SCIENTIFIC REPORT

Anterior chamber depth measurement by optical pachymetry: systematic difference using the Haag-Streit attachments

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Background/aim: Haag-Streit recommends that for the most accurate anterior chamber depth (ACD) results, the corneal thickness, as determined with attachment No I, should be deducted from a measurement from corneal epithelium to the anterior lens surface, made with attachment No II (method A). Often ophthalmologists use the measurement made from the corneal endothelium to the anterior lens surface, using only attachment No II (method B), which is a simpler and faster method. This study examined agreement between methods A and B.

Methods: Two studies were conducted independently by each author. PHA measured 127 (27 men, 100 women; mean age, 66.9 years) consecutive Danish patients referred for evaluation because of possible angle closure. RRB measured 109 subjects (30 men, 79 women; mean age, 61.3 years) consecutively from a population based glaucoma survey in Rom Klao, Thailand.

Results: Using method A, mean ACD was 1.97 mm (SD 0.29) in the Danish study and 2.59 mm (SD 0.27) in the Thai study. ACD measured with method B was significantly ($p < 0.001$) deeper than method A in both studies (Danes: difference = 0.118 (95% CI: 0.109 to 0.127); Thais: difference = 0.166 mm (95% CI: 0.158 to 0.174)). With an increase in ACD of 1 mm, the methodological difference increased by 0.052 mm (regression formula: difference (B – A) = $0.0667 \times \text{mean ACD} - 0.0148$; $R^2 = 0.31$). This positive correlation did not differ significantly between the two studies.

Conclusions: The relevance and importance of estimating ACD as a risk factor in primary angle closure glaucoma suspects and patients has been repeatedly emphasised. This is the first empirical study to quantify the difference in ACD using these two methods in two samples, one clinic based (angle closure suspects) and the other population based. The size of the methodological difference has a level that corresponds to the age reduction of ACD per decade, or to about 6% of ACD in a given eye. These findings highlight the importance of clinicians recognising that these two methods will give different results and recommend that one should standardise ACD measurements using the Haag-Streit optical pachymeter.

pachymeter has been used in several population based glaucoma studies, such as Greenland¹, Mongolia,⁸ Nigeria,⁹ and Taiwan.⁵ Other uses for optical pachymetry include measurements of ACD following trauma which may result in a deepened anterior chamber secondary to lens subluxation, or in other cases of anterior chamber shallowing.

The Haag-Streit pachymeter (Haag-Streit, Bern, Switzerland) is probably the most commonly used instrument for optical pachymetry in eye clinics. For use with the Haag-Streit slit lamp 900, there are two measuring devices: No I, which measures widths up to 1.2 mm and is used for measuring corneal thickness, and No II, which measures widths up to 6.0 mm and is used for ACD measurements with or without inclusion of corneal thickness.

Haag-Streit¹⁰ recommends that for the most accurate ACD results, the corneal thickness, as determined with attachment No I, should be deducted from a measurement from corneal epithelium to the anterior lens surface, made with attachment No II ("method A"). Many ophthalmologists seem to use the measurement made from the corneal endothelium to the anterior lens surface, using only attachment No II ("method B"), which certainly is more rapid in that it uses only one pachymeter device.

The intention of this methodological study was to investigate how results with these two methods agree and especially to investigate whether a systematic difference exists between the two methods.

The two methods of recording ACD are explained below.

METHODS

The Haag-Streit 900 slit lamp BM model (fig 1) was used in both studies. The slit lamp was switched to 6 V and the slit reduced to a setting of about 0.05–0.1 mm—that is, the minimal slit width. The microscope and slit lamp were coupled together at the angle of 40 degrees towards the right ocular at which angle the slit beam passes through the diaphragm of the measuring device. The split image eyepiece was substituted for the right eyepiece of the slit lamp. The coupled slit lamp and microscope were then swung to the right until the slit was projected perpendicularly to the surface of the cornea in the centre of the pupil. The patient was instructed to look into the light, and the slit beam directed exactly into the centre of the pupil. For fine adjustment the slit beam was moved sideways and the horizontal dividing line of the two halves of the split image moved up or down until they both appeared in the middle of the pupillary area.

Measurement of anterior chamber depth (ACD) has several clinical applications in ophthalmology. There is a well described association between a shallow anterior chamber and primary angle closure glaucoma (PACG)^{1–4} and it has been suggested that measurement of ACD may have potential in screening for PACG.^{5–6} The optical

Abbreviations: ACD, anterior chamber depth; CCT, central corneal thickness; PACG, primary angle closure glaucoma

Figure 1 The Haag-Streit pachymeter measuring devices I and II, and a photograph of a Haag-Streit 900 slit lamp BM model fitted with measuring device I.

Corneal thickness measurement with attachment I (used only in method A)

The microscope was set to $\times 1.6$ magnification; +2.5 dioptres were added to the ophthalmologist's normal setting on the right eyepiece housing.

The alignment of the measuring points is illustrated in figure 2A. The "touch method" was used to derive the measurement by aligning the endothelial surface of the one half of the corneal profile to the epithelial surface of the other half.¹¹

ACD measurement with attachment No II

The microscope was set to $1.0\times$ magnification. +6 dioptres were added to the ophthalmologist's normal setting on the right eyepiece housing.

Specific diagrams are given for method A and method B, as illustrated in figures 2B and C, respectively.

Both authors had considerable experience with these instruments, and had used them previously in population based glaucoma surveys. Measurements using method B were made immediately after method A; however, the calculation of ACD (required for method A) was performed after the pachymetry was finished, and therefore the examiner was unaware of the calculated value for ACD made by method A in advance of method B. Author PHA took three values for each measurement and used the mean measurement for the analysis, while author RRB obtained a single value for each measurement.

Author PHA measured ACD and central corneal thickness (CCT) in a consecutive sample of patients referred by nine primary eye care practitioners for evaluation for possible angle closure at a hospital in Denmark, which serves a community of approximately 350 000 inhabitants. One hundred and twenty seven patients were examined in a 5 year period (1990–5), consisting of 27 men and 100 women, a sex structure that would be expected in a cohort of angle closure suspects. There was a mean age of 66.9 years (SD 12.8 years; range 41–90 years).

Figure 2 (A) Corneal thickness measurement using the "touch method" with attachment I (used only in method A). (B) Anterior chamber depth measurement with attachment No II. Method A. (C) Anterior chamber depth measurement with attachment No II. Method B.

Author RRB measured ACD and CCT in 108 subjects consecutively recruited from a population based glaucoma survey¹² in Rom Klao, Thailand (November 1999–February 2000). There was a mean age of 61.3 years (SD 6.8) years; range 43–81 years). Approval for the study was obtained from the institutional review board at Chulalongkorn University Hospital, Bangkok. Informed consent was obtained from each subject.

RESULTS

The Danish and Thai studies obtained measurements using both methods for 127 and 109 subjects, respectively. Demographic data and ACD measurements using each of the two methods are given in table 1.

ACD measured in Danish angle closure suspects were markedly more shallow than in the population based sample of Thai subjects. This simply reflects the different selection criteria used between these studies. Both studies show that ACDs were significantly deeper when using method B rather than method A (for right and left eyes when analysed separately). This systematic methodological difference was about 0.12 mm among the shallow angle closure sample of Danes and significantly ($p < 0.001$) higher among the deeper population based Thai group (about 0.165 mm). There was a significant difference (independent t test, $p < 0.001$) in corneal thickness measurements between the two studies with thicker corneas measured in the Danish study (mean 0.555 mm; standard deviation 0.039) than in the Thai study (mean 0.486; SD 0.025).

Figure 3A illustrates the variation of the difference between measurements compared across the range of ACD. The difference between methods increased with increasing ACD. Regression of the difference between methods against method A for anterior chamber depth resulted in R^2 values of 0.06, 0.15, and 0.26 for the Danish study, the Thai study, and both studies combined, respectively.

Table 1 Demographics and anterior chamber depth measurements obtained from the two studies

	Danish study (PHA)	Thai study (RRB)
No of subjects	127	109
Men, women	27, 100	30, 79
Mean age (range; SD)	66.9 (41–90; 12.8)	61.3 (43–81; 6.8)
Right* mean ACD using method A (range; SD)	1.97 (1.37–2.73; 0.29)	2.59 (2.00–3.30; 0.27)
Left† mean ACD using method A (range; SD)	2.01 (1.18–2.76; 0.29)	2.61 (1.80–3.97; 0.35)
Method B – method A (right eyes)	Mean: 0.118 SD: 0.05	Mean: 0.166 SD: 0.04
(paired <i>t</i> test, <i>p</i> value)	95% CI: 0.109 to 0.127 (<i>p</i> <0.001)	95% CI: 0.158 to 0.174 (<i>p</i> <0.001)
Method B – method A (left eyes)	Mean: 0.111 SD: 0.05	Mean: 0.165 SD: 0.04
(paired <i>t</i> test, <i>p</i> value)	95% CI: 0.102 to 0.120 (<i>p</i> <0.001)	95% CI: 0.157 to 0.174 (<i>p</i> <0.001)

*105 right eyes in Thai study and 127 in Danish study

†109 left eyes in Thai study and 125 in Danish study; 105 paired eyes were compared in the Thai study and 125 pairs in the Danish study

Figure 3B illustrates the relation between the two measurements by pooling the data from both studies. The regression line for this relation is $y = 0.931x + 0.0249$. Using this equation, one can predict the value of ACD using method A from a value obtained using method B.

DISCUSSION

Lowe³ gave the first description of the new Haag-Streit attachments. He also discussed the use of attachment No II alone to measure from corneal endothelium to anterior lens surface. He called this the “apparent” ACD, and found the true depth to be approximately 0.1 mm less. This study has confirmed Lowe’s findings and demonstrated that there is indeed a significant difference between the results of these

two methods of measuring ACD. To our knowledge this is the first empirical study of this problem.

The size of such a methodological difference (mean of 0.12 mm in the Danish study and 0.17 mm in the Thai study) approximates to the age reduction of ACD per decade, or to about 6% of ACD in a given eye. The study also demonstrated that the difference between methods B and A shows a positive correlation with ACD. This was illustrated within each sample and by the methodological difference being greater in the Thai group where the ACD of the subjects were on average deeper than in the Danish group (angle closure suspects).

Ultrasound offers an alternative to optical pachymetry. Ultrasonic measurement of ACD gives a measure corresponding to the full distance in method A with corneal thickness included. Yet variability is probably greater with ultrasound, because of the indentation of the cornea particularly when the intraocular pressure is low.¹³ Although accurate and reproducible,^{7,14} optical pachymetry is less ideal from a practical perspective for screening for shallow anterior chambers (as in the detection of primary angle closure glaucoma) because it requires bulky equipment and requires substantial training. However, optical ACD measurement has been shown to be more efficient in the detection of occludable angles or primary angle closure compared with hand held or slit lamp mounted ultrasonic pachymetry.¹⁵

From a clinical standpoint, it is important that it is recognised that these two methods of ACD measurement will give different results. Therefore, ACD measurements using the optical pachymeter should be standardised. Corneal thickness measurements have received considerable attention and importance recently in clinical glaucoma work.¹⁶ However, for clinicians who wish to use method B (which has the advantage of speed, requiring a measurement with only one instrument), we recommend the regression formula given in figure 3B be used to predict the “true” measurement, or alternatively a simple reduction of 6%. At the very least, we recommend the clinician denotes the method used and clearly stipulates whether or not corneal thickness was involved.

Figure 3 (A) The variation of the difference between anterior chamber depth (ACD) measurements (using the two measurement methods) compared against the mean ACD measured using the two methods. (B) Correlation between the two methods of measuring ACD: method A (instruments I and II) versus method B (instrument II only).

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