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New frontiers for the perioperative data method for IOL calculation following corneal refractive surgeries

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PURPOSE. *To evaluate the efficiency of the perioperative data method for intraocular lens (IOL) calculation after correction of myopia and hyperopia with different techniques, including reoperated cases.*
METHODS. *Thirty-five eyes (26 patients) that developed cataract after corneal refractive procedures were evaluated retrospectively. They were categorized according to initial error of refraction into myopes and hyperopes and according to types of refractive procedures into ablative, incisional, both, or others. Reoperated cases were also considered. Number of refractive procedures was noted. Time interval between the first procedure and cataract extraction was indicated. Perioperative method was used to calculate the K value. SRK/T formula was used to calculate IOL power. Difference between intended and finally achieved manifest refraction was an indicator for efficiency of the calculation.*
RESULTS. *Postoperatively, 77.2% of cases had manifest refraction ±1.5 D of intended refraction. There was no difference between myopes and hyperopes in terms of final manifest refraction, best-corrected visual acuity, and difference between intended and finally achieved manifest refraction. Similarly were groups of different types of surgeries. Efficiency of the method decreased with high axial lengths and low IOL powers. Neither the number of refractive surgeries nor time interval between surgeries affected efficiency of the method.*
CONCLUSIONS. *The perioperative data method is equally effective for myopes and hyperopes. The types, numbers of refractive procedures, as well as the time interval between refractive surgery and cataract extraction do not alter the credibility of the method. In high degrees of myopia, the method gives less accurate results. (Eur J Ophthalmol 2006; 16: 809-15)*

KEY WORDS. *Cataract surgery, IOL, Refractive surgery, IOL calculation, LASIK, PRK, RK*

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INTRODUCTION

The growth in number of refractive surgeries in the early 1990s was followed by a wave of cataract extraction in the same patients a few years later. Most of the patients were at an age at which they were likely to develop cataract soon. This led ophthalmologists to face a previously existing problem with more decisive solutions. In eyes operated upon by refractive surgeries, corneas are altered. Ablation removes layer from the stroma. Incisions weaken the stroma and redistribution of the pressure according to the new resistance modifies the final shape. Fi-

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nally, procedures like laser thermo keratoplasty (LTK) and conductive keratoplasty (CK) modify the curvature by shrinkage of the stroma. Then corneas possess new criteria upon which traditional means of intraocular lens (IOL) calculation are not applicable. These alterations are as follows:

Improper evaluation of anterior and posterior corneal curvatures by standard keratometry or computerized videokeratography (1)

Improper conversion of K reading into diopters due to change in index of refraction (2)

Improper evaluation of the effective lens position (3)

As a result of these, K of a previously myopic eye is overestimated. Subsequently, the IOL power is underestimated and a residual hyperopia ensues. In hyperopia, the opposite is true (4).

Many solutions were proposed to calculate the proper K. The perioperative data (previously known as clinical history) method (5-7) is the most popular one. A less popular one but one that carries a similar rate of success is the Feiz-Mannis method (8). While in the perioperative data method, values are referred to the corneal plane, the Feiz-Mannis formula refers refraction to the spectacle plane and corrects it by a factor of 0.7 (8). Both methods necessitate the presence of old values that might not be available (8). The contact lens over-refraction method overcomes this drawback. The actual data of the patient in addition to the lens base curve serve to calculate the K value. Still, it is limited by media opacities (9). Rosa and collaborates (10) and Ferrara et al (11) 3 years later each developed their own formula independent from the preoperative values. The first one relied upon a correcting factor for the corneal curvature and the second was based on correcting the refractive index. However, both methods lack further support in the literature.

The perioperative data method was initially designed for cases which have had refractive keratotomy (5-6). However, it solved newly introduced excimer laser ablated corneas. In this method, the refractive change done by the surgery (at the corneal level) is subtracted from the K reading of pre-refractive surgery. This new value is utilized in one of the recent IOL calculation formulae such as SRK/T or Holladay 2 to reach the desired IOL power (1). This method has been extensively studied for myopic cases but to a lesser extent for hyperopic cases. Reoperated cases and cases operated by different types of surgery were not studied altogether.

The aim of the study is to evaluate the efficiency of the perioperative data method of IOL calculation in previously operated and reoperated cases of myopia and hyperopia with different techniques of corneal refractive surgeries.

PATIENTS AND METHODS

This is a retrospective observational consecutive noncomparative study, including 35 eyes of 26 patients. All cases have had one or more type of refractive surgeries. All patients signed a written consent form in accordance with the Helsinki Declaration. No institutional review board approval was required for this study.

Perioperative data

Data were recorded in terms of manifest refraction spherical equivalent (SE), best corrected visual acuity, mean keratometric value, and axial length of the globe, before any refractive procedure was performed (Tab. I).

Data after the last refractive surgery (Tab. II) were recorded: SE of manifest refraction (hence the amount of refractive change), types and numbers of refractive surgeries.

The time interval between the first refractive surgery and cataract extraction was indicated in months.

TABLE I - PREOPERATIVE DATA

	N	Minimum	Maximum	Mean	SD
Pre SE	35	–20	8.25	–5.9	1.33 (SEM)
BCVA	32	0.2	1.0	0.6	0.23
AL	35	19.55	32.6	26.1	3.9
Avg K	35	39.25	45.5	43.6	1.31

Pre SE = Preoperative manifest refraction (spherical equivalent in D); BCVA = Best corrected visual acuity; AL = Axial length; Avg K = Average keratometric value

TABLE II - DATA AFTER THE LAST REFRACTIVE SURGERY

	N	Minimum	Maximum	Mean	SD
Post SE	35	–12	10.25	–0.38	0.64 (SEM)
Ref. change	35	–19	15	–2.89	1.36 (SEM)
Interval	35	22	173	95.28	41.69

Post SE = Manifest refraction after last refractive surgery

TABLE III - CLASSIFICATION ACCORDING TO INITIAL ERROR OF REFRACTION

	N	Age	Male	Female
Myopes	26	52.73±7.89	11	15
Hyperopes	9	57.33±3.84	8	1

Patient classification

Patients were classified according to their initial refractive errors as myopes or hyperopes (Tab. III).

According to the type of refractive surgeries they received, they were also classified as ablative (PRK and LASIK), incisional (for RK and AK), mixed (both types), or others (LTK and CK) (Tab. IV).

TABLE IV - CLASSIFICATION ACCORDING TO TYPES OF REFRACTIVE SURGERIES

	Frequency	Percent
Ablative	22	62.9
Incisional	4	11.4
Ablative/incisional	3	8.6
Others	6	17.1

IOL calculation

K value calculation was done by the perioperative method in all cases:

K value of pre-refractive surgery – refractive change (SE pre-refractive surgery – SE post-refractive surgery)

All values are calculated at the corneal level (5-6). In reoperated cases, K value of the cornea before any procedure was considered as K pre and the last K value after the last refractive procedure was considered as K post.

IOL calculation was done by inserting this new value into SRK/T formula.

All cataract extractions were done by ultrasound phacoemulsification, whether coaxial or bimanual, microincisional. The main incision was always at the steepest meridian of the cornea. No concomitant antiastigmatic correction (relaxing incision, AK) was done in any case at the moment of cataract extraction.

Main outcome measures

At least 1 month after cataract surgery had to pass for evaluation. Postoperative data were recorded in terms of SE of manifest refraction and BCVA. Finally, the difference between the intended and finally achieved refraction was noted and considered as an indicator for efficiency of the calculation (Tab. V).

Statistical analysis

Statistical analysis was done using SPSS V. 10.0 software.

Descriptive statistics were calculated in terms of range (minimum – maximum), mean, and standard deviation (±SD) or standard error of the mean (±SEM).

TABLE V - MAIN OUTCOME MEASURES

	N	Minimum	Maximum	Mean	SD
IOL power	35	6	35.5	21.34	6.37
Postop. ref.	35	–2.25	10.5	0.21	0.38 (SEM)
SE diff.	35	–3.5	11	0.32	0.41 (SEM)
BCVA postop.	30	0.1	1	0.61	0.26

IOL = Intraocular lens; SE diff. = Difference between intended and finally achieved manifest refraction; BCVA = Best corrected visual acuity

Analytical statistics were calculated in terms of Student *t* test to compare between two independent means, correlation matrix and coefficient of correlation using Pearson method r to correlate two variables in the same group, and chi- square test χ^2 for qualitative data.

p Value indicates the level of significance where >0.05=NS (not significant), <0.05=S (significant), and <0.001=HS (highly significant).

RESULTS

The mean age of patients at time of cataract extraction was 53.9±7.31 years (range 38–66). A total of 54.3% were men and 45.7% were women.

The initial error of refraction was myopic in 74.3% (26) and hyperopic in 25.7% (9). The mean error in myopic patients was –9.68±5.17 (range –20 to –1.3). In hyperopia, it was 4.74±2.47 (range 2 to 8.25). In Figure 1 we show the distribution of cases according to their initial refractive error: 14.3% of cases had spherical equivalent more than +3.0 D, 8.6% from +3.0 D to 0 D, 14.3% from 0 D to –4.0 D, 22.9% from –4.0 D to –8.0 D, and 40.0% <–8.0 D.

Regarding the types of refractive surgery done, 62.9% (22) of patients had ablative surgeries only (whether surface or deep), 11.4% (4) had incisional surgeries alone, 8.6% (3) of cases had both types, and 17.1% (6) had at least one of the category “other” refractive surgery (LTK and CK). The last group had at least one or more of the other forms of refractive surgeries, i.e., “others” were not performed alone (Tab. IV).

In terms of number of refractive surgeries, 74.3% of cases had only one surgery and 25.7% had more than one surgery (14.3%, 5.7%, and 5.7% for 2, 3, and 5 surgeries consecutively).

After the cataract extraction, manifest refraction in 37.1% of cases was ±0.5 D and 77.2% of cases were ±1.5 D of intended refraction. A total of 5.7% were on the myopic side and 17.1% were on the hyperopic side. Among the initially myopic patients, 38.5% were ±0.5 D, 76.9% were ±1.5 D, and 23.1% were >+1.5 D. Among the initially hyperopic group, 33.3% were ±0.5 D, 81.8% were ±1.5 D, and 22.2% were <–1.5 D (Fig. 2).

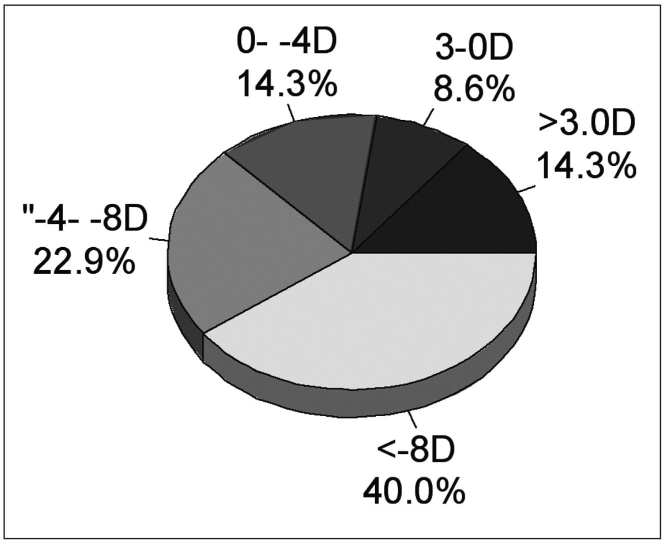

Fig. 1 - *Distribution of cases according to their initial error of refraction.*

By comparing means, a highly significant statistical difference (p<0.01) was found between initial and last manifest refractions. However, there was no significant statistical difference (p>0.05) between initial and last BCVA.

Values between initially myopic patients and initial hyperopes were compared. Both groups were matched in age. There was no statistically significant difference (p>0.05) between both groups in term of initial sim K value. The highly significant statistical difference (p<0.01) between both groups indicates that the type of error was purely axial. At the final stage, there was no statistically

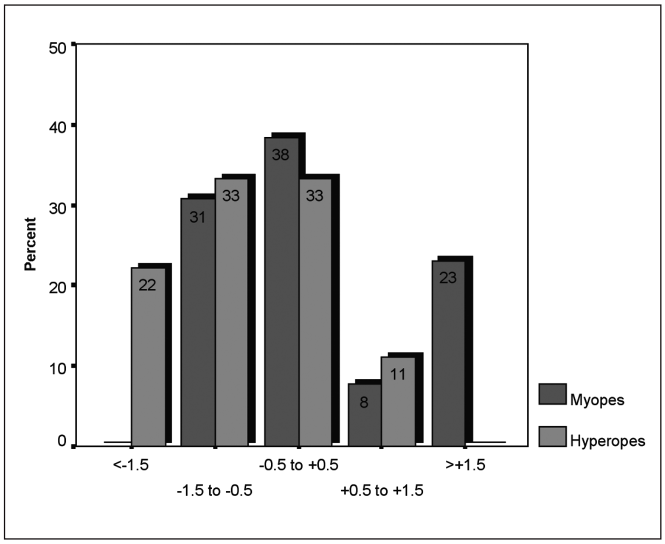

Fig. 2 - *Difference between intended and final achieved refraction.*

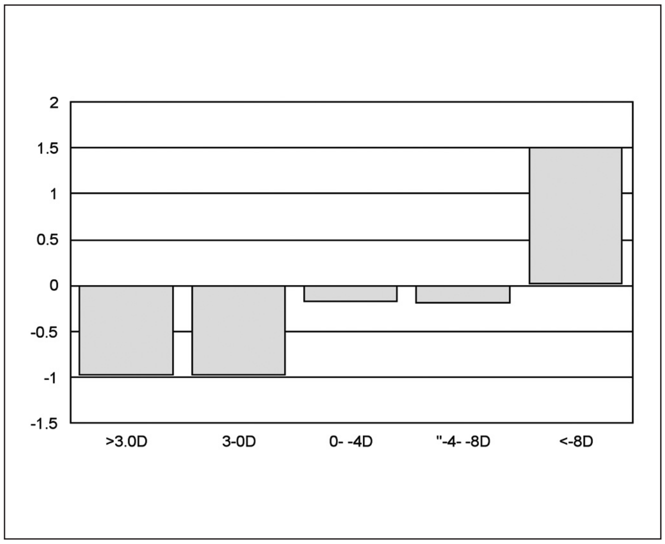

Fig. 3 - *Mean of difference between intended and finally achieved refraction in groups classified according to their initial error of refraction.*

significant difference between both groups in terms of final manifest refraction, BCVA, or difference between intended and finally achieved refraction (p>0.05). For further analysis, according to the error of refraction before any refractive procedure, cases were classified into five groups: Group 1, moderate and severe hyperopia (>+3.0 D); Group 2, mild hyperopia (+3.0 to 0 D); Group 3, mild myopia (0 to –4.0 D); Group 4, moderate myopia (–4.0 to –8.0 D); and Group 5, severe myopia (<–8 D). Groups were compared individually according to the mean value of the difference between intended and finally achieved final refraction (–1.0 D, –1.0 D, –0.2 D, –0.22 D, and +1.5 D consecutively). Except between Groups 1 and 5 and 2 and 5, where the statistical differences were significant (p<0.05), statistical differences were insignificant (p>0.05) (Fig. 3).

By comparing patients who had different types of surgeries, there was no statistically significant difference (p>0.05) between any two individual groups to indicate that the type of surgery might be related to the difference between intended and finally achieved manifest refraction.

At last, the difference between intended and finally achieved manifest refraction was correlated to various parameters. There was a statistically highly significant positive correlation (p<0.01) with the axial length and a negative one with the power of the implanted IOL. There was a statistically highly significant negative correlation (p<0.01) with the sim K after refractive surgery. Finally, there was no statistically significant correlation (p>0.05) with sim K preoperative or with the number of refractive surgeries or with the time interval between the first refractive surgery and cataract extraction.

DISCUSSION

IOL calculation after refractive surgeries is a challenge. Much research has been done on this issue; however, there are many questions to be answered. The perioperative data method is the most popular solution. In our study, we relied upon the perioperative method for many reasons. First, it has a longstanding credibility (since 1989). Second, most of the published work on this issue was done using the same method. Thus comparison of the results would have more significance. Finally, all our patients had a properly preserved long-term filing. All previous data were available and easily compared.

For our cases we utilized the difference between the intended and finally achieved manifest refraction as an indicator for efficiency of the calculation.

Here, up to 37.1% of the patients were + 0.5 D and 77.2% ± 1.5 D. Cases with a difference between the intended and finally achieved manifest refraction >1.5 D (6) were all initially myopes. Five of these had axial length >29.5 mm. Also, the cases with difference between the intended and finally achieved manifest refraction <–1.5 D were originally hyperopes (2). These two cases could not be explained besides their hyperopic origin. Our final results are acceptable but are not as high as previous results obtained, which had in some publications as high as 94% of patients were +1D (12). This discrepancy could be explained by the fact that the cases of this study had a wide range of errors, were operated by different techniques, might have had more than one procedure, and had variable time intervals between different procedures in comparison to other studies. In addition, in this study, the K value was retrieved from autorefractometry, which might be less accurate than topography values.

The aim of our study was to answer new questions rather than establishing the credibility of one method or the other. The first was the handling of the problem facing initially hyperopic patients. In part of the work, the patients were divided into two groups, myopes and hyperopes, according to their initial error of refraction. For all final outcome results, both groups showed no statistically significant difference in terms of final manifest refraction, BCVA, or difference between intended and finally achieved refraction. This proved the credibility of the method to calculate IOL for previously hyperopic patients.

Few publications tackled this issue. In 2002, Wang and coauthors (12) published the only research to our knowledge applying the perioperative method to hyperopia. However, their results stopped at the corneal power calculation level rather than IOL calculation. Other publications concerning hyperopia were using the Feiz-Mannis method (8) and not the perioperative data one.

One important issue that was studied in our work is the different types of refractive surgeries and whether the sensitivity of the method differs accordingly. Previously, incisional types of surgeries named refractive keratotomy were the starting point in this campaign. Going further, PRK and LASIK (ablative types) were fully studied. Still, the credibility between both types was not correlated. In addition, other forms of surgeries, like LTK and CK, which do not depend on either principle, were not considered. Only one study by Packer et al (13) considered LTK, but only for three cases. The method used for calculation was different (the effective refractive power off the Holladay Diagnostic Summary on the EyeSys Corneal Analysis system). In our study, these other forms were considered. Cases were stratified according to the types of surgery they received regardless of their number. Twenty-two (62.9%) cases had only ablative surgeries, 4 (11.4%) cases had incisional surgeries, 3 (8.6%) cases had both types of surgeries, and 6 (17.1%) had at least one of the other forms. Cases of this last group were all initially hyperopes and have all had more than one surgery that was ablative or incisional, or both. By comparing the difference of finally reached and intended refraction as an indicator for efficiency of the calculation, we found no statistically significant difference. This means that the method is equally feasible for all types. We could not consider the initial error during comparison as some surgeries like RK are exclusive to myopia, while others are exclusive to hyperopia, like LTK and CK.

The ocular axial length is a constant variable in IOL calculating formulae. In our study, it was correlated to the difference between the intended and the finally achieved refraction. There was a highly significant positive statistical correlation between both. As mentioned earlier, five out of six cases with difference of >1.5 D had axial length >29.5 mm. Moreover, besides these five cases, four of those who had axial length >29.5 mm were properly calculated (±1.5 D). This is an important factor in the credibility of the method. This might be explained by the fact that eyes with high axial length might have in reality a posterior staphyloma. In these cases measuring the axial length might be inaccurate as the direction of sound vector might be directed to the edge of the staphyloma, its slope, or its base. This leads to a fallacy in the final outcome. This controversy might be solved by using an incorporated B-scan mode to direct the vector to the maximum diameter. It is also suggested in cases of extremely high axial length that IOL calculation would be done by more than one method. When using the perioperative data method, the investigator should stick to the most ideal circumstances. Refraction should be referred to the corneal plane and calculated properly. K values should be referred as much as possible to corneal topography values. After solving the K value, various formulae should be used to reach the IOL power.

In our study, two more factors were correlated to the difference between the intended and finally achieved manifest refraction. Nine (25.7%) cases in this series had more than one surgery (two of them up to five surgeries). This factor was too significant to be considered. However, after correlating the number of surgeries to the difference between the intended and finally achieved manifest refraction, there was no statistically significant correlation.

Again, during data recording, the time interval between the first refractive surgery and cataract extraction was significantly variable (mean in months 95.28±41.69, range 22–173). This was correlated to the difference between the intended and finally achieved manifest refraction and again there was no statistically significant correlation.

This indicates that the perioperative data method is feasible with a wide range of patients, even those who had multiple surgeries or those who passed a long period since they had their refractive surgery.

CONCLUSIONS

The credibility of the perioperative data method is equally feasible for myopia and hyperopia. The types of refractive surgeries performed or the multiplicity of the procedures would not alter this credibility. However, in high myopia (axial length >29.5 mm), this method gives less precise results. In these cases, IOL calculation should be done with more than one method, including this one.

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