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Accuracy of intraocular lens power estimation in eyes having phacovitrectomy for rhegmatogenous retinal detachment

Abbreviated title: IOL accuracy in phacovitrectomy for RRD

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Key words:

Biometry; phacovitrectomy; rhegmatogenous retinal detachments

Summary Statement:

Combined phacovitrectomy as primary repair surgery for rhegmatogenous retinal detachment (RRD) included a small biometric error that was within the tolerable range in most cases. The biometry used for IOL power selection must be checked by comparing with the fellow eye and the known refraction, especially in macula-off RRD cases.

ABSTRACT

PURPOSE: To evaluate the accuracy of intraocular lens (IOL) power estimation in eyes having phacovitrectomy for rhegmatogenous retinal detachment (RRD).

METHODS: Retrospective case series review of 100 consecutive eyes that underwent phacovitrectomy for RRD. Axial lengths (ALs) were measured using optical biometry and/or ultrasound. Achieved and predicted refraction were compared to calculate the mean postoperative refractive prediction error and the mean absolute prediction error (MAE). Factorial analysis of variance (ANOVA) models were developed to assess outcome overall and between subgroups.

RESULTS: 95 eyes had postoperative refraction; 41 macula-on (43%), 54 macula-off (57%). The mean postoperative prediction error was -0.34 ± 0.89D. There was no statistical significant difference in the refractive outcomes between macula-on and macula-off groups ($p > 0.05$). Overall, using MAE as the outcome measure, optical biometry was more accurate then ultrasound ($p = 0.040$). However, significantly more ultrasound measured ALs were selected for IOL power estimation in macula-off group compared to the macula-on group ($p = 0.016$).

CONCLUSIONS: Combined phacovitrectomy in RRD included a small biometric error that was within the tolerable range in most cases. The accuracy of AL used for IOL power calculations must be checked by comparing with the fellow eye and the known refraction, especially in macula-off RRD cases.

INTRODUCTION

Patients with rhegmatogenous retinal detachment (RRD) often have coexisting cataract at presentation. Nuclear sclerotic cataract is also a common complication of vitrectomy, and patients with previous vitrectomy often require subsequent cataract surgery for visual rehabilitation.[1] Combined phacoemulsification and pars plana vitrectomy (phacovitrectomy) has become a common procedure in many vitreoretinal diseases as a result of the continual advances in both cataract and vitrectomy surgery, and favourable patient outcomes.[2, 3] The combined procedure is more time-consuming and technically a slightly more challenging procedure, but reduces costs and offers quicker visual rehabilitation by avoiding the need for additional surgery and allowing a single recovery period.[4-6] The aphakic state during surgery also gives excellent visibility and ensures unimpeded view for treatment of peripheral pathology.[7]

As the anatomic success of combined surgery has improved, greater attention has been directed toward reducing refractive error to maximise postoperative visual function. Refractive results of phacovitrectomy for macular pathology have been shown to be comparable to cataract surgery outcomes.[8, 9] However, little is known about the postoperative refraction after phacovitrectomy surgery for RRD repair. The presence of a detached retina is likely to make axial length (AL) measurements more challenging. Other variables that could affect refractive outcomes in combined surgery include procedure type, surgical technique, patient age, and use of adjunctive measures such as silicone oil.[10]

The accuracy of AL measurement is crucial for intraocular lens (IOL) power calculation. Optical non-contact biometry has been shown to achieve a high degree of accuracy of IOL power estimation in patients having phacovitrectomy for macular hole or pucker.[9] However,

it was our clinical observation that when used for AL measurements in RRD, optical biometry tends to underestimate the true AL, especially in macula-off cases. Hence we conducted a retrospective analysis of the refractive outcome of all RRD cases undergoing phacovitrectomy as primary repair to evaluate the accuracy of AL measurement by different methods.

METHODS

This retrospective study comprised 100 eyes of 96 consecutive RRD patients who had combined phacovitrectomy surgery from January 2007 to February 2012 by the same surgeon. The adequacy of the sample size to detect effects small to medium in magnitude ($R^2 < 0.1$) at standard levels of power and significance was verified using a power calculation.

ALs were measured using either or both IOLMaster (Carl Zeiss version 5.4, Oberkochen, Germany) and Nidek (EchoScan US-1800, Gamagori, Japan) prior to phacovitrectomy at presentation of RRD. Skilled operators performed 10 reliable readings using IOLMaster and/or Nidek Ultrasound on all patients. IOL power was calculated using SRK/T formula, as it is accurate across a range of ALs[11], using the manufacturer's recommended A-constant. The refractive status in the fellow eye determined the refractive aim in the operated eye.

The choice of AL measurement method in this study was based on our current protocol for AL estimation in the presence of RRD. In all patients with RRD the AL was first evaluated with IOLMaster, if the AL measured was shorter than the fellow eye in the absence of significant difference in refractive error, then Nidek was used to verify the AL measurement. In cases where both IOLMaster and Nidek measured the AL shorter than the fellow eye, then

the surgeon used the fellow eye's AL meaurements provided there was no significant difference in refractive error.

Phacoemulsification was performed through a 2.75mm or 2.2mm clear corneal incision. A 3-port 23-gauge pars plana vitrectomy was then performed and subretinal fluid was internally aspirated. Fluid-air exchange was followed by retinopexy using endophotocoagulation and/or cryotherapy. A one piece injectable acrylic IOL was implanted into the capsular bag (with capsulorhexis no larger than IOL optic diameter) followed by endotamponade with gas (either SF_6, C_2F_6 or C_3F_8 gas) or silicone oil. None of the patients had any sclera buckling combined with vitrectomy. Only patients who achieved anatomical success were included in the study. Patients with intraoperative posterior capsule rupture necessitating sulcus fixation of IOL at the time of primary surgery were excluded.

Refraction was performed at least 12 weeks after surgery (silicone oil removed if used) upon full recovery and no cystoid macular oedema. Where possible, subjective refractions by community/high-street optometrist were used, otherwise autorefractions were recorded. The achieved postoperative refraction was expressed as a spherical equivalent. The main outcome measure was refractive prediction error, obtained by subtracting achieved postoperative refraction from the predicted refraction. Mean prediction error (ME) and mean absolute prediction error (MAE) were used as the outcome measures.

The number and percentage of patients with an achieved refraction within ±0.50 dioptre (D), ±1.00 D, ±2.00 D and more than ±2.00 D of the refractive aim was recorded. The equipment used for biometry (IOLMaster or Nidek) was recorded for each eye in the study, together with the tamponade medium (gas or silicone oil).

Descriptive statistics were derived for all eyes in the analysis, and for sub-groups of eyes partitioned by equipment used and macula status. Factorial analysis of variance (ANOVA) models were developed to assess the ME and MAE outcome overall and between subgroups.

RESULTS

A. Refractive outcomes of intraocular lens implanted

Five eyes were excluded from the analysis due to lack of any form of refraction. Thus 95 eyes were included in the analysis (83 subjective refractions, 12 autorefractions). Patients had mean age of 61.9 years; 50 (53%) were men. Of the 95 eyes, 41 (43%) were macula-on RRD and 54 (57%) were macula-off. The AL measurement selected and used for biometry calculation and tamponade agent used are listed in Table 1.

The overall refractive prediction error ranged from +2.06 D to -3.11 D. 47 eyes (49.5%) had refractive prediction error within ±0.50 D; 72 eyes (75.8%) were within ±1.00 D; 89 eyes (93.7%) were within ±2.00 D; and 6 eyes (6.3%) were >±2.00 D (Figure 1).

1 macula-on eye and 5 macula-off eyes had refractive prediction error of more than ±2.00 D. There was no significant association between macula status and the outcomes of eyes achieving the refractive aim ±0.50 D ($\chi_{(1)}^2$=0.896, p=0.344); eyes within ±1.00 D ($\chi_{(1)}^2$=0.201, p=0.654); and eyes within ±2.00 D ($\chi_{(1)}^2$=1.83, p=0.176).

An overall small myopic shift of -0.34 D (SD 0.89 D) was noted. Descriptive statistics (Table 2) indicated that the ME and MAE values were lower in eyes with AL measured by

the IOLMaster equipment than with the Nidek equipment, with similar variability in both groups. ME and MAE were also lower in the macula-on group than in the macula-off group. When eyes were partitioned by both equipment type and macula status together, the lowest ME and MAE values were found in macula-on group using AL measured by the IOLMaster, and the highest ME and MAE values were found in macula-off group using AL measured by the Nidek equipment.

Using MAE as the outcome measure, a factorial ANOVA performed on the overall data set found IOLMaster to be statistically significantly more accurate than Nidek in measuring AL in eyes with RRD ($F_{(1,91)}=4.34; p=0.040$). The factorial ANOVA model also showed that neither the tamponade medium nor the equipment-medium interactions were significant. No main effects or interactions were found to be significantly associated with the ME outcome measure (Table 3).

As shown in Tables 4 and 5, factorial ANOVAs did not find a statistically significant difference in ME or MAE using either equipment when performed on the macula-on and the macula-off subgroup ($p>0.05$). Similarly, neither the tamponade medium nor the equipment-medium interactions were found to be significant.

AL measurements used for biometry calculation in our study ranged from 21.7 mm to 29.7 mm, with a mean length of 24.9 mm (SD 1.61 mm). AL measurements were not found to statistically correlated with either refractive prediction error ($r=0.069$, $p=0.507$) or absolute refractive prediction error ($r=0.033$, $p=0.754$).

40 eyes had AL re-measured post-operatively after at least 8 weeks using IOLMaster. There was no statistical significant difference between the selected AL used for calculating biometry preoperatively and the AL measured post-operatively (*p*=0.845).

Preoperatively, 90.2% of the macula-on RRD eyes and only 5.4% of macula-off eyes had a best corrected visual acuity (BCVA) of 6/12 or better (Table 6). The macula-off RRD group showed significantly improvement in BCVA post-operatively, with 52.7% achieving 6/12 or better BCVA.

B. Potential refractive outcomes if alternative axial length used for biometry instead

37 eyes had an alternative AL that were deemed by the surgeon as the lesser accurate AL and hence not used for actual biometry calculation. The difference in IOL power if the alternative AL were used instead range from +1.50 D to -18.50 D, with mean difference of -2.94 D (SD 4.82 D), and mean absolute difference of 3.31 D (SD 4.57 D).

22 macula-off eyes had AL measured by both IOLMaster and Nidek. AL measured by IOLMaster was on average 0.98 mm (SD 1.55 mm) shorter than the corresponding recordings made by Nidek. Significantly more Nidek-measured ALs compared to IOLMaster measurements were selected for IOL power calculation in the macula-off group than the macula-on subgroup (*p*=0.016).

DISCUSSION

To the authors' best knowledge, this study is the largest analysis of refractive outcome of eyes after combined phacovitrectomy for RRDs to date. The sample size was such that the study had sufficient power to successfully detect at least a small-to-medium sized effect of the equipment or tamponade on the outcome.

Accurate measurement of the AL is essential for preventing significant refractive error postoperatively. This can often be difficult in eyes with RRDs. Our study showed that overall IOLMaster appeared to be superior to Nidek in AL measurement (p=0.04), which is consistent to previous studies of normal eyes. [12-14] However, such significant finding from the full data set was not replicated on either of the subgroups (macula-on and macula-off) considered in the second series of analysis. This is not unexpected as a statistically significant finding would be unlikely in a retrospective audit such as this one, in which the more accurate AL is selected for biometry calculation *a priori* based on the surgeon's clinical experience. Furthermore, the lower sample size of the sub-groups analyses leads to reduced power of comparison.

To perform a *post hoc* assessment of the suitability of the AL selected for biometry for each case, an alternative IOL power calculation was made corresponding to the use of AL measured by the alternative method, and the difference between the actual IOL power used and the alternative power was determined. The mean absolute difference in IOL power if the alternative AL were used in those 37 eyes was 3.31 D (SD 4.57 D). Such a large difference in power implies the potential for a substantive difference in the refractive outcome if the more accurate AL had not been selected.

We have shown that there is no statistically significant difference in the mean refractive outcome in macula-on and macula-off RRD using our current AL selection method. This would also imply that there is no evidence of systematic selection of inappropriate AL during the decision-making process. In addition, there was no statistical significant difference between the selected AL used for calculating biometry preoperatively and the AL measured post-operatively after retinal reattachment (p=0.845).

IOLMaster appeared to be generally more accurate than the Nidek equipment, with a mean improvement of 0.18 D in the macula-on subgroup and a mean improvement of 0.12 D in the macula-off subgroup. However, it has also been noted in our study that Nidek measured AL were more frequently selected for calculating IOL power in the macula-off cases than the macula-on group (p=0.016).

IOLMaster is based on the principle of dual beam partial coherence interferometry.[16] Its high precision, resolution, accuracy, and reproducibility of the AL measurements of normal eyes have been demonstrated.[17, 18] However, optical biometry is not without its limitations. It is not suitable in dense ocular media and non-optimal fixation.[19, 20] Lege et al[21] has also reported the disadvantage of optical biometry revealed in cases of RRD. In clinical practice, we have noticed that IOLMaster can underestimate the true AL measurements in macula-off detachments especially in those with bullous RRD in spite of good signal-to-noise-ratio (SNR) readings. This was shown in the subgroup of 22 macula-off eyes which had AL measured by both IOLMaster and Nidek. The AL measured by IOLMaster was on average 0.98 mm (SD 1.55 mm) shorter than the corresponding recordings made by Nidek.

There may be several explanations for the underestimation of AL by IOL master in the setting of macula-off RRD. Patient ability to fixate is essential for accurate optical biometry measurements as it evaluates the AL along the visual axis, whereas ultrasonic biometry measures along the optical axis. Patients with RRD, particularly those with macula-off RRD, may have non-optimal fixation due to reduced vision or dense ocular media caused by vitreous haemorrhage. Usually optical biometry measures from the front of the cornea to the retinal pigment epithelium, but sometimes an even higher peak, (apparently corresponding to the inner limiting membrane) is detected anteriorly. In macula-off RRD eyes, a similar strong interference from interfaces in the detached retina will give a good SNR measurement, although the result is incorrect.[21] Light scattering of the incoming and outgoing rays can also cause inaccurate AL measurements. In clinical practice, we have noticed that shorter AL were more consistently noted in bullous macula-off RRD than shallow detachments of macula, so possibly the amount of subretinal fluid under the macula may serve as an impediment to light penetration resulting in erroneous measurement. Therefore the advent of the optical biometry has not rendered ultrasonic biometry obsolete. There are pearls and pitfalls as with all devices, so the surgeon must be vigilant when interpreting the readings and disregard erroneous measurements accordingly.

The AL measurements for biometry in our study were not found to statistically correlated with either refractive prediction error (r=0.069, p=0.507) or absolute refractive prediction error (r=0.033, p=0.754). Similar observations were reported by Manvikar et al[9] who studied eyes that had undergone small gauge combined phacovitrectomy surgeries. However, in a study of 20-gauge phacovitrectomy surgery, Jeoung et al[2], found that myopic shifts developed in eyes with longer AL (>24.5mm) and that the shift was associated with an increase in AL.

The mean refractive prediction error in our study was -0.34 D. Other studies have also reported a similar myopic shift after combined phaco-vitrectomy surgery.[2, 3, 7, 8, 22, 23] Previous authors have suggested that aiming for residual hyperopia, using Haigis formula for biometric calculation[9] or using individualised surgeon's A-constant may help to counteract the myopic shift.

Previous studies in eyes that had phacovitrectomies have shown that postoperative refractive error was not influenced by the intraocular air or gas tamponade.[2, 9] Our analysis showed that the postoperative refractive prediction error was not influenced by gas or silicone oil tamponade in phacovitrectomy for eyes with RRD.

The achieved refractive results after combined phacovitrectomy for RRD in our study are comparable to those in studies of phacoemulsification alone. In our study, 75.8% of eyes were within ±1.00 D of the refractive aim. A study of refractive outcomes after phacoemulsification in 1978 eyes found that 73% were within +/-1.00D of the intended refraction.[24]

This retrospective study is not without other limitations. The individual subgroups are small and may not have adequate power when performing subgroup analysis. A direct comparison group of eyes with previous pars plana vitrectomy for RRD which then undergo subsequent phacoemulsification may be useful.

CONCLUSION

This single-surgeon retrospective case series review has shown that combined phacovitrectomy in RRD included a small biometric error that was within the tolerable range in most cases. Optical biometry may be more accurate than ultrasound in measuring AL, but its accuracy must always be checked by comparing with the fellow eye and the known refraction. When there is clinical doubt about the validity of the AL measurement, the ultrasound AL measurement should be obtained for comparison. The advent of the optical biometry has simplified considerably the process of ocular biometry, but ultrasound biometry must not be rendered obsolete as a significant number of eyes will still require it for accurate measurements.

REFERENCES:

1. Thompson JT, Glaser BM, Sjaarda RN, et al. Progression of nuclear sclerosis and long-term visual results of vitrectomy with transforming growth factor beta-2 for macular holes. Am J Ophthalmol 1995;119:48-54

2. Jeoung JW, Chung H, Yu HG. Factors influencing refractive outcomes after combined phacoemulsification and pars plana vitrectomy: results of a prospective study. J Cataract Refract Surg 2007; 33:108-114

3. Iwase T, Sugiyama K. Investigation of the stability of one-piece acrylic intraocular lenses in cataract surgery and in combined vitrectomy surgery. Br J Ophthalmol 2006; 90:1519-1523

4. Demetriades A-M, Gottsch JD, Thomsen R, Azab A, et al. Combined phacoemulsification, intraocular lens implantation, and vitrectomy for eyes with coexisting cataract and vitreoretinal pathology. Am J Ophthalmol 2003; 135:291-296

5. Smiddy WE, Mady M, Anagnoste S. Acrylic intraocular lens placement in conjunction with pars plana vitrectomy. Am J Ophthalmol 2001; 131:748-750

6. Scharwey K, Pavlovic S, Jacobi KW. Combined clear corneal phacoemulsification, vitreoretinal surgery, and intraocular lens implantation. J Cataract Refract Surg 1999; 25:683-698

7. Suzuki Y, Sakuraba T, Mizutani H, et al. Postoperative refractive error after simultaneous vitrectomy and cataract surgery. Ophthalmic Surg Lasers 2000;31:271-275

8. Patel D, Rahman R, M Kumarasamy. Accuracy of intraocular lens power estimation in eyes having phacovitrectomy for macular holes. J Cataract Refract Surg 2007; 33:1760-1762

9. Manvikar SR, Allen D, Steel DH. Optical biometry in combined phacovitrectomy. J Cataract Refract Surg 2009; 35:64-69

10. Randleman JB, Hewitt SM, Stulting RD. Refractive changes after posterior segment surgery. Ophthalmol Clin North Am 2004; 17:521-526

11. Retzlaff JA, Sanders DR, Kraff MC. Development of the SRK/T intraocular lens implant power calculation formula. J Cataract Refract Surg 1990; 16:333-340; correction, 528

12. Finsl O, Drexler W, Menapace R, et al. Improved prediction of intraocular lens power using partial coherence interferometry. J Cataract Refract Surg 2001; 27:861-867

13. Olsen T. Improved accuracy of intraocular lems power calculation with the Zeiss IOLMaster. Acta Ophthalmol 2008; 19:13-17

14. Wang JK, Hu CY, Chang SW. Intraocular lens power calculation using the IOLMaster and various formulas in eyes with long axial length. J Cataract Refract Surg 2008; 34:262-267

15. Eleftheriadis H. IOLMaster biometry: refractive results of 100 consecutive cases. Br J Ophthalmol 2003;87:960-963

16. Lee AC, Qazi MA, Pepose JS. Biometry and intraocular lens power calculation. Curr Opin Ophthalmol 2008;19:13-17

17. Findl O, Kriechbaum K, Sacu S, et al. Influence of operator experience on the performance of ultrasound biometry compared to optical biometry before cataract surgery. J Cataract Refract Surg 2003;29:1950-1955.

18. Rajan MS, Keilhorn I, Bell JA. Partial coherence laser interferometry vs conventional ultrasound biometry in intraocular lens power calculations. Eye 2002;16:552–556.

19. Hill W, Angeles R, Otani T. Evaluation of a new IOLMaster algorithm to measure axial length. J Cataract Refract Surg 2008;34:920–924

20. Lege BAM, Haigis W. Laser interference biometry versus ultrasound biometry in certain clinical conditions. Graefe's Arch Clin Exp Ophthalmol 2004;242:8-12

21. Falkner-Radler CI, Benesch T, Binder S. Accuracy of preoperative biometry in vitrectomy combined with cataract surgery for patients with epiretinal membranes and macular holes: results of a prospective controlled clinical trial. J Cataract Refract Surg 2008;34:1754-1760

22. Lee DK, Lee SJ, You YS. Prediction of refractive error in combined vitrectomy and cataract surgery with one-piece acrylic intraocular lens. Korean J of Ophthal 2008; 22:214-219

23. Daniel C, Tuft S, Ionides A. Effect of visual acuity on biometry prediction error after cataract surgery. J Cataract Refract Surg 2003; 29:4698-1369
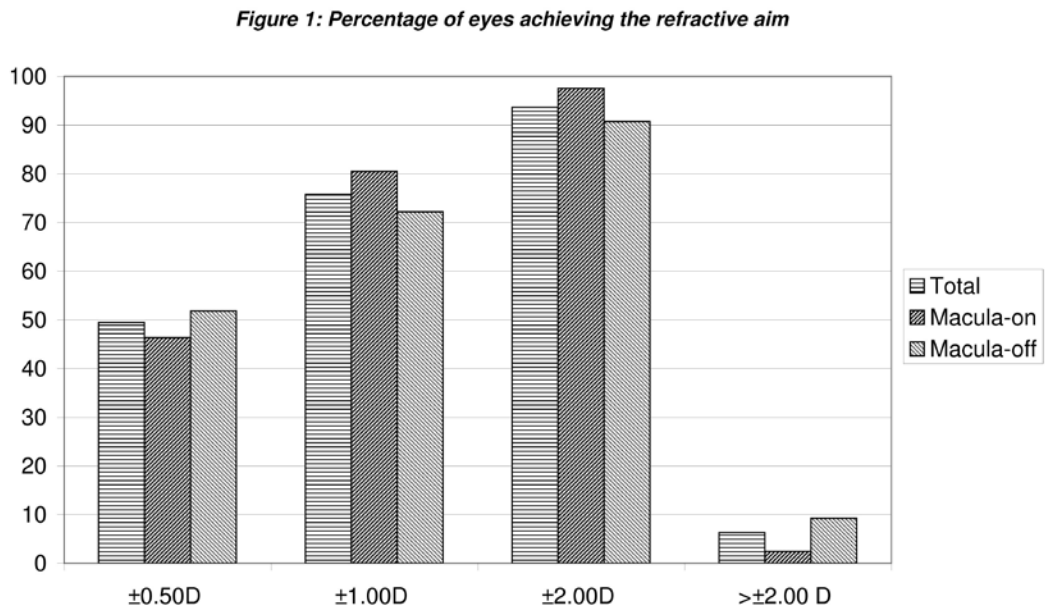
Figure 1

Figure 1: Percentage of eyes achieving the refractive aim

Table 1: Study subgroups

	Total	Macula-on	Macula-off
No. of eyes	95	41	54
AL measurement used:			
Nidek	51	18	33
IOLMaster	35	22	13
Fellow eye	9	1	8
Type of tamponade used:			
Gas	83	36	47
Silicone oil	12	5	7

Table 2: Descriptive summary of patient sub-groups

Group	ME (Mean(SD))	MAE (Mean(SD))
All eyes	-0.34 (0.89)	0.70 (0.65)
Equipment		
IOL Master	-0.22 (0.88)	0.60 (0.67)
Nidek	-0.43 (0.90)	0.76 (0.63)
Macula status		
Macula-on	-0.23 (0.84)	0.65 (0.57)
Macula-off	-0.42 (0.93)	0.73 (0.71)
IOL lens and macula status		
IOL Master; macula-on	-0.16 (0.86)	0.57 (0.65)
IOL Master; macula-off	-0.29 (0.93)	0.65 (0.71)
Nidek; macula-on	-0.31 (0.83)	0.75 (0.45)
Nidek; macula-off	-0.49 (0.94)	0.77 (0.72)

Table 3: p-values of main effects and interactions in ANOVA model: all eyes

Factor/interaction	ME	MAE
Equipment	0.089	0.040
Tamponade	0.369	0.533
Equipment x tamponade	0.217	0.092

Table 4: p-values of main effects and interactions in ANOVA model: macula-on subgroup

Factor/interaction	ME	MAE
Equipment	0.622	0.209
Tamponade	0.618	0.729
Equipment x tamponade	0.832	0.409

Table 5: p-values of main effects and interactions in ANOVA model: macula-off subgroup

Factor/interaction	ME	MAE
Equipment	0.164	0.178
Tamponade	0.172	0.376
Equipment x tamponade	0.274	0.214

Table 6: Best corrected visual acuity (in percentages)

BCVA	Total	Macula-on	Macula-off
Pre-operative:			
6/12 or better	41.2	90.2	5.4
6/18 or worse	58.8	9.8	94.6
Post-operative:			
6/12 or better	69.4	90.7	52.7
6/18 or worse	30.6	9.3	47.3