Original research

Adjustment formulae to improve the correlation of white-to-white measurement with direct measurement of the ciliary sulcus diameter by ultrasound biomicroscopy

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Abstract

Purpose: This study evaluates the correlation between horizontal white-to-white (WTW) distance using Caliper and Orbscan IIz with the ciliary sulcus diameter measured by high frequency ultrasound biomicroscopy (UBM) and presents an adjustment formula to improve the correlation.
Methods: We measured horizontal STS dimension of 273 right eyes of 273 high myopic patients with 35 MHz UBM and horizontal WTW using Orbscan IIz and Caliper. Mean WTW diameter, differences, and the correlation of measurement methods were evaluated.
Results: The mean spherical equivalent was −8.79 ± 4.87 diopters. Mean horizontal STS dimension with UBM was 12.13 ± 0.45 mm (range, 10.81−13.42 mm). Mean WTW diameter in the Caliper method was 11.70 ± 0.40 mm (range, 10.6−12.8 mm) and 11.70 ± 0.40 mm (range, 10.5−13.1 mm) in the Orbscan method. Mean difference of UBM STS and WTW with Caliper was 0.48 ± 0.28 mm (range, −0.19 to 1.37 mm). Mean difference of UBM STS diameter and Orbscan WTW was 0.38 ± 0.31 mm (range, −0.64 to 1.29 mm). The Pearson correlations of WTW diameter measured by Caliper and Orbscan with UBM's STS diameter were 0.778 and 0.773, respectively. This difference diminished after adjustment. The 95% limit of agreement was almost the same in Caliper and Orbscan (−0.07 to 1.03 compared with −0.23 to 0.99).
Conclusion: There is a significant difference in measurements between STS diameter using UBM and WTW diameter utilizing Caliper and Orbscan. This difference diminished after our recommended adjustment.

Introduction

Posterior chamber phakic intraocular lenses (pIOLs) are gaining popularity in the correction of moderate to high ametropia[1,2] up to 20 diopter. This is mainly due to the fact that this method is not dependent on the cornea ablation utilized in the laser vision correction. Therefore, it is able to correct high refractive errors without comprising the cornea integrity hence avoiding cornea ectasia.

Quality of vision in posterior chamber pIOLs may be better than corneal refractive surgery or anterior pIOLs due to its closer position to the nodal point of eye. This lens is folded and placed within the posterior chamber, behind the iris and anterior to crystalline lens in ciliary sulcus.

It is necessary to measure the sulcus diameter for a proper pIOL fit. As the direct measurement of sulcus was technically impossible in the past, most surgeons used to measure the WTW with a Caliper or Orbscan and then adjust it by adding 0.5–1.00 mm for myopic eyes and subtracting 0.5 mm for hyperopic eyes.[3,4]

One of the challenges in posterior chamber pIOLs surgery is the IOL sizing relying on sulcus-to-sulcus (STS) measurement. An undersized pIOL (low vault < 125 μ) results in the pIOLs rubbing against the natural crystalline lens, which may result in cataract development.[1] On the other hand, an oversized pIOL (high vault > 1000 μ) leads to iris pigment dispersion, angle crowding, peripheral anterior synechia and angle-closure glaucoma.[1]

Correct pIOL size and vault are critical in proper implantation. The empirical methods for determining pIOLs length may not be reliable or reproducible since WTW horizontal corneal diameter does not always represent the STS diameter.[5,6]

Visualizing the posterior chamber anatomy with ultrasound biomicroscopy (UBM) technology has facilitated the calculation of the STS diameter and pIOL size.

The availability of devices that can directly measure the dimensions of the posterior chamber may provide an opportunity to improve the predictability of the optimal size of pIOLs for implantation. A number of studies have been performed to investigate a possible correlation between WTW and STS diameters. All these studies have concluded that a direct measurement of sulcus diameter is more accurate when compared to using WTW measurement.[7,8]

The aim of this study was to find an adjustment formula to improve the calculation of STS diameter and pIOL sizing. We assessed the correlation between two measurement methods of horizontal STS diameter with UBM and horizontal WTW distance with Caliper and Orbscan in a group of Iranian high myopic individuals presented for pIOL surgery.

Methods

This cross-sectional observational study evaluated 273 right eyes of 273 myopic patients assessed for posterior chamber pIOL surgery. All individuals with ocular comorbidities were excluded. The study was conducted according to the tenets of the Declaration of Helsinki. It was approved by the Ethical Committee of Eye Research Center, Rassoul Akram Hospital.

Horizontal WTW diameters were measured with Caliper and Orbscan IIz (Bausch & Lomb Inc., Salt Lake City, USA). The STS diameters on horizontal meridian were measured with VuMax-II UBM with a 35-MHz transducer (Sonomed Inc. USA). Following capturing cross-sectional images at the horizontal meridian, STS diameters were measured using high zoom function by S.J.H. An example can be seen in Fig. 1.

Ultrasound biomicroscopy ciliary sulcus measurement

Topical tetracaine 0.5% was instilled to anesthetize the cornea before measurement. One of 3 available eyecups (18 mm, 20 mm or 22 mm) was placed over the eye depending on the vertical palpebral aperture measurement. Then the individual was asked to fixate on a distant target with the other eye while the eyecup filled with sterile normal saline was fitted on the eye being examined.

The ciliary sulcus diameter was measured using VuMax-II UBM equipped with a 35-MHz transducer. In vivo, cross-sectional or transverse images can then be obtained detailing the cornea, iris, ciliary body, anterior chamber angle, and peripheral sclera to demonstrate structural relationships. Cross-sectional images were obtained at the horizontal meridians. Sulcus and anterior chamber (AC) diameters were measured in captured images using the zoom function to improve the accuracy of angle and sulcus measurements (Fig. 1).

All measurements were taken under normal light condition. Following capturing a video clip of eye, the clip was reevaluated, and the best captured image was selected (Fig. 1).

The selection criteria for best image were:

1) Horizontal capture
2) The capture that demonstrated the largest surface area of anterior and posterior surface of crystalline lens.
3) The capture that showed the best image of iris pigment epithelium.
4) The capture that recorded the best image of anterior chamber angle and angle to angle distance without any tilt.

To assess the reliability of the UBM measurements, 21 images were selected. Then they were unlabeled and randomly presented to S.J.H. for measurement on 5 different occasions. We used intra cluster correlation (ICC) to measure the repeatability of measurements. According to the Cicchetti (1994) ICC, any value more than 0.75 was considered an excellent reliability. ICC showed that measurements of STS by 35-MHz UBM were reliable as the ICC was 0.876 [95% confidence interval (CI): 0.787 to 0.940].

To measure the horizontal WTW diameter by Caliper, in all patients, the author (S.J.H.) used Asico Caliper RE 1500 with 1 mm unit. Under topical anesthesia, horizontal WTW diameters were measured 3 times and rechecked with a ruler under a slit-lamp microscope.

One expert operator took Orbscan IIz (Bausch & Lomb Inc., Salt Lake City, USA) in all patients. Scans were taken in automatic release mode. If the system considered the measurement to be unreliable, the measurement was repeated.

The operator selected the best capture to determine the horizontal WTW diameter.

Statistical analysis

As can be seen from Table 1, the mean, standard deviation (SD), median and range were calculated. In order to check the normal distribution of differences between measurements, Kolmogorov-Smirnov test and Q-Q plot were utilized. Median, range, and 95% CI were calculated to assess the differences between the values of STS measured by UBM and WTW diameter measured by Orbscan II and Caliper. We also applied repeated measurements ANOVA to assess the