Original article

Influence of axial length in refractive outcome after cataract surgery

V. de Juan*, R. Martín, I. Pérez and J. M. Herreras

*Graduate in Optics and Optometrics, University Institute for Applied Ophthalmobiology (IOBA), Optometry Unit, University of Valladolid, TAO Physics Dept, University of Valladolid, Valladolid, Spain

Graduate in Nursing, University Institute for Applied Ophthalmobiology (IOBA), University of Valladolid, Valladolid, Spain

Ph.D. in Medicine, University Institute for Applied Ophthalmobiology (IOBA), Ocular Surface and Immunology Group, University of Valladolid, Ophthalmology Service, University Clinical Hospital of Valladolid, Valladolid, Spain

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ABSTRACT

Purpose: To analyse the influence of axial length (AL) and age on refractive outcome after cataract surgery in terms of uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA) and subjective refraction.

Methods: A retrospective review of 171 consecutive cases of uncomplicated cataract surgery was done. The refractive outcome was analysed (UCVA, BCVA and postoperative refraction) according AL before surgery (AL < 22 mm, between 22 and 25 mm and AL > 25 mm) and age (< 40, between 40-60 years and > 60 years).

Results: After surgery mean UCVA was 0.6 ± 0.33 Diopters (D) and mean BCVA was 0,93 ± 0,23 D. Mean refractive outcome was 0.89 ± 0.78 D. There were no significant differences in post-operative UCVA, BCVA and refraction between the three age groups. There were statistically significant differences (p = 0.004) in UCVA between the three AL groups. The group with AL between 22 and 25 mm had better UCVA. Mean refractive outcome was -0.95 ± 1.91 D in the group with AL < 22 mm, -0.36 ± 0.88 D in the group with AL between 22 and 25 mm and 0.23 ± 1.15 D in the group with AL > 25 mm.

Conclusions: AL influences refractive outcome and UCVA after cataract surgery. Eyes with AL < 22 mm have a worse refractive outcome.

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Introduction

Cataracts are a chronic disease, frequently associated to the ocular ageing process, characterized by a progressive lens opacification, usually bilateral but asymmetric, that causes in the subject a visual acuity reduction, loss of sensitivity to contrast, light blindness and occasionally monocular diplopia. Although it can appear in subjects of any age, it is more frequently found after the sixth decade of life, exhibiting a growing prevalence in elderly groups. In addition, the progressive increase of life expectation has led to a substantial increase in the prevalence of cataracts that affect a growing proportion of the population. Even though until now we haven’t found cataract prevalence studies in Spain, by extrapolation of the data of other countries with populations having similar characteristics it can be deduced that the prevalence of cataracts varies between 5% and 30%. This increase in the prevalence of cataracts, together with the increased requirements for very good visual capacity in advanced societies, has made cataracts surgery one of the most frequent surgical operations in our societies. For instance, in the USA about 1.8 million such operations were carried out in 2004.

On the other hand, technological developments require highly efficient surgical techniques, and this enhances the patients’ demands for the best post-surgery refractive result which, on many occasions, cannot be reached because, among other facts, it is difficult to achieve a precise calculation of the intra-ocular lens.

The objective of this study is to analyze the refractive and visual results obtained in cataracts surgery on the basis of the axial length (AL) and age in order to identify their repercussion in post-surgery results.

Material and method

We reviewed the clinical records of all patients submitted to cataracts surgery in 2006 by a single surgeon. The patients who exhibited complications and incomplete records were excluded. The data of 171 eyes were obtained, of which we analyzed visual acuity, axial length and post-surgery refraction. All the subjects had the same surgical technique, and the same type of intra-ocular lens had been implanted (AJL Miñano, Álava, Spain. Mod. Y601075).

Each subject was submitted to ultrasound biometry with OTIScan-1000 in both eyes (OTIScan-1000 3D/B/A-Scan Ophthalmic Ultrasound. OTI Technologies Inc. Toronto, Ontario, Canada). Previously, one drop of anesthetic eye solution was administered (Colircusí Anestésico Doble. Alcon Cusí S.A. El Masnou, Barcelona, Spain). If the subject was allergic, said anesthetic was substituted by one drop of 2% lidocaine (Lidocaine Braun. Braun Medical S.A. Melsungen, Germany).

The keratometry was made with the RK-2 automated kerometer (AutoRef-Kerometer RK-2. Canon Inc. Nueva York, USA), taking three consecutive measurements and utilizing the mean values found by the instrument.

All the tests were carried out by personnel trained in the use of said instruments in order to avoid errors attributable to the learning curve.

The explorations were made according to manufacturers’ indications, so that the OTIScan-1000 biometry obtained the four
best captures, understanding as such those which exhibited the lowest standard deviation value in the axial length measurement, which in all cases had to be under 0.1 mm.

The statistical analysis was made with SPSS 14.0 for Windows (SPSS, Chicago, Illinois, USA). The mean values for uncorrected visual acuity (ucVA) and corrected visual acuity (cVA) after surgery and post-surgical refraction. We also calculated the 5% reduction mean of cVA (the arithmetic mean calculated after eliminating 5% of the lowest and highest observations).

A variance analysis (ANOVA) with Bonferroni correction was made to identify differences between the different age groups classified in three groups: under 40, between 40 and 60 and over 60; and between different axial lengths (AL) (differentiated in three groups: <22 mm, 22 - 25 mm and >25 mm). A p=0.05 value was taken as statistically significant.

The degree of independence between the post-surgical result (ucVA, cVA and refraction) and age and AL was assessed with a Chi square test ($\chi^2$), taking value of p=0.05 as statistically significant.

Results

The results of 171 eyes with cataracts surgery were analyzed. 67.3% were females and 32.7% were male, with a mean age of 68.54±14.05 (confidence interval [CI] 95% from 66.38 to 70.71 years) which is slightly lower than that found by other authors in similar studies (75.42 years, 71 years, 69.5 years).

The mean AL was of 24.22±2.60 mm (CI 95% from 23.82 to 24.61 mm), which matches the results of other studies that analyzed AL measured with different biometers. The results of said studies show an AL of 24.37 mm measured with the optic biometer and of 23.43 mm measured with the contact biometer.

Uncorrected visual acuity

The mean ucVA obtained 30 days after surgery was of 0.60±0.33 (CI 95% from 0.55 to 0.65) in the decimal Snellen scale. 52% of operated eyes exhibited a VA ≥ 0.5 thirty days after surgery. This value is dependent on AL ($\chi^2=0.014$) and independent of age ($\chi^2=0.259$), as it was observed that only 23.8% of eyes with AL <22 mm achieved an ucVA over 0.5.

No statistically significant differences were found (p=0.174 ANOVA) in the ucVA values in any of the three age groups, although higher VA values were observed in subjects under 40 years of age (fig. 1). When analyzing the influence of age in cVA or spherical refraction, no statistically significant differences were found (p=0.118 and 0.472 respectively) between the three age groups.

However, statistically significant differences were observed in the ucVA values obtained by each AL group, with a higher ucVA in eyes with AL between 22 and 25 mm (fig. 2).

Post-surgical refraction

Thirty days after surgery, the spherical component of the mean subjective refraction was of –0.28±1.15 dioptres (D) (CI of 95% from –0.49 to –0.08 D). When analyzing the spherical component of refraction without considering the sign (absolute value), we found a mean of 0.89±0.78 D (CI of 95% from 0.75 to 1.03 D). The value of the subjective refraction cylinder was always measured with a negative sign and exhibited a mean value of –0.81±0.87 D (CI of 95% from –0.96 to –0.66 D).

When analyzing the spherical component of post-surgery refraction for the 3 AL (fig. 3), statistically significant differences were found. In this case, eyes having AL <22 mm exhibited the results most further away from emmetropia with a mean of –0.95±1.91 D (CI of 95% from –2.01 to –0.11).

Over half (50.3%) of the eyes submitted to surgery obtained a spherical value from post-surgery refraction after surgery of±1.00 D; the result is dependent on the AL ($\chi^2=0.021$), so
that 56.6% of eyes with AL values from 22 to 25 mm exhibited refraction values comprised within ±1.00 D. This percentage goes down to 23.8% for the eyes having AL of <22 mm.

Corrected visual acuity

The mean corrected visual acuity (cVA) is of 0.93±0.23 (CI of 95% from 0.89 to 0.97) in the decimal scale, and the mean, cut back to 5% is of 0.95±0.23 with a lowest value of 0.1 and highest value of 1.2. No significant differences were found in cVA in what concerns age groups (p=0.118 ANOVA).

However, differences were found (p=0.007 ANOVA) in cVA with respect to AL (fig. 4). Eyes with AL <22 mm achieved the lowest cVA.

Discussion

In this study we have found a mean ucVA of 0.60±0.33 (CI of 95% from 0.55 to 0.65) in the decimal scale. Statistically significant differences were found between ucVA and cVA in eyes with AL <22 mm and eyes having AL values from 22 to 25 mm. Although there are no studies comparing the refractive result by groups based on AL, it is known that the refractive result in eyes with extreme axial lengths is greater due to the sum of various factors. In very long eyes, it can be partly due to the posterior pole anatomy. In fact, it has been described that eyes with AL values over 30 mm more frequently exhibit posterior staphyloma so that the distance between the cornea and the fovea is between 0.5 and 1.5 mm shorter than the cornea-base distance of the staphyloma, which is where the ultrasound biometer normally measures the AL. Eyes with short AL values require greater precision to maintain the same error margin in the final refraction.9 On the other hand, there are formulae for calculating the intra-ocular lens (IOL), such as the Sanders-Retzlaff-Kraff theoretical formula (SRK/T) that predicts the effective position from the lens (the distance between the cornea and the anterior face of the IOL) depending on the corneal curvature and AL. This prediction is precise in most eyes with standard axial lengths, but mistakes can appear in hypermetropes due to a rupture in the ratio between the AL and anterior chamber depth. In these cases, the prediction of the effective lens position does not follow the normal algorithms of the SRK/Treatment formula. In order to improve this shortcoming, the Hoffer Q formula was developed with new constants that improved the prediction of the effective IOL position and which appears to be more precise than the SRK/T formula in eyes with axial lengths below 22 mm. In addition, in eyes with high myopia values, errors in the effective IOL position have a lower impact in the post-op refraction because the dioptre power of said lenses is very low. The opposite is the case with intra-ocular lenses having high power. The prediction of the effective lens position gains importance because small errors could cause important undesired refractive defects.5 A limitation of this study is that the same formula has been applied to all AL, which could explain poor results in hypermetropes. In any case, we believe that existing studies which assess various formulae are frequently confusing, contradictory and lacking randomization.

The mean spherical value of subjective refraction after surgery is very low (–0.28 D), although it must be taken into account that in the process of finding said mean value, positive spherical refractions are being offset with negative ones, thus yielding a value close to zero. The “true” value of ammetropia can be expressed utilizing the spherical value in absolute terms, which is close to one dioptre. The opposite is the case with intra-ocular lenses having high power. The prediction of the effective lens position gains importance because small errors could cause important undesired refractive defects.5
As regards the value of the post-op astigmatism, a retrospective study of this nature is unable to determine if it was caused by the incision during surgery or the patient had astigmatism previously because the pre-surgical refraction may have been affected by the degree of the cataract.

cVA is not of 1.0 as expected because the total number of patients comprised 45 eyes (26% of the total) with ocular pathologies which could impact visual acuity, such as retina diseases like age-related macular degeneration (ARMD), epi-retinal membranes or retinal thrombosis (26 eyes), amblyopia (2 eyes), previous keratoplasty (1 eye), posterior uveitis (7 eyes), diabetic retinopathy (2 eyes) and other causes (7 eyes).

In what concerns the reduced mean for visual acuity values, it is slightly greater because, when deleting the extremes, the lowest cVAs (0.05 or similar) present in eyes with severe pathologies are avoided, although this also eliminates some patients without pathology that achieved with correction visual acuity levels of 1.2. As expected, this caused a reduction in the corrected visual acuity values below 1.0.

In conclusion, new prospective, randomized and double blind studies are needed to analyze post-surgery refraction and results based on AL in order to determine the extent at which this factor affects the final result. On the other hand, it would be recommendable to know which pre-surgery factors such as biometry, formula type or intra-ocular lens may play a part (and how) in the post-surgery refractive result in order to minimize post-surgery refraction errors and improve outcomes in refractive terms.

REFERENCES