Differences in Axial Length and IOLs Power Basing on Alternative A-Scan or Fellow-Eye Biometry in Macular-off Rhegmatogenous Retinal Detachment Eyes

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Research article

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Abstract

Background: To observe the potential refractive prediction error basing on alternative A-scan ultrasound and fellow-eye biometry for phacovitrectomy in macula-off rhegmatogenous retinal detachment (RRD) eyes, when the optic biometry IOLMaster fails to obtain data.

Methods: Phakic macula-off RRD eyes without axial length (AL) measured using IOLMaster were included. Vitrectomy with silicone oil tamponade but not lens extraction was performed. Preoperative AL was measured using A-scan ultrasound, and postoperative AL, as well as fellow-eye biometry, was obtained using IOLMaster. The IOLs power was calculated according to preoperative A-scan, postoperative IOLMaster and fellow-eye AL.

Results: AL measured by alternative A-scan (AL-US) was 25.39±2.14 mm, and AL of fellow-eyes (AL-FE) was 25.85±2.16 mm, and AL in eyes with silicone oil tamponade (AL-SO) was 26.08±2.53 mm. The Bland-Altman agreements among AL-US, AL-FE and AL-SO were well (95.5%, 21/22 of cases were in LoA). The mean IOLs power calculated using AL-US (Power-US) was 16.81±7.19 D, using AL-FE (Power-FE) was 14.74±6.95 D, and using AL-SO (Power-SO) was 13.54±8.32 D. The difference between AL-US and AL-SO was significant ($P<0.05$), while that between AL-FE and AL-SO was not ($P>0.05$). The difference between Power-US and Power-SO was significant ($P<0.05$), while that between Power-FE and Power-SO was not ($P>0.05$).

Conclusion: The alternative A-scan ultrasound leads to a significant difference in AL and prediction error in IOLs power, while fellow-eye biometry provided similar results compared with those of silicone oil-filled eyes after RRD repair.

Introduction

Retinal detachment is the term used to describe the separation between the neurosensory retina and the underlying retinal pigment epithelium. Due to the postoperative complications of the crystalline lens, more than half phakic patients underwent vitrectomy for rhegmatogenous retinal detachment (RRD) repair need subsequent cataract surgery within 1 year [1]. Thus, a combined phacovitrectomy was encouraged for patients aged 50 or older for the lower cost of surgery, reduced complications and better visual outcome [2–5]. However, in some cases (10–17%) of RRD with macular involvement, the performance of the optic biometry (IOLMaster) in measuring the axial length (AL) became impossible because of the limitations of the machine, such as dense media opacity (corneal or lens opacity), poor fixation by the patients, or no machine availability [6–8]. Rahman et al. suggested that the AL measured by acoustic biometry (A-scan ultrasound, US) could be an alternative for intraocular lens (IOL) power calculation [8], and El-Khayat et al. reported that fellow-eye biometry is also recommended, although there has been no published report on outcomes [9]. On the other hand, studies including our previous work showed that both underestimation of the AL and anterior displacement of IOL are potential mechanisms of postoperative myopic shift after phacovitrectomy [10, 11]. However, to our knowledge, most researches focusing on myopic shift after phacovitrectomy excluded case in which the preoperative IOLMaster measurement is absent. Therefore, we conducted the present study to evaluate the agreement of the AL and the predicted IOL power in macula-off RRD eyes among preoperative US, postoperative IOLMaster and fellow-eyes. And our purpose is to evaluate the potential refractive errors after phacovitrectomy according to alternative US or contralateral measurements in eyes which were lack of preoperative IOLMaster data.

Materials And Methods

Design This retrospective, self-control study was conducted in Eye and Ear, Nose and Throat Hospital, Fudan University between October 2017 and June 2019, with ethical approval granted by the associated ethics committee, adhering to the tenets of the Declaration of Helsinki.

Participants Phakic, macula-off RRD eyes in which the ocular biometric measurements could not be obtained using IOLMaster were included, and then underwent 23-gauge pars plana vitrectomy (PPV) with silicone oil (SO) tamponade but not lens extraction. History of anisometropia, and eyes with scleral buckling surgery, recurrent retinal detachment or other ocular problems, which may affect the biometric measurements, such as corneal scar and lens dislocation, were excluded [12].

Surgical procedure A standard 23-gauge PPV with the CONSTELLATION® Vision 106 System (Alcon Laboratories, Inc.) was performed in each case. During PPV, the RESIGHT™ Fundus Viewing System (Carl Zeiss Meditec Inc.) was used. Core vitrectomy, mid-peripheral vitrectomy, and vitreous base shaving under scleral depression were performed to remove the vitreous. Perfluorocarbon liquid (Perfluoron; Alcon Laboratories, Inc.) might be used in some cases depending on the retinal detachment extent. Endolaser photocoagulation was performed around the area of retinal breaks, and fluid–air exchange was performed before silicone oil injection (Oxane 5700 centistokes; Bausch & Lomb Inc., Waterford, Ireland).

Measurement techniques Preoperative AL of RRD eyes was measured using A-scan ultrasound biometry (UD-6000 Ultrasonic A/B scanner biometer; Tomey Corporation, Nagoya, Japan) as formerly described [13] instead of IOLMaster. Before SO removal, an optical coherence tomography scan was performed to ensure the macula-on condition in both eyes, and then the AL of postoperative RRD eyes and fellow-eyes were obtained with IOLMaster (Carl Zeiss Meditec Ltd, Jena, Germany) using phakic and SO-filled phakic eyes program, respectively. Calculation of IOLs power was based on the A constant of AcrySof® IQ ReSTOR® SN6AD1 IOL (Alcon Laboratories, Inc., Fort Worth, USA) with SRK/T formulas.

Statistical analysis Continuous variables were expressed as the mean ± standard deviation. Statistical analyses were performed using the software package, SPSS Statistics 26.0 for Windows (SPSS Inc., Chicago, IL, USA). Bland-Altman plots were drawn using the MedCalc 15.2.2 (MedCalc Software bvba, Ostend, Belgium). A statistical significance was set at $P < 0.05$.

Results

Data from 22 eyes of 22 patients (12 males and 10 females) with an age range from 36 to 65 years (mean 51.6 ± 8.3 years) were enrolled. The mean duration of SO tamponade was 4.3 ± 0.8 months. The mean AL in eyes with RRD measured by A-scan ultrasound (AL-US) was 25.39 ± 2.14 mm (22.59 to 31.53 mm), the mean AL of fellow-eyes (AL-FE) was 25.85 ± 2.16 mm (22.47 to 31.56 mm), and the mean AL in eyes with SO tamponade after RRD repair (AL-SO) was 26.08 ± 2.53 mm (22.75 to 32.81 mm), respectively. Independent samples t-test revealed that there was no significant difference in AL-US, AL-FE or AL-SO between genders (all $P > 0.05$). The mean IOL power calculated using AL-US (Power-US) was 16.81 ± 7.19 diopter (D), the mean IOL power calculated using AL-FE (Power-FE) was 14.74 ± 6.95 D, and the mean IOL power calculated using AL-SO (Power-SO) was 13.54 ± 8.32 D, respectively. The Bland-Altman plots demonstrated that the agreement between AL-US and AL-SO is well since 95.5% (21/22) of samples were included in the 95% limits of agreement (LoA), and the agreement between AL-FE and AL-SO (95.5%, 21/22 in LoA) was similar, as shown in Fig. 1A and B.

However, paired t-test showed that the difference between AL-US and AL-SO was statistically significant ($P < 0.05$), while that between AL-FE and AL-SO was not ($P > 0.05$, Fig. 1C). The mean absolute error between AL-US and AL-SO ($MAE_{AL-US-SO}$) was 0.69 ± 0.78 mm, and $MAE_{AL-FE-SO}$ was 0.61 ± 0.79 mm. Correspondingly, the difference between Power-US and Power-SO was statistically significant ($P < 0.05$), while that between Power-FE and Power-SO was not ($P > 0.05$, Fig. 1D). The mean absolute error between Power-US and Power-SO ($MAE_{Power-US-SO}$) was 3.27 ± 3.79 D, and $MAE_{Power-FE-SO}$ was 2.36 ± 3.38 D.

Discussion

The AL of an eye, which would be measured as the distance from the cornea to the inner limiting membrane using A-scan US [14], or from the cornea to retinal pigment epithelium using IOLMaster [14], is the most crucial parameter in the IOL power calculation. A 1-mm change in the AL corresponds to around 2.7-D refractive error in the IOL power [15]. Nepp et al. reported that the mean difference between the US- and IOLMaster-measured AL in SO-filled eyes was 0.4 mm, and only 46% cases had a value less than 0.3 mm while in 26% the value was greater than 1 mm [16]. Thus, we measured the AL of these SO-filled eyes and normal fellow-eyes in the present study by means of IOLMaster for more accuracy and less deviation [12]. Our results showed that the AL of SO-filled eyes after RRD repair is comparable to that of fellow-eyes, so it was not surprising that IOL power calculated using AL-SO is similarly comparable to that using AL-FE. Nevertheless, there were significant differences in both AL and IOL power between US-measured preoperative data of macula-off RRD eyes and IOLMaster-measured postoperative data of SO-filled eyes. The mean AL-US was about 0.68-mm shorter than AL-SO, and the mean Power-US was accordingly 3.27-D greater than Power-SO. Namely, there would be clinically significant myopic shift after SO removal if we performed phacovitrectomy for RRD repair according to the alternative A-scan-based IOL power calculation.

Phacovitrectomy is a safe and effective procedure to treat RRD. Kang et al. [17] and Sakamoto et al. [18] confirmed that there is a tolerable biometric error after the treatment of RRD with phacovitrectomy, which is comparable between acoustic and optic biometry in macula-sparing cases. Although the anatomical and functional results were comparable with those obtained with PPV and delayed cataract surgery, however, the refractive outcomes were less favorable and shifted toward myopia, especially in macula-off cases [19]. When the macula is involved, there would be a mean prediction error of -1.22 ± 2.32-D for the RRD eye and a mean prediction error of -0.01 ± 1.09-D for fellow-eye [9]. Pongsachareonnont et al. attributed it to the underestimation of 0.59 ± 0.90-mm in AL measurement by IOLMaster [20]. Rahman et al. found that in less than a quarter (13/54, 24.1%) cases IOLMaster could provide available AL measurement [6]. Kim et al. found that the underestimation is associated with macular retinal detachment height [7]. Unlike these above studies, there was no preoperative IOLMaster data as reference, so we could not calculate a user-adjusted AL by combining acoustic and optic biometry as described [8]. Patients with worse vision, greater central macular thickness, and shallow anterior chambers require more caution since they are prone to inaccurate preoperative biometry [21]. In this situation, a delayed cataract surgery or a phacovitrectomy using contralateral AL might be more recommended.

Our results of this study should be interpreted with its limitations in mind. All the participants we recruited underwent SO tamponade, which is the current routine procedure for RRD cases [22]. However, the interference in biometry was not entirely quantified, such as underfill/overfill, or the emulsion of SO. Some characteristics of the retinal detachment which might be associated with the accuracy of AL measurement, for example, macular detachment height, were neither controlled. Besides, we have not been obtained the data of final refractive error from all cases after SO removal, phacoemulsification and IOL implantation due to the various degrees of complicated cataract, even though that should be the final answer. Summarily, according to the present study, if the performance of IOLMaster is failed in eyes with macula-off RRD, ultrasound might lead to a refractive prediction error in IOL power. Phacovitrectomy using fellow-eye biometry as well as secondary IOLs implantation should be the better choice in this situation, in the absence of an anisometropia.

Declarations

Ethics approval and consent to participate

All study procedures were performed in accordance with the tenets of the Declaration of Helsinki, and the Study was approved by the Ethics Committee of Fudan University. Written informed consent was obtained from all the study participants.

Consent to publish

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors have no proprietary or commercial interest in any materials discussed in this article.

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Authors' contributions

RL drafted and revised the manuscript.

HL collected the data and performed the statistical analysis.

QL conceived the study and approved the final manuscript.

All authors have read and approved the manuscript.

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Figures

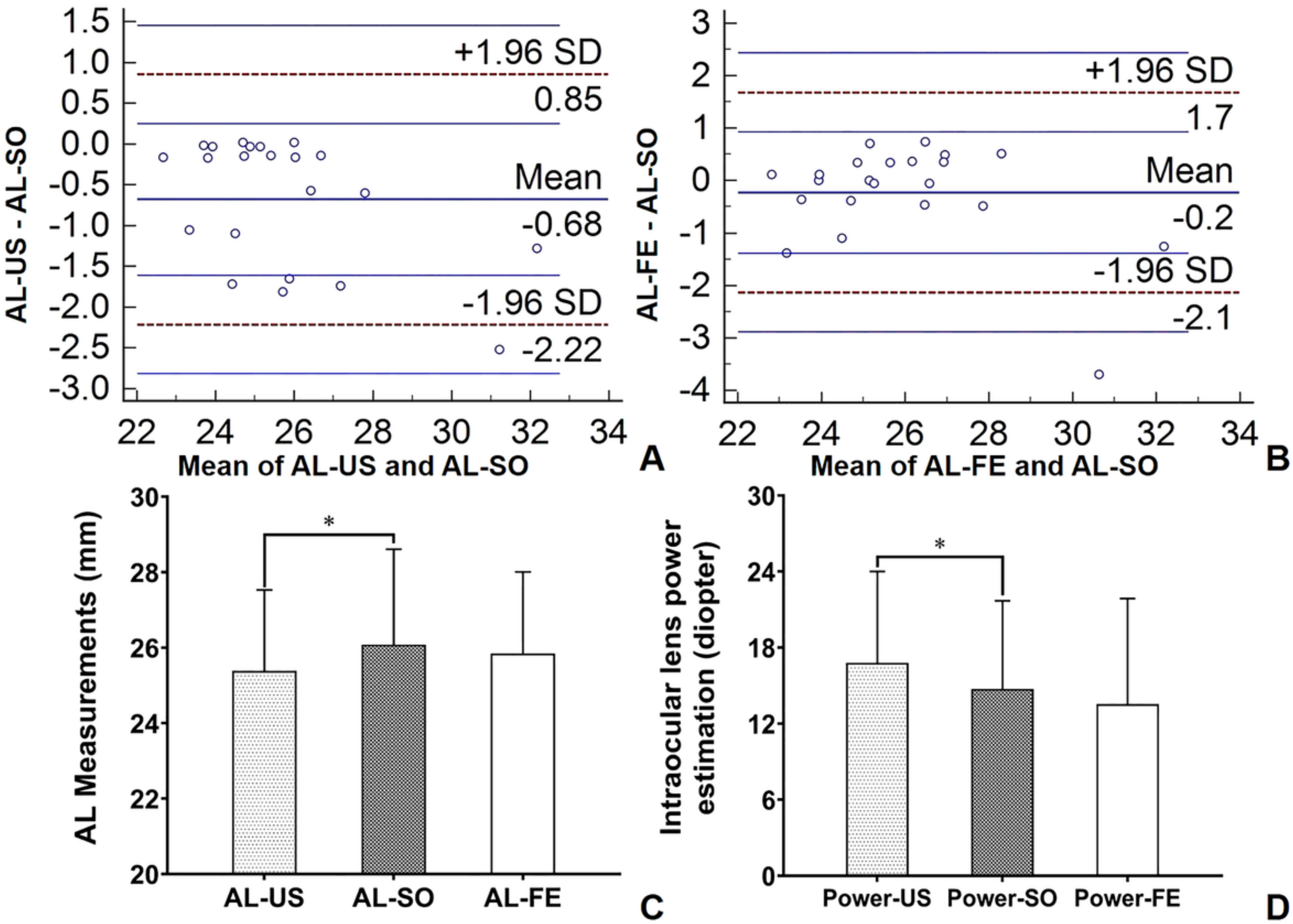

Figure 1

The Bland-Altman plots of AL-US and AL-SO (A), of AL-FE and AL-SO (B). The bold solid line indicates the mean difference; the dotted lines represent the 95% limits of agreement (LoA), and the thin solid lines represent the 95% CI of upper/lower limits of LoA. Differences in axial length (C) and IOLs power estimation (D) among RRD eyes, SO-filled eyes and fellow-eyes (Paired t-test, *P<0.05). AL-US, the axial length of RRD eyes measured by A-scan; AL-SO, the axial length of eyes with silicone oil tamponade for RRD repair; AL-FE, the axial length of fellow-eyes; Power-US, estimated IOLs power of RRD eyes measured by A-scan; Power-SO, estimated IOLs power of eyes with silicone oil tamponade for RRD repair; Power-FE, estimated IOLs power of fellow-eyes.