Optical Biometry versus Ultrasonic Biometry in Intraocular Lens Power Calculations in High Axial Myopia

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Abstract

Background: Intraocular lens implantation is now seen as a type of refractive surgery rather than merely being used to improve visual rehabilitation. In this context, accurate preoperative biometric measurement is a crucial requirement.

Aim: Comparing the refractive predictability of optical biometry versus applanation ultrasonic biometry in high axial myopic eyes undergoing cataract surgery.

Patients and methods: A total of 50 eyes from 50 patients with axial lengths greater than 26.5 mm and just cataracts were analyzed in this study. In this study, patients were randomly assigned to one of the two groups. Twenty-five patients were split evenly between the two groups, with group 1 using optical biometry and group 2 using applanation ultrasound.

Results: Group 1 mean age was 53.8 ± 8.9 years as it was 51.8 ± 10.8 years in group 2. There were seven (28%) males and 18 (72%) females in group 1, while there were 11 (44%) males and 14 (56%) females in group 2. There was no statistically significant variation in axial length between groups ($P = 0.101$). There was a statistically significant increased K1 and K2 among group 1 when compared with group 2 ($P = 0.003$ and 0.001, respectively). There was statistically significant ($P = 0.015$) increased anterior chamber depth in group 1 when compared with group 2. Significant differences in postoperative refraction were seen across the groups ($P = 0.001$) (spherical equivalence values).

Conclusion: Optical biometry offers significantly more precise intraocular lens power prediction and refractive outcomes in cataract surgery for high axial myopia than applanation ultrasound biometry.

Keywords: High myopia, Optical biometry, Ultrasonic biometry

1. Introduction

To put it simply, cataracts are the most common cause of avoidable blindness in the world. Among all eye surgical procedures, cataract removal with intraocular lens (IOL) implantation has the highest volume of cases. However, research is still needed to determine the best method of determining the IOL power necessary to achieve the target postoperative refraction.[1]

Variables such as axial length (AL), keratometry (K), and lens formulae all play a role in the refractive outcome of cataract surgery. Preoperative AL assessment is one of the most important elements in determining the appropriate IOL power for cataract surgery.[1]

Direct contact with the eye (applanation technique) or indirect contact through a liquid (immersion technique) is necessary for ultrasonic biometry.[2]

Ultrasound used in a procedure called 'applanation' has the potential to injure the corneal epithelium, which can lead to infection, pain for the patient, and incorrect procedures.[3]

To get around ultrasound's drawbacks, researchers came up with optical biometry, which operates on the same idea as optical coherence tomography. Because

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it does not involve physical touch with the patient, this technique offers the dual benefits of being easy on the patient and reducing observer error.[4]

The IOL Master from Carl Zeiss Meditec was the first clinically available automated noninvasive optical biometry instrument in September 1999. Using infrared laser light (wavelength 780 nm), it functions as a modified interferometer to provide reliable measurements of anterior chamber depth (ACD), horizontal visible iris diameter (white-to-white diameter), corneal curvature and the AL.[5]

In the case of high axial myopia, the refractive error is greater than 8.00 D, or the AL is greater than 26.5 mm.[6]

Ultrasound biometry presents its challenges and quirks when dealing with a patient who has severe or extremely severe axial myopia. As opposed to the refractive AL (corneal vertex to foveal center), ultrasound typically provides the anatomic AL (corneal vertex to the most posterior area of the macular region), which results in an IOL power that is too low. Due to measuring ocular AL throughout the visual axis while the patient fixes at the measurement beam, optical biometry is more precise than ultrasonic biometry.[7]

Ultrasound biometry still has a place in patients with mobility issues and in cases of dense ocular media, such as in age-related macular degeneration, where optical biometry cannot provide an accurate measurement of AL.[8]

This work aimed to compare the refractive predictability of optical biometry versus applanation ultrasonic biometry in high axial myopic eyes undergoing cataract surgery.

2. Patients and methods

The 50 patients with high axial myopia (AL> 26.5 mm) who were scheduled for phacoemulsification cataract surgery at Al-Azhar University Hospitals between January 2022 and June 2022 were the patients of a randomized prospective comparison study. In this study, patients were randomly assigned to one of the two groups. Twenty-five patients were split evenly between the two groups, with group 1 using optical biometry and group 2 using applanation ultrasound. Patients were given information about the surgery and its potential risks before signing an informed permission form.

Inclusion criteria: cases of advanced cataracts that can be surgically treated with phacoemulsification and a posterior chamber IOL implant are considered candidates.

Exclusion criteria: presence of proliferative diabetic retinopathy and retinal detachment. Eyes whose AL could not be determined by optical biometry due to severe ocular media opacities like corneal scars or high-density posterior cataracts. Previous experience with eye operations. Abnormalities or opacities of the cornea. Failed attempt to insert the IOL so that it is completely contained within the bag.

All the patients underwent: full history taking including age, sex, residence, special habits of the patients or their relatives, main complaint (painless gradual diminution of vision), analysis of the complaint, present history of any ocular symptoms and diseases, and presence of any systemic diseases. Also, previous operations, history of previous ocular surgery, ocular trauma, drug intake, and family history of any ocular disease.

Complete ophthalmological examination including examination of the anterior segment with slit-lamp biomicroscopy, recording of intraocular pressure with Goldmann's applanation tonometry, recording of intraocular pressure, evaluation of the retina and optic disk, measurement of uncorrected and best-corrected visual acuity, and evaluation of the fundus.

2.1. Preoperative biometry

Group 1 patients underwent biometry using the Aladdin optical biometer (Topcon, Aladdin HW 2.0, San Giovanni Valderno, Italy) to obtain AL, keratometric values (K1 and K2), ACD, and IOL power.

Group 2 patients underwent biometry using applanation A-scan (Sonomed Escalon; Sonomed Inc., New York, New York, USA). One drop of topical anesthetic (0.4% benoxinate hydrochloride) applied to the lower conjunctival fornix provides temporary relief from discomfort to calculate AL, ACD, and IOL power. An automated keratometer (AK; Topcon, Auto Kerato-Refractometer, KR 800, Tokyo, Japan) was used to collect keratometry values (K). The measurements were obtained with the patient sitting in an upright position and the transducer held with the ultrasound beam perpendicular to the surface of the globe.

Utilizing the SRK-T formula, our goal for IOL power is to obtain postoperative refraction that ranges from −0.50 to 0.00.

2.2. Surgical procedure

Through a superior clear corneal incision, all procedures were carried out under local anesthesia. Foldable IOLs inserted using an injector into the capsular bag. At 2 days, 7 days, and 1 month after surgery, all patients were reexamined. After a month, an auto-refractor was used to measure the patient's true postoperative spherical equivalence (SE).

2.3. Statistical analysis

Version 24 of the Statistical Package for the Social Sciences (SPSS) was used to analyze the data. Quantitative information was summarized as a mean SD. Quantitative information was presented as a proportion of the whole, and qualitative information as frequency counts. The mean (average) of a set of numbers is calculated by dividing the total by the total number of numbers in the set. The dispersion of a set of numbers is quantified by their SD. If the SD is small, the value cluster around the set's mean, but if it is large, the numbers are more dispersed. To verify this, we ran the following tests: When contrasting two means, a t test for independence was performed (for normally distributed data). Mann−Whitney when comparing two means, the U test was utilized (for abnormally distributed data). When comparing nonparametric data, the χ^2 test was utilized. A significant P value cutoff was set at 0.05. A P value of 0.001 was determined to be statistically significant. If the P value was higher than 0.05, it was not considered to be statistically significant.

3. Results

Fifty eyes from 50 severely myopic patients with cataracts were examined in this study: 18 men (36% of the total) and 32 (64%) women.

The group 1 mean age was 53.8 ± 8.9 years and it was 51.8 ± 10.8 years in group 2. There were seven (28%) males and 18 (72%) females in group 1, while there were 11 (44%) males and 14 (56%) females in group 2 (Table 1).

There was no observable statistically significant change in Table 2 ($P = 0.101$) with respect to the AL between the groups in the study. Group 1 mean AL was 28.5 ± 1.83 while it was 29.6 ± 2.1 in group 2.

The data in Table 3 demonstrate: statistically significant ($P = 0.003$) increased K1 in group 1 (44.6 ± 1.5) when compared with group 2 (43.3 ± 1.9). Statistically significant ($P = 0.001$) increased K2 in group 1 (46.1 ± 1.9) when compared with group 2 (44.5 ± 1.9).

The data in Table 4 are statistically significant ($P = 0.015$) increased ACD in group 1 (3.6 ± 0.3) when compared with group 2 (3.3 ± 0.3).

In terms of postoperative refraction, a comparison of the several study groups is shown. Variations statistical significance are displayed in Table 5 ($P = 0.001$) between the studied group as regards postoperative refraction (SE values). The mean postoperative refraction in group 1 was -0.13 ± 0.5, while it was -0.72 ± 0.7 in group 2.

Variations in statistical significance are displayed in Table 6 ($P = 0.005$) between the studied groups as regards postoperative ametropia (SE values). In group 1, there were four (16%) patients more than -0.5, 12 (48%) patients in the range of 0 to -0.5, and nine (36%) patients were hypermetropic while in group 2, there were 14 (56%) patients more than -0.5, nine (36%) patients in the range of 0 to -0.5 and two (8%) patients were hypermetropic (Figs. 1−5).

4. Discussion

In this study, there was no statistically significant difference ($P = 0.101$) between optical biometry and ultrasonic biometry as regards AL. The mean AL in the optical group was 28.5 ± 1.83 while it was 29.6 ± 2.1 in the ultrasonic group.

Gopi and Sathyan[9] applanation A-scan as well as optical biometry measurements of AL and ACD were reported to be in high agreement throughout all ranges of ALs.

Cho et al.[10] reported that the IOL Master 700's AL significantly correlated with that of the IOL Master 500 and A-scan, indicating that all three methods were reliable.

However, Wang et al.[8] indicated that in the optical biometry group, the mean AL was much longer than in the applanation A-scan group ($P = 0.03$) in 68 eyes when the AL measured was greater than 25.0 mm.

In this study, we found statistically significant ($P = 0.003$) increased K1 in the optical group (44.6 ± 1.5) when compared with the ultrasonic group (43.3 ± 1.9) and statistically significant ($P = 0.001$) increased K2 in the optical group

Table 1. Comparison between the studied groups as regards age and sex.

	Group I ($N = 25$)	Group II ($N = 25$)	Statistical test	P value
Age (years)				
Mean $\pm$ SD	53.8 ± 8.9	51.8 ± 10.8	$t = 0.68$	0.5 NS
Sex				
Male	$7 \pm 28\%$	$11 \pm 44\%$	$\chi^2 = 1.38$	0.239 NS
Female	$18 \pm 72\%$	$14 \pm 56\%$		

Table 2. Comparison between the studied groups as regards axial length.

	Group I ($N = 25$)	Group II ($N = 25$)	Statistical test	P value
Axial length				
Mean ± SD	28.5 ± 1.83	29.6 ± 2.1	MW = 228	0.101 NS

Table 3. Comparison between studied groups as regards K readings.

	Group I ($N = 25$)	Group II ($N = 25$)	Statistical test	P value
K1				
Mean ± SD	44.6 ± 1.5	43.3 ± 1.9	MW = 159	0.003 S
K2				
Mean ± SD	46.1 ± 1.9	44.5 ± 1.9	MW = 143	0.001 S

Table 4. Comparison between studied groups as regards anterior chamber depth.

	Group I ($N = 25$)	Group II ($N = 25$)	Statistical test	P value
ACD				
Mean ± SD	3.6 ± 0.3	3.3 ± 0.3	MW = 187.5	0.015 S

ACD, anterior chamber depth.

Table 5. Comparison between the studied groups as regards postoperative refraction.

	Group I ($N = 25$)	Group II ($N = 25$)	Statistical test	P value
Postoperative refraction (SE)				
Mean ± SD	−0.13 ± 0.5	−0.72 ± 0.7	$t = 3.4$	0.001 S

Table 6. Comparison between the studied groups as regards postoperative ametropia.

	Group I ($N = 25$)		Group II ($N = 25$)		Statistical test	P value
Postoperative refraction (SE)						
>−0.5	4	16%	14	56%		
0 to −0.5	12	48%	9	36%	$\chi^2 = 10.4$	0.005 S
Hypermetrope	9	36%	2	8%		

(46.1 ± 1.9) when compared with the ultrasonic group (44.5 ± 1.9).

Elbaz et al.[11] reported that the mean interdevice difference in keratometry for the AK versus the IOL Master was −0.424 D. Measurements of keratometry by the IOL Master differed statistically significantly from AK ($P < 0.01$).

Whang et al.[12] reported that the IOL Master optical biometer tends to generate high values relative to those of the AK as regards the absolute value of astigmatism (K2−K1) ($P = 0.048$) and the mean keratometric values (K1+K2/2) ($P = 0.000$).

We speculate that this is because the diameter is smaller in the area where the IOL Master was used for measurement. IOL Master keratometric values are obtained by measuring corneal thickness at six points spaced 2.3−2.5 mm from the corneal center. An AK takes readings from four separate points of light between 3.0 and 3.5 mm in diameter.

However, Lopez et al.[13] reported that keratometry provided by the AK (WAM 5500) is clinically interchangeable with that of the IOL Master optical biometer.

In this study, we found a statistically significant ($P = 0.015$) increased ACD in the optical group (3.6 ± 0.3) when compared with the ultrasonic group (3.3 ± 0.3).

Németh et al.[14] reported that ACD values were significantly larger with optical biometry than with applanation A-scan ($P < 0.001$).

Hashemi et al.[15] reported that ACD values were significantly larger with optical biometry than with applanation A-scan ($P < 0.001$) and the mean difference was +0.09 ± 0.14 mm.

Cho et al.[16] also observed that compared with noncontact optical instruments, contact ultrasound biometry was found to have a substantially shorter mean ACD.

When using the contact method of ultrasound biometry, corneal applanation can occur accidently, leading to potentially shorter ACD readings than when using the noncontact approach.[11] However, the Santodomingo et al.[17] IOL Master measurements of ACD were found to be substantially shallower [by 0.06 (0.25) mm, $P = 0.02$] than applanation ultrasonic measurements. There is a possibility that the IOL Master's ACD reading will be up to 0.43 mm higher or lower than what is seen by ultrasonography.
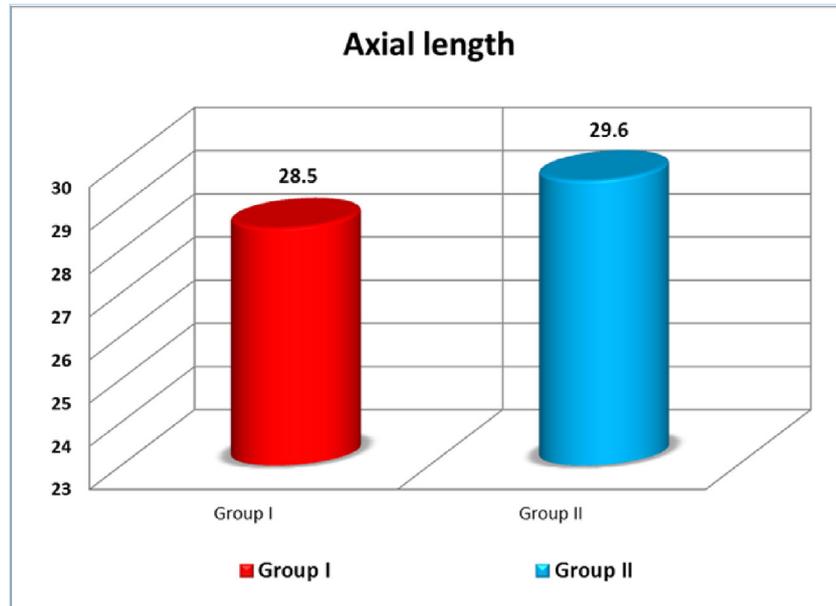
Fig. 1. Comparison between the studied groups as regards axial length.
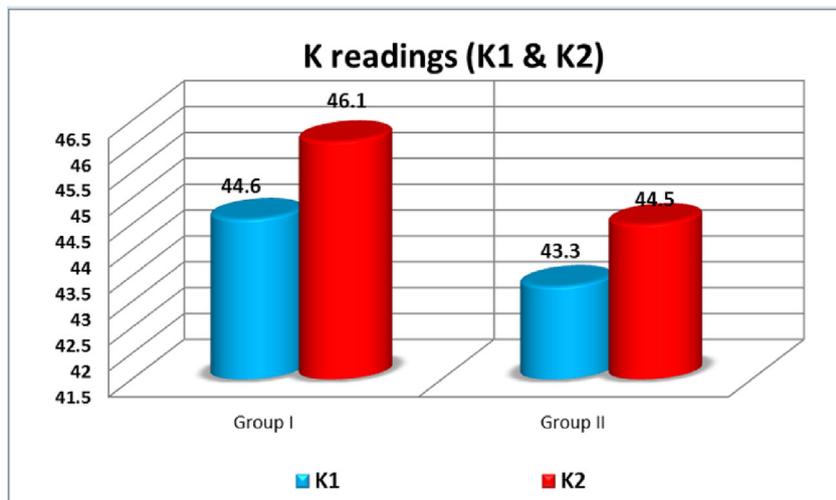

Fig. 2. Comparison between the studied groups as regards K readings.

In this study, a statistically significant ($P = 0.001$) distinction in postoperative refraction was seen between the groups (SE values). The mean postoperative refraction in the optical group was -0.13 ± 0.5 while it was -0.72 ± 0.7 in the ultrasonic group.

We also found that 12 (48%) patients achieved the desired postoperative refraction (0.00 to -0.50) in the optical group, while in the ultrasonic group nine (36%) patients achieved it. The difference was statistically significant ($P = 0.005$).

Farahat et al.[18] observed that compared to applanation ultrasound-based assessments, the results of the Haigis regression method using data from optical biometers using partial coherence interferometry are much superior for the group of people with extreme myopia (we used the SRK-T formula in our study).

The Saha et al.[19] optical biometry with partial coherence interferometry has been shown to provide a considerably more accurate prediction of IOL power before surgery in patients with extreme myopia than does the traditional ultrasound-based biometry. For this purpose, the SRK-T formula was used to determine the appropriate power for the IOL. However, Wang et al.[8] reported that IOL power prediction using optical or ultrasound biometry was found to be just as accurate using the SRK/T, SRK II,
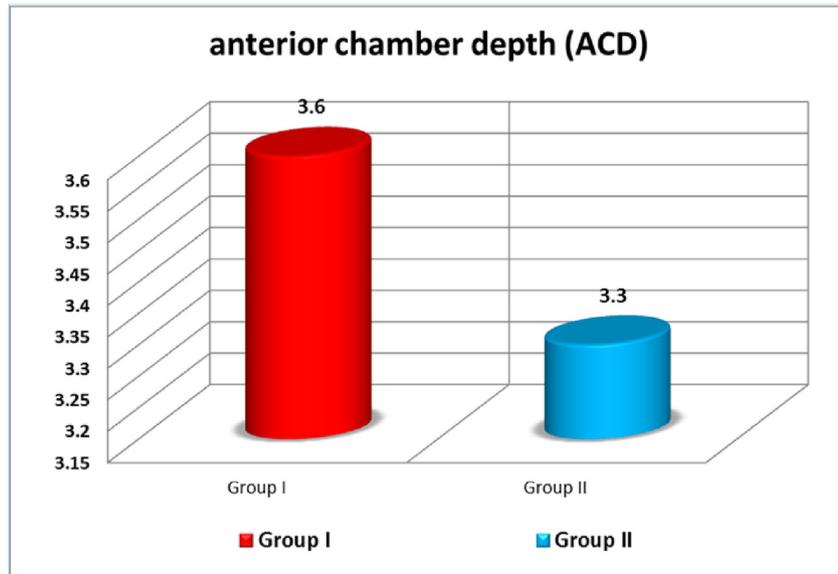
Fig. 3. Comparison between the studied groups as regards anterior chamber depth (ACD).
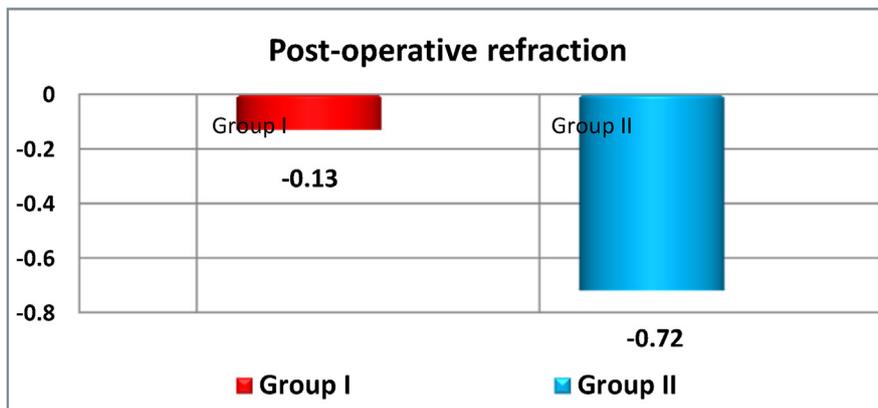

Fig. 4. Comparison between the studied groups as regards postoperative refraction.
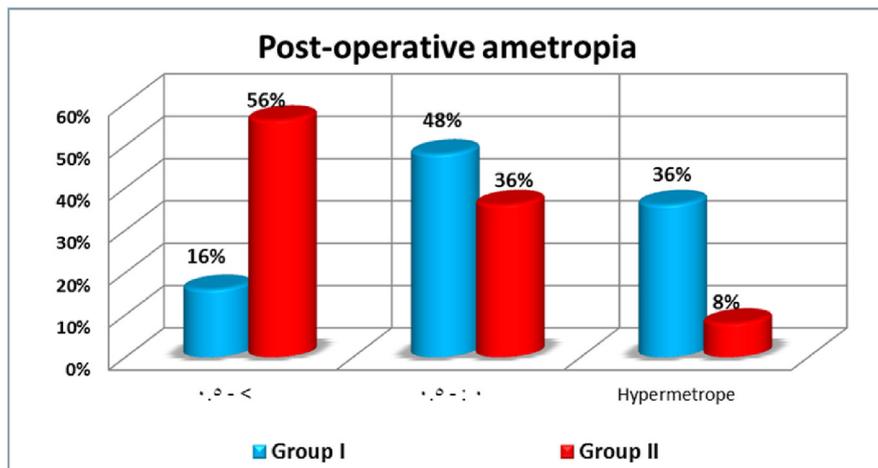

Fig. 5. Comparison between the studied groups as regards postoperative ametropia.

and Holladay 1 formulas, even in eyes with higher myopia.

In this study, there were nine (36%) patients who achieved hyperopic postoperative refraction in the optical group, while in the ultrasound group, there were two (8%) patients.

In this study, there were four (16%) patients who achieved myopic postoperative refraction more than −0.50 in the optical group while in the ultrasound group, there were 14 (56%) patients more than −0.50.

Bang et al.[20] reported that the results that were obtained were less optimistic than those anticipated by the Holladay 1, Holladay 2, SRK/T, Hoffer Q, and Haigis formulae. It is better to shoot for a more narrowly focused outcome.

Farahat et al.[18] reported that the calculation of IOL power using the IOL Master resulted in a tendency for hyperopic shifts with all three formulas. This hyperopic shift was minimal with the Haigis formula followed by SRK-T and was largest with the Hoffer Q formula.

Özcura et al.[21] applanation A-scan ultrasound was used to determine whether or not 31 long eyes (>25.0 mm) were myopic or hyperopic utilizing biometric algorithms. After surgery, SRK II patients showed the most hyperopic shift (48.4%), along with the lowest myopic shift (51.6%). Holladay I had the lowest hyperopic shift (29%) and the highest postoperative myopic shift (71.0%) and a hyperopic shift of only 8%, I ranked first and last, respectively (29% percent). Postoperatively, SRK/T caused a myopic shift in 62.1% and a hyperopic shift in 37.9%.

4.1. Conclusion

Optical biometry by Aladdin provides much more accurate IOL power prediction and, thus, refractive results in cataract surgery for patients with high axial myopia than applanation ultrasound biometry. It is well accepted by patients, takes very little time to apply, and avoids the dangers of a contact method (infection and corneal abrasion). It should be noted, however, that there is a failure rate associated with this procedure, especially in the presence of dense cataracts.

Ethical Approval

The study was approved by the Research Ethical Committee of Al-Azhar University and the patients were given all the information they need about the trial. An informed written consent was taken from each participant in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Conflict of interest

There are no conflicts of interest.

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