodative amplitude of the eye (9). Remarkably, in some eyes with a large anterior movement of the crystalline lens the IOL shift was less than the shift of the natural lens. In contrast, in eyes with poor accommodative shift of the natural lens the IOL showed a larger shift than the crystalline lens. One possible explanation is that the IOL shift is rather driven by a muscular action of the ciliary body/iris complex than by a direct "pushing" action of the crystalline lens. Indeed, in a recent paper by Kohnen et al. a case of the IOL-claw-induced over accommodation of 4 D was presented (10). The authors hypothesized that the haptic of the IOL can trigger a tractive power on the ciliary body causing the ciliary body to move inward and forward (10). In our study, the accommodative response was much less, but its amplitude did not strongly correlate with patients´age. Thus, it is quite possible, that some additional accommodative mechanisms can be triggered by this type of the IOL itself. However, one neither can exclude some minor changes in the interlenticular space during the accommodation process, nor the iris role as a "cushion" between the two lenses.

Our findings raise several clinical issues. As stated above, an anterior chamber (AC) depth of 3 mm, measured from the endothelium, is currently considered to be safe for the implantation of the iris-claw IOLs. Indeed, the recommendations for the necessary clearance appear to have increased as compared to the recommendations given just a few years ago, when a distance of 2.9 mm measured from the epithelium was felt to be sufficient (11). Nevertheless, many surgeons including the first author of this paper follow up numerous patients operated under the old guidelines with no detectable damage to the corneal endothelium whatsoever. Could the accommodation related shift shed some light onto this issue? Critically looking at our data one first has to realize that about one half of our patients had an anterior IOL shift under 50 µm, that is 0.05 mm: a number that makes up about 2% of the *central* anterior chamber depth even in a fairly shallow AC of 2.5 mm. However, the critical zone is located at the edge of the IOL optic. Hypothetically, in an eye with the posterior corneal radius of 6.8 mm and the distance between the posterior corneal surface and the anterior iris claw lens surface of 2.5 mm the distance between the edge of the 6mm-IOL optic and the corneal endothelium is 0.8 mm. In the case of the maximum anterior shift of 178 µm (= 0.178 mm), as shown in our study, this safety distance would decrease by 17%. Whether this change might ever become relevant is a matter of speculation. We would expect a similar study, performed on hyperopic eyes with a phakic implant, to be able to shed more light on this important issue. Indeed, one would expect hyperopic eyes to have a much stronger accommodation effort than myopic eyes examined in our study. Because our group predominantly uses phakic implants for the correction of high myopia, no hyperopic eyes were available for such comparison.

The follow-up period of the 17 patients examined in our study differed from 0.5 to 4 years. Thus, we were unable to find any correlation between the endothelial cell count and the anterior shift of the implant. Because the accommodative amplitude reduces with time, only a prospective mid-to–long-term combined comparative endothelial cell count/ accommodation – study could provide a definitive answer to this question.

In summary, an anterior displacement of the iris-claw phakic IOL was shown in a series of 28 eyes during the accommodation process. First simulation programs for high resolution imaging already take into account aging changes of the crystalline lens prior to implantation (12). Our investigation provides another new aspect of IOL-position change, namely the individual accommodative amplitude. We believe, the questions raised herein will provoke further research on this issue.

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