

Refractive error after combined phaco-vitreectomy: A multicentric study

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European Journal of Ophthalmology
2023, Vol. 33(2) 1175–1180

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DOI: 10.1177/11206721221143165

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Abstract

Purpose: To study the post-operative refractive error (RE) of patients undergoing combined phaco-vitreectomy and to find out which intraocular lens (IOL)-power formula had the best refractive outcomes.

Methods: In this retrospective multicentric study we compared the preoperative expected target with the postoperative RE of patients undergoing combined phaco-vitreectomy due to vitreomacular traction, macular pucker, full thickness macular hole or lamellar macular hole. A multinomial logistic regression was performed to compare the postoperative REs and the differences between expected and postoperative REs among the SRK-T, Olsen's and Holladay-2 formulas. The correlation between the difference in REs and IOL-power was also studied.

Results: Sixty-seven eyes with a mean axial length of 23.73 ± 1.21 mm were included. Forty-two (63%), 14 (21%) and 11 (16%) eyes were implanted with an IOL that was calculated respectively with SRK-T, Olsen's and the Holladay-2 formula. The mean preoperative expected- and post-operative REs were -0.16 ± 0.12 D and -0.48 ± 0.17 , respectively ($p = 0.045$). SRK-T and Holladay-2 formulas led to a significant myopic shift whereas Olsen's caused a significant hyperopic error, independently from the IOL power.

Conclusion: Independently from the IOL power, none of the analyzed formulas is precise at calculating the post-operative RE.

Keywords

Combined phaco-vitreectomy, IOL-power formula, postoperative refractive error, SRK-T, Holladay 2, Olsen

Date received: 20 July 2022; accepted: 13 November 2022

Introduction

Pars plana vitrectomy (PPV) combined with phacoemulsification was first reported by Koenig et al.,¹ and has since evolved into a very practical and effective technique. The benefits of performing these surgical steps simultaneously include better visualization of the retina during vitrectomy and avoidance of the possible complications associated with the performance of phacoemulsification in an already vitrectomized eye.² Also, phakic patients undergoing PPV as a standalone procedure have been shown to require cataract surgery in up to 87% of cases within 2 years.³ Indeed, combining cataract extraction and vitrectomy could avoid the need for an early reoperation.⁴

When performing phaco-vitreectomy, accurate preoperative intraocular lens (IOL)-power calculation is mandatory

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Table 1. Preoperative macular conditions in the three subgroups.

Disease	Total population	SRK-T	Holladay	Olsen	p
VMT	3/67 (4.5%)	1/42 (2.4%)	2/11 (18.2%)	0/14 (0%)	0.084
ERM	49/67 (73.1%)	33/42 (78.6%)	5/11 (45.5%)	11/14 (78.6%)	
FTMH	15/67 (22.4%)	8/42 (19.0%)	4/11 (36.4%)	3/14 (21.4%)	

to obtain satisfactory refractive results. This is achieved through a precise biometric evaluation and appropriate lens-power-formula selection with optimized lens constants.

Some evidence in the literature suggests that combined phaco-vitreotomy surgery may be more susceptible to mild myopic shifts compared to phacoemulsification and IOL implantation alone.⁵ However, the exact postoperative refractive error (RE) and the exact causes of this shift remain uncertain.

The device used for axial length (AL) measurements may be one of the sources of error. Kovács et al. revealed a myopic shift when the refractive target was calculated through an ultrasound biometry and proposed that a thicker retina could have led to an underestimation of the distance between the cornea and the photoreceptor layer.⁶ Indeed, while ultrasound biometry measures the distance between the anterior corneal surface and the internal limiting membrane, optical biometry detects the anterior corneal surface and the retinal pigment epithelium.⁷

Studies regarding the refractive outcomes after phaco-vitreotomy in patients with AL measurements calculated via the IOLMaster device (Carl Zeiss Meditec AG) have provided conflicting results, some identifying a myopic shift and others denying it.^{8–10} On the other hand, there is some evidence suggesting that calculations made using swept-source optical coherence tomography are more reliable.¹¹

The aim of this multicentric study was to point out the RE after combined phaco-vitreotomy using optical biometry and to determine which IOL-power formula (among SRK-T, Olsen's and Holladay-2) would be more precise in these cases.

Methods

This retrospective multicentric study was conducted in accordance with the tenets of the Declaration of Helsinki and included data from five different Italian medical centers (i.e., Fondazione Policlinico Universitario A. Gemelli – Rome, University Hospital of Pisa, University Hospital of Torino, University Hospital of Verona and the Hospital of Casale Monferrato).

We retrospectively analyzed clinical and biometrical values of patients who underwent combined phaco-vitreotomy with internal limiting membrane peeling due to one of the following macular disorders: vitreomacular traction, macular pucker,

full thickness macular hole and lamellar macular hole.¹² All retinal abnormalities were confirmed by a preoperative optical coherence tomography B-scan. Patients suffering from other concomitant macular disorders (e.g., diabetic macular edema, retinal vein occlusion-related macular edema) as well as those without an emmetropic target (0 ± 0.25 D) were excluded from the study. High myopic (axial length > 26 mm) and high hypermetropic (axial length < 20 mm) eyes were also excluded from the study.

For each patient we compared the preoperative expected target (calculated as spherical equivalent), with the actual objective postoperative (between 4- and 6-months post operatively) RE (also calculated as spherical equivalent). This was made considering three different IOL-power formulas (i.e., SRK T- Group 1, Olsen – Group 2, Holladay 2 – Group 3), which were then compared with regards to their preciseness.

Statistical analysis was conducted using SPSS v26 (IBM Software). Sample size calculation was performed considering an 80% power, an alpha error of 5% and a significant difference in expected and effective RE of ± 0.25 D. Normality of the distribution for quantitative variables was tested using Shapiro-Wilk test. Quantitative variables were described using mean and standard deviation whereas the number of cases over total and percentage were used for qualitative variables. Multinomial logistic regression was used for comparison of quantitative and qualitative variables between groups. A two tailed T test for dependent samples (pairwise) was used to assess the significance of the difference between expected and effective RE in the total population and for each of the subgroups.

All included patients were implanted with an IOL having an A constant of 118.7 and all biometric data were acquired via the same infrared-based Biometer (Lenstar, Haag-Streit, Köniz, Switzerland).

Results

We included 67 eyes of 67 patients with a mean age of 70 ± 7.06 years, 37 (55.2%) of which were males and 30 (44.8%) were female. Forty-nine patients (73%) were operated because of a clinically significant epiretinal membrane, 15 (22%) had a full thickness macular hole, and 3 (4.5%) a vitreomacular traction. Air tamponade was used in 48 cases (71.6%) while SF6 was applied in the rest (28.4%). The mean axial length was 23.73 ± 1.21 mm, with a mean ACD of 2.91 ± 0.48 mm. Forty-two patients

(63%) were implanted with an IOL that was calculated using the SRK-T formula, 14 patients (21%) with Olsen's formula and 11 patients (16%) with Holladay-2's.

There were no statistically significant differences in any of the preoperative clinical characteristics (i.e., age- $p = 0.482$, sex- $p = 0.64$, and disease- $p = 0.084$ – Table 1) nor in the axial length ($p = 0.173$) amongst these three sub-populations.

Group 3 was treated more frequently with SF6 (7/11, 63.6%, $p = 0.018$) and had a significantly higher mean K max ($p = 0.041$) than the other groups.

While the mean expected postoperative RE (i.e., -0.16 ± 0.12 D) did not differ ($p = 0.159$), the post-operative RE was significantly different amongst the various groups, i.e., -0.60 ± 0.12 D in group 1, $+0.09 \pm 0.14$ D in group 2 and -0.56 ± 0.22 D in group 3 ($p = 0.032$).

The difference between expected and postoperative RE resulted to be statistically significant in all groups ($p < 0.05$), (Table 2).

The relation between IOL power and difference between expected and effective RE for SRK-T, Olsen

and Holladay-2 formulas is shown in Figures 1–3, respectively.

Discussion

The results of this study suggest none of the three analyzed formulas is precise enough at estimating the post-operative refractive outcome in patients undergoing combined phaco-vitreectomy with ILM peeling-procedures. While the SRK-T and the Holladay 2 formulas led to a myopic shift, Olsen's seems to be affected by a hypermetropic error.

Overall, there still isn't enough evidence in the literature to support the use of one IOL-power formula or the other in these patients. Indeed, ours is amongst the few studies to analyze the topic of final combined-phaco-vitreectomy RE distinguishing between the different IOL power formulas.^{13,14} Also, to our knowledge, this is the first study to look for a relation between IOL-power and the difference between expected and final RE.

Since most of our patients underwent a myopic shift, one could suppose that it is actually the AL measurement-method to be biased. Despite there still being debate on this topic, a recently published meta-analysis on optical vs ultrasound-based biometry, found a mean RE of -0.1 D (clinically insignificant), when the former is used.⁵ Nonetheless, there are several other factors influencing the final RE other than the instrumentation used for biometric assessments and the IOL power calculation-formulas themselves. In patients undergoing combined

Table 2. Results of paired analysis for each formula.

	Expected RE	Postoperative RE	p
Total population	-0.16 ± 0.12	-0.48 ± 0.17	0.0455
SRK-T	-0.09 ± 0.16	-0.60 ± 0.12	0.0167
Holladay 2	-0.12 ± 0.18	-0.56 ± 0.22	0.002
Olsen	-0.25 ± 0.09	$+0.09 \pm 0.14$	0.0243

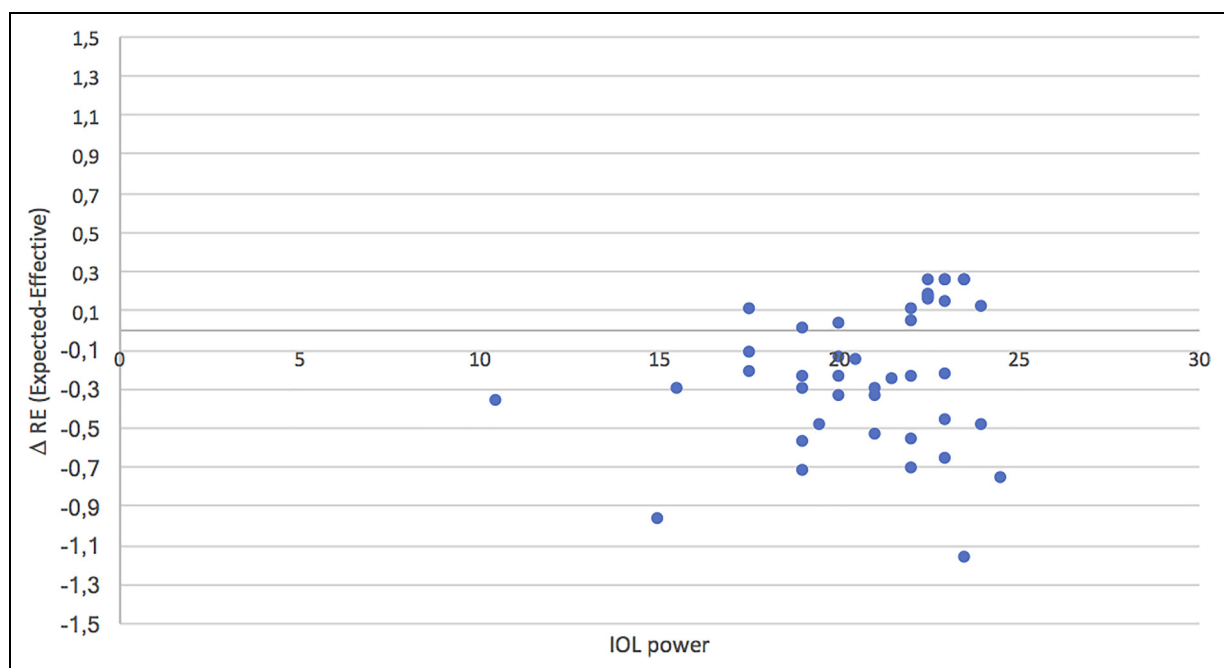


Figure 1. Variation of expected – postoperative RE with different IOL powers using the SRK-T formula.

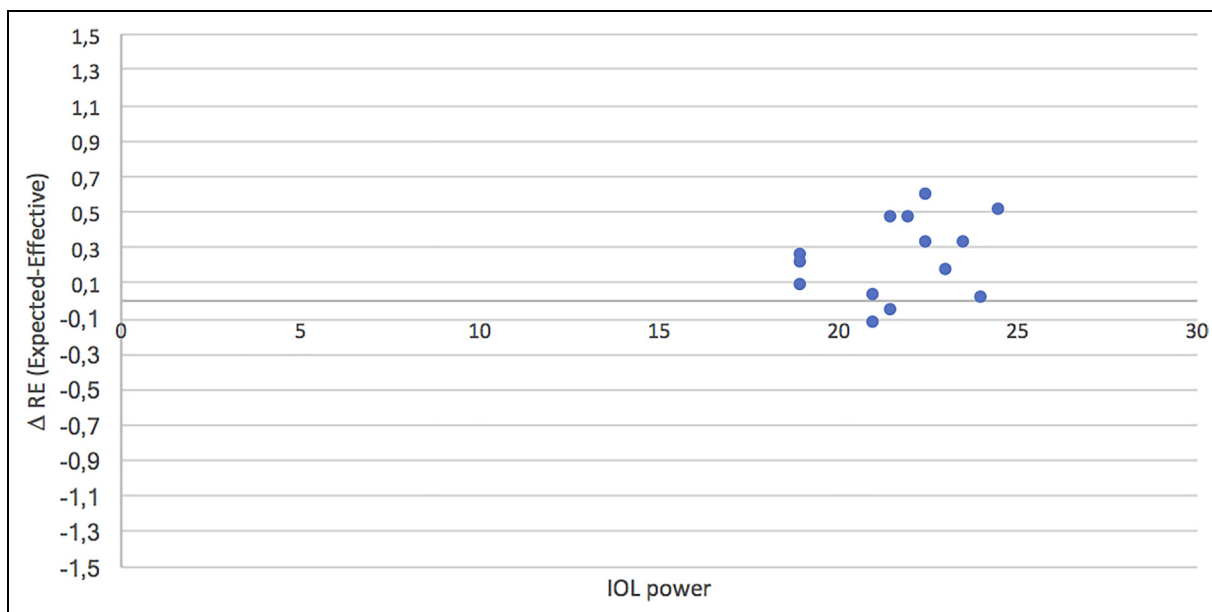


Figure 2. Variation of expected – postoperative RE with different IOL powers using Olsen's formula.

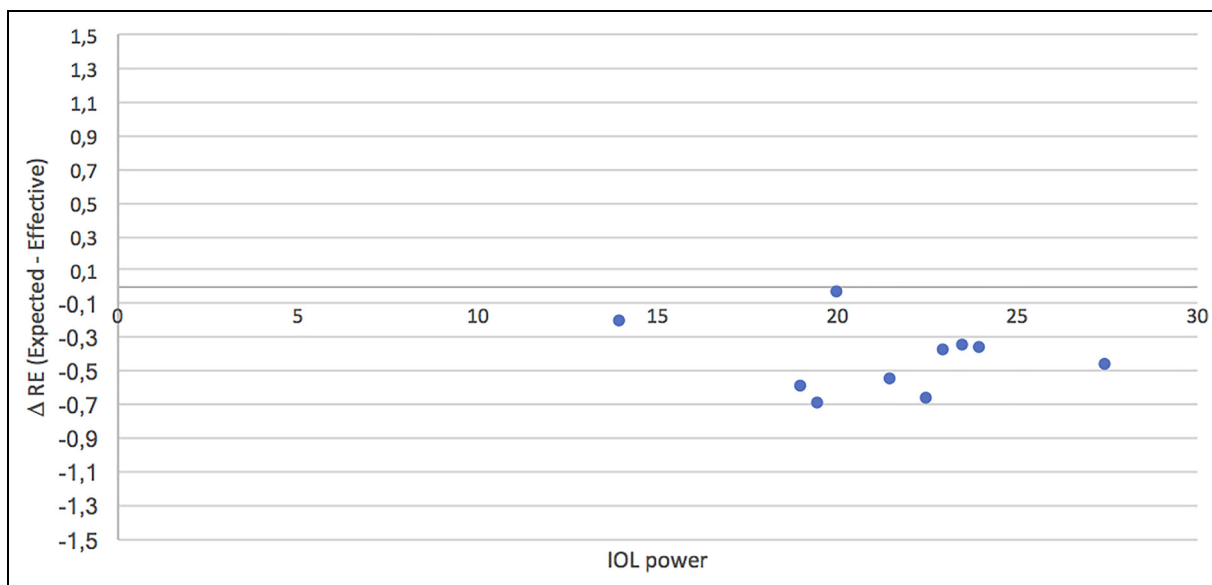


Figure 3. Variation of expected – postoperative RE with different IOL powers using the Holladay-2 formula.

phaco-vitreotomy, anterior chamber depth (ACD) changes and the modification in the refractive indices of the posterior chamber (i.e., from vitreous to aqueous humor), should always be taken into consideration. While the preoperative estimation of the exact effective lens position (ELP) has already been described as a difficult task in these eyes,¹⁵ the change in refractive index from 1.3346 (vitreous) to 1.3336 (aqueous humor) has also been defined as a possible cause of a postoperative myopic shift.¹⁶

Our results are consistent with both those from Hipólito-Fernandes et al.¹³ and those from Vounotrypdis et al.¹⁴ The latter group of study analyzed 8 different optimized IOL-power formulas (i.e., Barrett, Haigis, Hill, Hoffer, Q, Holladay 1, Holladay 2, Kane, and SRK-T), and despite the Kane and the Holladay 2 being more precise, they found a myopic shift with all of them. Even though both were affected by a myopic shift, the superiority of the Holladay 2 over the SRK-T formula has been

suggested also by Hötte et al.¹⁷ (i.e., $-0.05D$ vs $-0.19D$ shift). On the other hand, despite a seemingly better performance of the Kane formula, Hipólito-Fernandes et al.¹³ could not find a statistically significant difference between the various biometric formulas (Barrett Universal II, EVO 2.0, Haigis, Hoffer Q, Holladay 1, Kane and PEARL-DGS), all of which were affected by a myopic shift.

Interestingly, for the first time our results seem to exclude a correlation between the power of the IOL and the difference between expected and final RE. Like others, in order to obtain satisfactory refractive outcomes, we think it is mandatory for the surgeon to use personal optimized A constants.

Finally, we should not forget that the results of this study depend on the actual preciseness of the considered formulas based on cases of phacoemulsification and IOL procedures as standalone procedures. Indeed, for cataract surgery various studies suggest that the Holladay 2 and Olsen formulas might predict the postoperative RE in a more precise way than the SRK-T.^{18–20}

The small number of patients and the circumscribed number of analyzed formulas represent some of the limitations of this study. However, differently from others, this multicentric study has included Olsen's formula and has analyzed the variations associated with different IOL powers. Importantly, the outcomes of our study cannot be applied to any patient in a straightforward manner. In fact, the mean AL of our population was around 23.7mm (high myopes and hyperopes were excluded) and the IOL that was implanted had an A constant of 118.7. However, our results might apply to patients undergoing two separate procedures, i.e., cataract surgery first and vitrectomy with ILM peeling afterwards, since this approach is affected by the same biases as those present when combining the two operations.

When the AL lays within the range of normality, independently from the IOL power, our study suggests that while SRK-T and Holladay-2 formulas are both subject to a myopic shift, Olsen's is affected by a hyperopic error. To confirm these results, we advocate performing larger randomized controlled trials.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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