Comparison of optical biometry and conventional acoustic biometry in the axial length measurement in silicone oil-filled eyes

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Purpose: To compare the axial length (AL) obtained by A-scan biometry (PAC SCAN 300AP; Sonomed Escalon, USA) and LENSTAR-LS 900 (Haag-Streit, Koeniz, Switzerland) in silicone oil (SiO)-filled eyes. Methods: AL measurements were taken in 50 SiO-filled eyes using A-scan and LENSTAR-LS 900 before SiO removal and 1 month following SiO removal. In the subset of patients requiring intraocular lens (IOL) insertion, the predicted refraction and the refraction obtained were compared. IOL power in these patients was calculated using SRK-T formula and the AL obtained by LENSTAR. Results: In SiO-filled eyes, a significant difference was noted between the AL values obtained using the two methods ($P = 0.0002$). No significant difference was noted after SiO removal ($P = 0.634$). In the subset of patients needing IOL insertion, no significant difference ($P = 0.07$) was seen between target refractive error and postoperative refractive error (mean deviation from the target being 0.176 diopter). AL of an SiO-filled eye is more accurately measured using optical low coherence reflectometry (OLCR)-based biometry (LENSTAR) than with conventional acoustic biometry (A-scan). Conclusion: We conclude that LENSTAR gives more accurate biometry in an SiO-filled eye. The AL obtained after SiO removal was comparable and showed no significant difference.

Key words: Conventional Acoustic Biometry, LENSTAR, optical low coherence reflectometry (OLCR), silicone oil-filled eye

Silicone oil (SiO) has become increasingly useful as a tamponading agent in the vitreous cavity for complicated retinal detachment surgery. The development of cataract is the most common complication in phakic eyes with SiO. The potential visual acuity in these eyes is good enough to warrant cataract extraction and intraocular lens (IOL) implantation. However, axial length (AL) measurement using acoustic biometry with A-scan in silicone-filled eyes is difficult to perform, and occasionally, measurement may be unobtainable due to sound attenuation. This would affect the accuracy of IOL power calculation, and thus, a postoperative refractive surprise may be seen. In SiO-filled eyes, there is an increase in AL when measured using A-scan biometry. This is because the velocity of sound in SiO (987 m/s in 1000 cS viscosity oil) is slower than in the vitreous humor (1532 m/s). Thus, it takes approximately one and a half times as long for an ultrasound pulse to travel the SiO-filled eye. Therefore, we need to apply a correction factor to the IOL power calculation formula to adjust for the same. Some of the ways to circumvent this problem are to calculate the AL of the fellow eye (without SiO), or AL ultrasound measurement before SiO insertion surgery. However, these methods might still lead to major IOL power measurement errors.

In recent years, a noninvasive method of AL measurement by optical biometry has been developed. While acoustic biometry measures along the optical axis of the eyes, the optical biometry evaluates the length of the visual axis of the eye and is proven to be 10 times more accurate than acoustic biometry in normal cataract eyes with no other pathologies. There are two devices designed for optical biometry using slightly different technologies. They are partial coherence interferometry (PCI) used in IOL Master and optical low coherence reflectometry (OLCR) used in LENSTAR, which was introduced later. The purpose of this study is to evaluate and compare the accuracy between the conventional acoustic method of AL measurement; that is, A-scan biometry, versus OLCR-based optical biometry used in AL measurement of SiO-filled eyes.

Methods

Fifty SiO-filled eyes (1000 cS) of individuals with successful retinal reattachment after retinal detachment surgery with SiO insertion done at a tertiary ophthalmic center were enrolled. Patients with or without cataract who were following up for SiO removal during the period of 1 year were included.

A detailed history was taken including the reason for SiO surgery, high myopia, any other ocular surgeries, or systemic illnesses like diabetes mellitus (DM), hypertension (HTN), and so on.

All selected subjects underwent a general physical examination and ocular examination including the following:

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Results were analyzed using Statistical Package for Social Sciences (SPSS) software version 21.0. For statistical significance, *P* value of <0.05 was considered as significant.

**Results**

A total of 50 patients were enrolled in the study and were thoroughly evaluated as per the evaluation protocol mentioned before. The mean age of the study subjects was 48.4 ± 14.6 years. Of the 50 patients, 38 were male and 12 were female.

The mean ± standard deviation (SD) of pre-op AL (mm) in A-scan was 24.66 ± 1.59, which was significantly different compared to LENSTAR in SiO mode (25 ± 1.68) (*P* = 0.0002).

Whereas the mean ± SD of 1-month post-op AL (mm) in A-scan was 24.97 ± 1.57 and in LENSTAR was 24.99 ± 1.62, with no significant difference between them (*P* = 0.634).

The mean ± SD of change in AL (mm) in A-scan was 0.31 ± 0.39, which was significantly higher compared to LENSTAR (−0.01 ± 0.19) (*P* < 0.0001).

It is shown in Table 1.

In our study, IOL insertion was done in 17 patients. We observed that the mean values of target refractive error and postoperative refractive error of study subjects were −1.18 ± 1.2 and −1.35 ± 1.21 with median of −1 (−2 to 0) and −1 (−2.25 to −0.5), respectively. No significant difference was seen in target refractive error and postoperative refractive error (*P* = 0.076).

In the present study, high myopia was present in 12 out of 50 patients (24%). In a subset of patients who were high myopes, the following results were obtained.

Table 2 shows that the mean ± SD of pre-op AL with SiO in situ (mm) in A-scan was 26.62 ± 0.93, which was significantly lower than in LENSTAR (27.19 ± 1.29) (*P* = 0.016).

The mean ± SD of 1-month post-op AL after SiO removal (mm) in A-scan was 26.98 ± 1.04 and in LENSTAR was 27.08 ± 1.19, with no significant difference between them (*P* = 0.323).

The mean ± SD of change in AL (mm) in A-scan was 0.36 ± 0.47, which was significantly higher compared to that in LENSTAR (−0.12 ± 0.19) (*P* = 0.012).

**Discussion**

AL estimation and accurate IOL power calculation in a SiO-filled eye are very challenging due to the optical and sound attenuation properties of SiO. The older available noncontact biometer is the IOL Master, which uses PCI-based technology to estimate AL. The newer noncontact biometer LENSTAR uses OLCR-based biometry to estimate AL along with lens, corneal, and retinal thickness.

This study was done with the aim of comparing the AL obtained by A-scan biometry and optical biometry in SiO-filled eyes. Also, it was aimed to estimate the postoperative refractive error (for patients requiring cataract extraction) with IOL in patients needing SiO removal with IOL insertion.

Tayyab et al. have shown that the mean AL measured with IOL Master preoperatively was 23.62 ± 0.36 mm, and 1 month after SiO removal, it showed a mean of 23.58 ± 0.29 mm. There was no statistically significant difference (*P* = 0.463). The pre- and postoperative AL measured by conventional acoustic A-scan showed statistically significant difference (*P* = 0.004). Preoperative AL was 23.34 ± 0.58 mm, and postoperative AL was 23.97 ± 0.71 mm. Postoperative refractive error in IOL Master group was 0.70 ± 0.32 diopter sphere (DS), whereas that of acoustic A scan group was 1.55 ± 0.98 DS. This study found
that the IOL Master is superior and more accurate for calculating AL, compared to A-scan biometry in a SiO-filled eye.

In our study, a total of 50 silicone-filled eyes from 50 patients of the age group ≥18 years were studied before and after SiO removal. The present study differs from literature as it compares OLCR technology (LENSTAR) with conventional acoustic biometry (A-scan) in SiO-filled eyes.

Changes in AL

In our study, we noticed a statistically significant difference in the pre- and postoperative AL measured by acoustic A-scan, while no significant difference between them was noted when measured by LENSTAR.

The mean values of pre-op AL (mm) and 1-month post-op AL (mm) of the study subjects were 24.66 ± 1.59 and 24.97 ± 1.57, respectively, when measured with A-scan (P < 0.0001). Whereas when measured with LENSTAR, the mean values of pre-op AL (mm) and 1-month post-op AL (mm) of the study subjects were 25 ± 1.68 and 24.99 ± 1.62, respectively (P = 0.684).

The mean ± SD of pre-op AL (mm) in A-scan was 24.66 ± 1.59, which was significantly lower compared to LENSTAR (25 ± 1.68) (P = 0.0002).

The mean ± SD of 1-month post-op AL (mm) in A-scan was 24.97 ± 1.57 and in LENSTAR was 24.99 ± 1.62, with no significant difference between them (P = 0.634).

Thus, the mean ± SD of change in AL (mm) in A-scan was 0.31 ± 0.39, which was significantly higher compared to LENSTAR (−0.01 ± 0.19) (P < 0.0001).

Similar findings were reported by Tayyab et al.\cite{9} while comparing the mean AL measured with IOL Master and A-scan pre- and post-SiO removal. They noted there was no statistically significant difference (P = 0.463) in the mean AL measured with IOL Master pre- and postoperatively, while the pre- and postoperative AL measured by conventional acoustic A-scan showed a statistically significant difference (P = 0.004).

Kunavisarut et al.\cite{1} also obtained similar results while comparing the AL measurements obtained using A-scan

### Table 1: Axial length results of the two machines

| Axial length (mm) | A-scan (n=50) | LENSTAR (n=50) | Total | P | Test performed |
|------------------|---------------|----------------|-------|---|----------------|
| Pre-op axial length with SiO in situ (mm) Mean±SD | 24.66±1.59 | 25±1.68 | 24.83±1.64 | 0.0002 | Paired t-test; t=4.083 |
| Median (25th-75th percentile) | 24.6 (23.67-25.892) | 24.94 (23.91-25.803) | 24.76 (23.8-25.878) | |
| Range | 21.22-28.55 | 20.57-29.92 | 20.57-29.92 | |
| One-month post-op axial length after SiO removal (mm) Mean±SD | 24.97±1.57 | 24.99±1.62 | 24.98±1.58 | 0.634 | Paired t-test; t=0.479 |
| Median (25th-75th percentile) | 24.91 (23.912-26.05) | 24.81 (24.25-29.1) | 24.91 (23.958-25.925) | |
| Range | 21.03-29.51 | 20.68-29.8 | 20.68-29.8 | |
| Change in axial length (mm) Mean±SD | 0.31±0.39 | −0.01±0.19 | 0.15±0.35 | <0.0001 | Paired t-test; t=5.363 |
| Median (25th-75th percentile) | 0.34 (0.065-0.505) | −0.04 (−0.138 to 0.098) | 0.08 (−0.12 to 0.34) | |
| Range | −0.41 to 1.09 | −0.43 to 0.54 | −0.43 to 1.09 | |

SD=standard deviation, SiO=silicone oil

### Table 2: Comparison of axial length (mm) between A-scan and LENSTAR in patients with high myopia

| Axial length (mm) | A-scan (n=12) | LENSTAR (n=12) | Total | P | Test performed |
|------------------|---------------|----------------|-------|---|----------------|
| Pre-op axial length with silicone oil in situ (mm) Mean±SD | 26.62±0.93 | 27.19±1.29 | 26.91±1.14 | 0.016 | Paired t-test; t=2.847 |
| Median (25th-75th percentile) | 26.31 (26-27.105) | 26.84 (26.232-28.292) | 26.76 (26.03-27.402) | |
| Range | 25.46-28.55 | 25.61-29.92 | 25.46-29.92 | |
| One-month post-op axial length after silicone oil removal (mm) Mean±SD | 26.98±1.04 | 27.08±1.19 | 27.03±1.09 | 0.323 | Paired t-test; t=1.035 |
| Median (25th-75th percentile) | 26.58 (26.24-27.59) | 26.68 (26.105-27.942) | 26.68 (26.222-27.78) | |
| Range | 25.87-29.51 | 25.91-29.8 | 25.87-29.8 | |
| Change in axial length (mm) Mean±SD | 0.36±0.47 | −0.12±0.19 | 0.12±0.43 | 0.012 | Paired t-test; t=3.024 |
| Median (25th-75th percentile) | 0.36 (0.08-0.792) | −0.14 (−0.19 to −0.103) | −0.09 (−0.163 to 0.362) | |
| Range | −0.41 to 0.97 | −0.43 to 0.3 | −0.43 to 0.97 | |

SD=standard deviation
immersion biometry and IOL Master before and after SiO removal. They observed the preoperative mean AL to be 23.91 ± 0.24 mm (range 21.33–28.61 mm) and 23.71 ± 0.59 mm (range 19.27–36.18 mm) by IOL Master and A-scan immersion, respectively. The postoperative mean AL by IOL Master was 23.90 ± 0.23 mm (range 21.58–27.94 mm), which showed a statistically significant difference from the preoperative mean AL by A-scan immersion (P = 0.005) and no significant difference from the preoperative AL by IOL Master.

This study is the first of its kind which shows that the AL measurement by LENSTAR is more accurate than A-scan ultrasound in SiO-filled eyes. We also observed that, there was no significant difference in AL measurement pre- and post-SiO removal when measured using LENSTAR, while a significant difference was noted in the AL measured by A-scan ultrasound pre- and post-SiO removal. Our study was performed under controlled conditions with all the measurements performed by a single experienced user, although the possibility of deviation still remained and could have influenced the results.

A conversion factor of 0.71 to AL (as measured on A- or B-scan ultrasonography) has been suggested in eyes filled with 1300 cS SiO by Murray et al.[2] This correction factor can be used to calculate the AL in eyes filled with 1300 cS SiO in the absence of optical biometer.

Post IOL insertion refractive error

In the present study, 17 subjects required IOL insertion. The IOL power was calculated with SRK-T formula using the AL and keratometry obtained by LENSTAR in the eye filled with SiO. In this subgroup of patients, the mean values of target refractive error and postoperative refractive error were −1.18 ± 1.25 and −1.35 ± 1.21 Ds, respectively. No significant difference was seen in target refractive error and postoperative refractive error (P = 0.076).

Tayyab et al.[3] compared the postoperative refractive error in IOL Master group with that of acoustic A-scan group. They observed that the postoperative refractive error in IOL Master group was 0.70 ± 0.32 D and that of acoustic A-scan group was 1.55 ± 0.98 Ds. IOL Master is more accurate for calculating AL compared to A-scan biometry.

Kunavisarut et al.[4] observed that the predictive postoperative refractive error in A-scan immersion (1.79 ± 1.04 D, range 14.62–16.41 D) was greater than in IOL Master (mean 0.60 ± 0.23 D, range 2.74–2.33 D), with a statistically significant difference between them (P = 0.049). Their study concluded that the IOL Master had more accuracy and less deviation in predicting postoperative refractive error than A-scan immersion in SiO-filled eyes.

In a study conducted by Minija et al.[5] at Sankara Eye Hospital, Bengaluru, India, in 2020, the AL of SiO-filled eyes was estimated using OLCR (LENSTAR) technology and the predicted refractive error as calculated with OLCR was correlated with the postoperative spherical equivalent. The mean AL of the eyes was 23.53 ± 1.86 (range 21.49–30.03 mm). The authors concluded that LENSTAR is a safe device that provides precise biometry and IOL power calculation in SiO-filled eyes.

High myopes

In our study, almost one-fourth of the study population (24%) were noted to be high myopes with an AL of ± 26 mm. We noted that the mean ± SD of pre-op AL with SiO in situ (mm) in A-scan was 26.62 ± 0.93, which was significantly lower than in LENSTAR (27.19 ± 1.29) (P = 0.016). While the mean ± SD of 1-month post-op AL after SiO removal (mm) in A-scan was 26.98 ± 1.04 and in LENSTAR was 27.08 ± 1.19, with no significant difference between them (P = 0.323). The mean ± SD of change in AL (mm) in A-scan was 0.36 ± 0.47, which was significantly higher compared to LENSTAR (−0.12 ± 0.19) (P = 0.012). This aspect of biometry has never been studied before in literature.

To the best of our knowledge, our study is the first to compare OLCR-based technology with conventional A-scan for AL measurement and calculation of postoperative refractive error in SiO-filled eyes.

Conclusion

Thus, our study is the first of its kind to safely conclude that, the AL of an SiO-filled eye is more accurately measured using OLCR-based biometry (LENSTAR) compared to conventional acoustic biometry (A-scan). In SiO-filled eyes undergoing IOL implantation, there is no significant difference between the target refractive error and postoperative refractive error obtained by LENSTAR.

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Conflicts of interest
There are no conflicts of interest.

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