Glaucoma anterior chamber morphometry based on optical Scheimpflug images

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ABSTRACT

Purpose: To compare the performance of gonioscopy and noncontact morphometry with anterior chamber tomography (High Resolution Pentacam - HR) using optical Scheimpflug images in the evaluation of the anterior chamber angle (ACA).

Methods: Transversal study. 112 eyes from 74 subjects evaluated at the Glaucoma Department, Federal University of Fluminense, underwent gonioscopy and Pentacam HR. Using gonioscopy, the ACA was graded using the Shaffer Classification (SC) by a single experienced examiner masked to the Pentacam HR findings. Narrow angle was determined in eyes in which the posterior trabecular meshwork could not be seen in two or more quadrants on nonindentation gonioscopy (SC Grade 2 or less). Pentacam HR images of the nasal and temporal quadrants were evaluated by custom software to automatically obtain anterior chamber measurements, such as: anterior chamber angle (ACA), anterior chamber volume (ACV) and anterior chamber depth (ACD).

Results: Based on gonioscopy results, 74 (60.07%) eyes of patients classified as open-angle (SC 3 and 4) and 38 (33.93%) eyes of patients classified as narrow-angle (SC 1 and 2). Noncontact morphometry with Scheimpflug images revealed a mean ACA of 39.20 ± 5.31 degrees for open-angle and 21.18 ± 7.98 degrees for narrow-angle. The open-angle group showed significant greater ACV and ACD values when compared to narrow-angle group (ACV of 193 ± 36 mm³ vs. 90 ± 25 mm³, respectively, p<0.001; and ACD of 3.09 ± 0.42 mm vs. 1.55 ± 0.64 mm, respectively, p<0.0001). In screening eyes with open-angle and narrow-angle with the Pentacam ACA of 20° (SC Grade 2) using the ROC curves, the analysis showed 52.6% of sensitivity and 100% of specificity.

Conclusions: The Pentacam showed ability in detecting eyes at risk for angle closure analyzing ACV and ACD.

Keywords: Anterior chamber; Cornea/anatomy & histology; Gonioscopy/methods; Image Processing, computer-assisted/methods.

INTRODUCTION

Primary angle-closure glaucoma (PACG) is a pathologic condition considered to be the result of some characteristics of the anterior segment of the eye11,2. Studies of biometric eye characteristics have shown primary PACG to be accompanied by narrow anterior chamber angle, shallow anterior chamber, lens abnormal thicker with steeper curvature of the anterior surface, anterior lens position, reduced corneal diame- ter, and a shorter axial length3-5. Among these biometric features, the narrow anterior chamber angle is thought to be the most important because a long-standing narrow angle or appositional closure may predispose to peripheral anterior synechiae formation causing uncontrollable rise in intraocular pressure (IOP)6-8.

In routine clinical use, different classification systems are used to evaluate and quantify the anterior chamber angle. The gold standard is the Goldmann contact lens examination and the classifications introduced by Shaffer. The value of gonios-
copic angle grading systems has been shown; however, based on anatomic landmarks, the numerical estimation of the anterior chamber angle remains subjective and highly dependent on the examiner’s judgment and experience. Reproducible quantification by different examiners is often difficult to assess. Thus, an imaging technique that is largely independent of the operators’ judgment is desirable.

The evaluation of gonioscopic findings is subjective, semi-quantitative. Although gonioscopic grading systems and biometric gonioscopy allow semiquantitative measurements of the anterior chamber angle (ACA) width, a precise and objective assessment is not possible with gonioscopy. Other methods to evaluate the ACA like ultrasound biomicroscopy (UBM) and optical coherence tomography (OCT) have been shown to represent the ACA width objectively and quantitatively, but it is time-consuming and relatively operator dependent to determine ACA values.

In this transversal clinical study, non-contact morphometry measures obtained with Scheimpflug images in HR Pentacam (Oculus, Germany) was compared with the traditional gonioscopic method, the Shaffer Grade Classification (SC).

In Scheimpflug principle, the images of the anterior eye are obtained with a camera perpendicular to a slit beam, creating an optic section of the cornea and lens. As with all optical and acoustic techniques, correction of the image distances needs to be made for the refractive index and the curvature of intervening surfaces. The digital Scheimpflug photograph, therefore, decreases in size perpendicular to the direction of the optical axis, reducing the curvature radius and increasing depths and thicknesses along this axis compared with the original photograph. The more recent instrumentations, HR Pentacam, has been designed to rotate around the visual axis, capturing multiple images to create a three-dimensional image of the anterior chamber.

**METHODS**

An experienced examiner (RSA) performed complete ophthalmologic examination, including best-corrected visual acuity measurement in Snellen chart, refraction, keratometry, slit lamp biomicroscopy, intraocular pressure with Goldmann applanation tonometry, and direct ophthalmoscopy using Volk fundus lens. The study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and was approved by the Fluminense Federal University, Niterói RJ Institutional Review Board. Informed consent for participation was obtained from each patient before the study.

All participants, subjects evaluated at the Glaucoma Department, Fluminense Federal University, underwent gonioscopy and a slit lamp-adapted HR Pentacam system (Oculus, Germany) in a dark room, on the same day. Gonioscopy was performed using a slit lamp angled at 45° (magnification 20) in a dark room with a Goldmann applanation tonometer, and direct ophthalmoscopy using Volk fundus lens. The study was performed with the same lighting conditions used for the Fluminense Federal University, Niterói RJ Institutional Review Board. Informed consent for participation was obtained from each patient before the study.

A hundred and twelve eyes of sixty patients were prospectively included. The study included 74 (66.07%) eyes of patients classified as open-angle and 38 (33.93%) eyes of patients classified as narrow-angle classified in Shaffer gonoscopic grade. The mean age of the patients was 51 ± 12 years (range, 21-72 years old). The female-male ratio was 32:28. Intraocular pressure mean was 20 ± 9 mmHg (range, 10-34 mmHg) using Goldmann applanation tonometry.

Anterior chamber angle average using noncontact morphometry with Scheimpflug images using Pentacam HR was 35° ± 90 (range, 31°-51°). For individual groups ACA mean was 39.20 ± 5.31 SD for open-angle and 21.18 ± 7.98 SD for narrow-angle.

Results show there was a moderate agreement (Kappa Test 0.513, p<0.001) comparing the traditional parameters and Pentacam considering open-angle and narrow-angle. Kaplan

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<tr>
<th>Table 1. Grade system according to Shaffer gonoscopic classification</th>
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<tr>
<td><strong>Shaffer grade 4</strong></td>
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<td><strong>Shaffer grade 3</strong></td>
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test was also used to correlate individually Shaffer classification compared with Pentacam results and the anterior chamber angle calculated by Pentacam HR has moderate relationship with examiner performing in narrow-angle (Grade 1) and open-angle (Grade 4). Intermediate angles (Shaffer Grade 2 and 3) have poor agreements comparing the two methods (Table 2).

Anterior chamber volume and anterior chamber depth values demonstrate difference statistically significant comparing open-angle and narrow-angle groups classified in Shaffer Grade and Pentacam values, 193 ± 36 mm3 SD ACV for open-angle and 90 ± 25 mm3 SD ACV for narrow-angle (p<0.0001) and 3.09 ± 0.42 mm ACD for open-angle and 1.55 mm ± 0.64 SD ACD for narrow-angle (p<0.0001).

The efficacy of the Pentacam parameters to screen out the open-angle (SC Grade 3 and 4) and narrow-angle (SC Grade 1 and 2) eyes as defined above were studied using ROC curves. According to the partition analysis, when ACA was used as the reference to classify the open-angle and narrow-angle eyes value of 20° using the Pentacam, results in 52.6% sensitivity and 100% specificity.

When ACV was used as the reference and partition analysis showed that those eyes were most effectively partitioned with an ACD threshold of 2.6 mm using the Pentacam, resulting in 100% sensitivity and 82.4% specificity.

DISCUSSION

Principal objective of gonioscopy is the visualization of the anterior chamber angle, parameter is determined whether the angle is open, and the most important closed and occludable. In PACG, gradual asymptomatic angle closure results in diminished aqueous outflow through the drainage angle of the eye and a subsequent rise of the intraocular pressure (IOP). Diminished aqueous outflow through the drainage angle of the eye and a subsequent rise of the intraocular pressure (IOP). Thus, angle closure is an anatomic disorder, and HR Pentacam imaging of the anterior eye segment may improve detection of angle closure vulnerable eyes noninvasively crossing morphometric parameters like ACV and ACD. The evolution in HR Pentacam will increase the sensitivity to detect relevant changes and will be particularly important in narrow or closed angles with low ACA and ACV.

Our results revealed the correlation in occludable and narrow or closed angles, which further improved the diagnostic accuracy in these conditions. The results suggest that the determination of the ACV with traditional clinic parameters was more effective in detecting open angles when compared with the HR Pentacam morphometry. Therefore, HR Pentacam gonioscopy with its noncontact format and improved handling could be used as an objective screening method on a population basis and could be implemented in epidemiologic studies of the ACA and ACD.

Further refinements with reduced costs and adaptation in a portable system will make HR Pentacam gonioscopy more affordable for these purposes. Noncontact HR Pentacam gonioscopy was helpful in evaluating the anterior chamber structures and could improve the noninvasive clinical assessment and treatment of patients with glaucoma. Although like other technologies, Scheimpflug non contact images cannot completely replace microscopic evaluation of the ACA anatomy and pigmentation with a gonioscopic lens, it has the potential to supplement quantification with current gonioscopic gra-
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In summary, some differences were found in clinical classification in Pentacam results. Our findings suggest that the determination whether the angle is open, closed and occludable is directly and more closely related to anterior chamber angle and anterior chamber depth. The most likely explanation for the results comparing ACA with the two methods is that Pentacam HR software systematically supersamples ACA compared with traditional gonioscopic method, although additional image processing factors could partially explain these results as well. The implications of our results are that improved and novel morphometric information of anterior segment may be available from Scheimpflug images that could enhance glaucoma decision-making and possibly improve outcomes.

REFERENCES