

Assessment of Anterior Chamber by Ultrasound Biomicroscopy and Anterior Segment Optical Coherence Tomography in Patients with Inflammatory Glaucoma

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Abstract

Objective: To investigate the clinical indications of ultrasound biomicroscopy (UBM) and anterior segment optical coherence tomography (AS-OCT) in eyes with inflammatory glaucoma.

Methods: Sixteen patients (16 eyes) with inflammatory glaucoma were analysed retrospectively. All of the subjects underwent UBM and AS-OCT scans, measuring the following parameters: central corneal thickness (CCT), central anterior chamber depth (ACD), angle-opening distance (AOD500), and trabecular-iris angle (TIA500) in four quadrants.

Results: Both the UBM and AS-OCT generated detailed, high-resolution images of the anterior segments of the eyes with inflammatory glaucoma. Moreover, the UBM and AS-OCT exhibited statistically similar measurement results for all of the indices. A Bland–Altman analysis showed a high level of agreement between the two imaging techniques. Additionally, the UBM was able to visualize the ciliary body and pars plana, while the cells and the flare in the anterior chamber appeared more pronounced in the UBM images.

Conclusions: Both the UBM and AS-OCT are useful tools for anterior segment imaging and taking measurements needed for evaluating inflammatory glaucoma. The AS-OCT has the advantages of being noninvasive and fast, whereas the UBM is presently unparalleled in the visualization of the ciliary body and pars plana.

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Keywords

Ultrasound biomicroscopy, anterior segment optical coherence tomography, inflammatory glaucoma, anterior segment, anterior segment imaging, glaucoma

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Introduction

Inflammatory glaucoma, or uveitic glaucoma, includes a range of disorders in which ocular inflammation causes persistent or recurrent elevation in the intraocular pressure (IOP).^{1,2} The overall prevalence of inflammatory glaucoma in eyes with uveitis varies from 10% to 20%, but it can be as high as 54% in chronic uveitis and specific uveitic syndromes, such as herpes simplex keratouveitis.^{3,4}

The pathogenic factors responsible for the increased IOP in inflammatory glaucoma are complex and diverse, including oedema of the trabecular lamellae, the accumulation of inflammatory elements in the anterior chamber angle and angle closure.^{2,5} The objective imaging and measurement of the anterior segment is particularly useful for the diagnosis and treatment of glaucoma.⁶ The introduction of ultrasound biomicroscopy (UBM) in the early 1990s allowed high-resolution visualization of the anterior segment and angle structures with an ultrasonic frequency of 50 MHz.⁷ A number of previous studies highlighted the potential of UBM in the diagnosis and treatment of ocular disorders by providing additional information not otherwise available through clinical examination.^{7,8} More recently, anterior segment optical coherence tomography (AS-OCT) using a coherent optical signal has been introduced as an anterior imaging technique alternative to UBM.^{9,10}

Many studies have been published comparing the applications of UBM and

AS-OCT for specific ocular conditions and disorders.^{11–13} However, to our knowledge, no study has determined that the two techniques provide comparable anterior segment imaging in patients with inflammatory glaucoma. Thus, the purpose of the current study was to investigate the clinical indications of UBM and AS-OCT in anterior segment imaging and measurement of eyes with inflammatory glaucoma.

Patients and methods

Study participants

This nonrandomized, prospective, observational study enrolled 16 patients (16 eyes) with inflammatory glaucoma who were admitted as outpatients to the Department of Ophthalmology at the Shanghai Tenth People's Hospital of Tongji University between February and May of 2017. Inflammatory glaucoma was defined as non-infectious anterior or intermediate uveitis and secondary elevated intraocular pressure greater than 21 mmHg on two or more consecutive occasions. Inclusion criteria comprised patients with inflammatory glaucoma and age >18 years. Exclusion criteria consisted of other forms of glaucoma, any previous glaucoma interventions, severe systemic diseases, history of ocular surgery, and eyes with poor-quality UBM or AS-OCT images. The study was approved by the local Institutional Review Board of Shanghai Tenth People's Hospital (ethical approval: 2017-RES-032), and it

was adherent to the tenets of the Declaration of Helsinki. Written informed consent was obtained from each subject participating in the investigation.

Anterior segment OCT

All of the subjects underwent anterior UBM (SW-3200L; Suoer Electronic Technology Co., Ltd., Tianjin, China) and AS-OCT (Casia SS-1000; Tomey Corporation, Nagoya, Japan) scans by the same skilled clinician under ordinary room light. The AS-OCT was performed first while the patient was in a sitting position. The patient was asked to gaze at the internal fixation and the scans were centred on the limbus using the anterior segment program. The process was repeated three times, and the parameters were calculated using the built-in software by choosing the best images.

Ultrasound biomicroscopy

The UBM was performed with the patient in the supine position following AS-OCT examination. After administration of topical anaesthesia, an appropriately sized eyecup was placed on the eye with normal saline as the couplant. The measurements were repeated three times, and the mean value was used for statistical analysis. Each parameter was measured with the two imaging methods, including the central corneal thickness (CCT), central anterior chamber depth (ACD), angle-opening distance (AOD500), and trabecular-iris angle (TIA500) in the superior, inferior, nasal, and temporal quadrants.

Statistical analysis

A statistical analysis was performed using the Statistical Package for the Social Sciences version 16.0 (SPSS Inc., Chicago, IL, USA). The data were expressed as the mean \pm standard deviation. The differences in the measurements between the UBM and

the AS-OCT were analysed using a paired *t* test. A Bland–Altman analysis was used to evaluate the agreement between the two techniques. All of the tests were two-tailed, and a *P* value of less than 0.05 was considered to be statistically significant.

Results

Baseline characteristics of study participants

The measurements were performed in 16 eyes of the 16 participants (10 females), whose mean age was 41.7 ± 10.6 years old (range = 21 to 63 years). Of the 16 eyes, 7 had idiopathic uveitis, 7 had glaucomatocyclitic crises, and 2 had Fuchs' heterochromic iridocyclitis. All 16 eyes had secondary open-angle glaucoma. All of the patients were available for the analyses.

Anterior segment measurements

Table 1 compares the UBM and AS-OCT measurements of the anterior segment parameters of the 16 eyes. The UBM and AS-OCT exhibited statistically similar measurements for all of the indices (all $P > 0.05$). The measurement agreement of the parameters between the two methods was illustrated using Bland–Altman plots (Figure 1).

Anterior segment images

Figure 2 shows representative AS-OCT and UBM photographs of an eye with idiopathic uveitis. Both the AS-OCT and UBM generated detailed, high-resolution images of the anterior segment of the eye. However, the AS-OCT was unable to visualize the structures behind the iris plane, whereas the UBM was able to visualize the ciliary body and pars plana. Moreover, the cells and flare in the anterior chamber appeared to be more pronounced

Table I. Comparison of anterior segment parameters measured by UBM and AS-OCT.

Parameter	UBM	AS-OCT	P
ACD (mm)	2.80 ± 0.72	2.99 ± 0.30	0.304
TIA (Nasal) (degrees)	37.91 ± 13.69	38.66 ± 12.90	0.196
TIA (Temporal) (degrees)	40.60 ± 10.48	40.46 ± 11.30	0.913
TIA (Superior) (degrees)	37.84 ± 10.71	37.39 ± 7.40	0.709
TIA (Inferior) (degrees)	35.08 ± 12.13	35.12 ± 11.40	0.945
AOD500 (Nasal) (mm)	0.64 ± 0.30	0.64 ± 0.28	0.951
AOD500 (Temporal) (mm)	0.71 ± 0.31	0.68 ± 0.28	0.112
AOD500 (Superior) (mm)	0.62 ± 0.25	0.64 ± 0.26	0.057
AOD500 (Inferior) (mm)	0.65 ± 0.32	0.64 ± 0.29	0.318

UBM: Ultrasound biomicroscopy; AS-OCT: Anterior segment optical coherence tomography; ACD: Anterior chamber depth; TIA: trabecular-iris angle; AOD500: angle-opening distance.

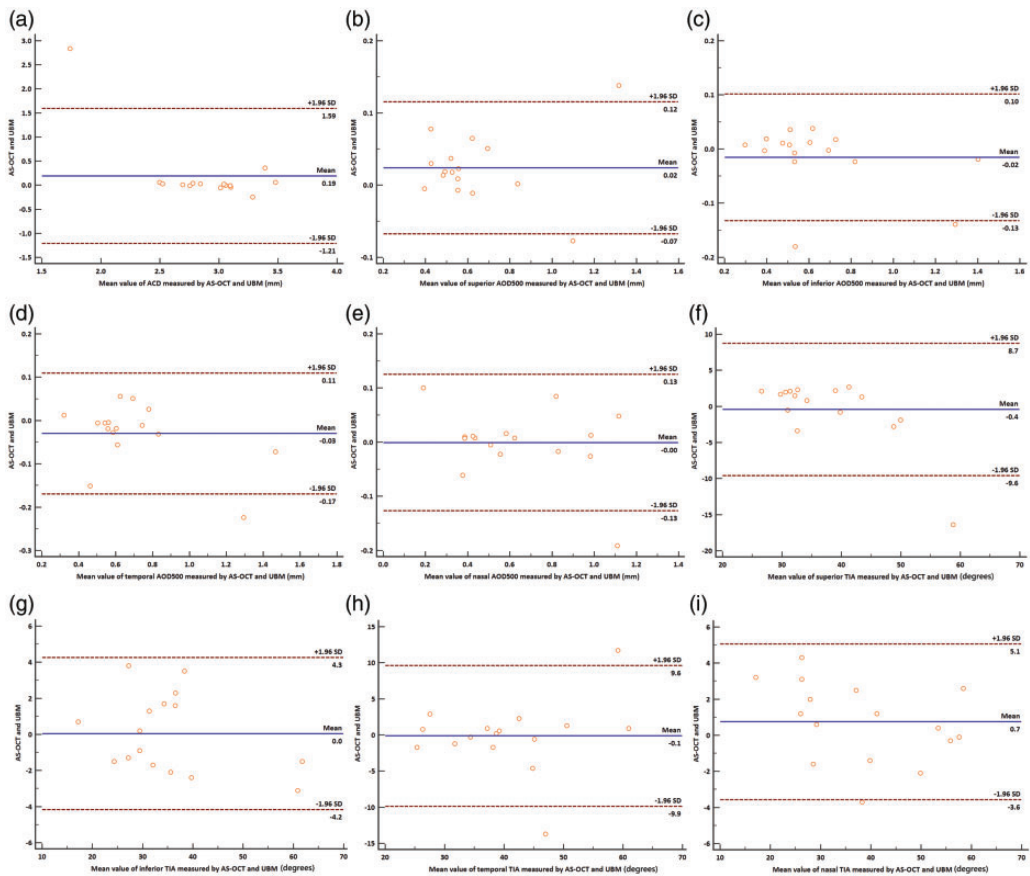


Figure 1. Bland–Altman plots of the differences between UBM and AS-OCT of anterior segment parameters (a: ACD; b: superior AOD500; c: inferior AOD500; d: temporal AOD500; e: nasal AOD500; f: superior TIA; g: inferior TIA; h: temporal TIA; i: nasal TIA). UBM: Ultrasound biomicroscopy; AS-OCT: Anterior segment optical coherence tomography.

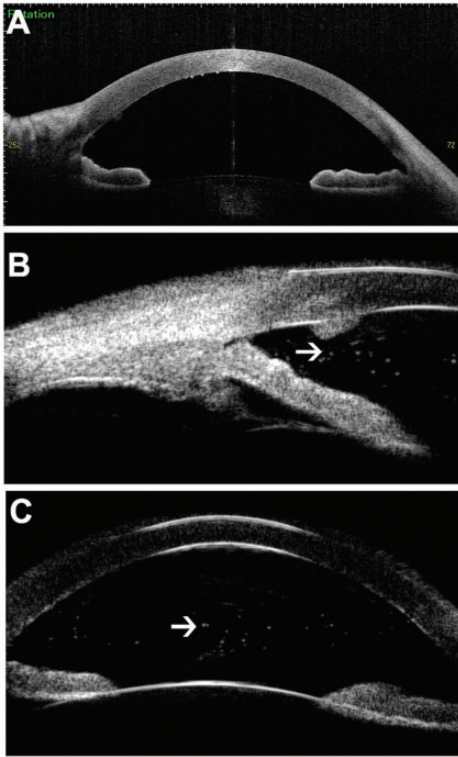


Figure 2. Representative AS-OCT (a) and UBM (b, c) photographs of an eye with idiopathic uveitis. Both AS-OCT and UBM generated detailed, high-resolution images of the anterior segment of the eye. However, AS-OCT was unable to image the ciliary body, whereas UBM did allow visualization of the ciliary body and pars plana (b). Moreover, the cells and flare in the anterior chamber (white arrow) appear more pronounced in the UBM images (b, c). UBM: Ultrasound biomicroscopy; AS-OCT: Anterior segment optical coherence tomography.

in the UBM images, which could be used to objectively evaluate the severity of the intraocular inflammation.

Discussion

In the current study, we compared the anterior chamber measurements from UBM and AS-OCT scans of patients with inflammatory glaucoma. To our knowledge, this

has not been reported before. No significant differences were identified between the UBM and AS-OCT images for any of the parameters. Therefore, both UBM and AS-OCT could be used to obtain measurements of the angle and anterior segment in inflammatory glaucoma eyes.

The accuracy and repeatability of the anterior segment parameter measurements for UBM and AS-OCT have been reported in previous studies that indicated a high level of agreement between the two techniques among specific eye conditions.^{11,14-17} Our findings in eyes with inflammatory glaucoma were in agreement with these studies. However, some previous studies found that the AS-OCT measurements slightly overestimated the ACD when compared with UBM.¹⁸ The authors speculated that maintaining the patient in the supine position during UBM as well as the inadvertent posterior pressure of the eyecup and immersion could produce a backward movement of the iris-ciliary diaphragm leading to an artificial widening of the angle.^{18,19} However, we did not find this difference in our study. The reason may be that the position change and eyecup pressure do not cause movement of the iris-ciliary diaphragm in eyes with elevated IOP.

Although our results showed that either of these two methods could be options for measuring the angle and anterior segment, the invasive nature of UBM requires direct contact with the eye and an experienced technician, thus making it cumbersome and time consuming.¹³ In contrast, the AS-OCT is a noncontact, rapid, and well-tolerated technique with easily-practiced data collection and analysis. Therefore, the AS-OCT is ideal for the measurement of the anterior segment in patients with inflammatory glaucoma. In addition, the recent application of artificial intelligence based on deep learning using OCT may have the potential to play an important

role in the diagnosis and treatment of ocular diseases in the near future.¹⁹

Unfortunately, the AS-OCT does have a major shortcoming with regard to its low tissue penetration when compared with the UBM. The posterior pigmented layer of the iris and sclera prevent the passage of infra-red light, rendering the ciliary body and suprachoroidal space invisible.²⁰ In contrast, UBM has the advantage of being able to image the structures behind the iris plane; therefore, it provides clinicians with more information. For instance, the illustration of the ciliary body is particularly useful for diagnosing chronic ocular hypotony, which paradoxically may be a late development in eyes with chronic inflammatory glaucoma.³ It is also of additional value in the evaluation of the anatomical extent of ocular inflammation and in subsequent therapeutic decision making by imaging the ciliary body and pars plana, whether inflammation is involved or not.^{6,21} Moreover, the cells and flare in the anterior chamber appeared to be more pronounced in the UBM images, which is useful in the follow-up during the course of inflammatory glaucoma.

In conclusion, both UBM and AS-OCT are useful tools for anterior segment imaging and conducting measurements for evaluating inflammatory glaucoma. As a noncontact imaging technique, AS-OCT is better than UBM in the anterior segment parameter measurements with its advantages of being fast and easy for the technician and patient. However, the UBM is irreplaceable when visualization of the ciliary body and peripheral iris is necessary in the differential diagnosis of inflammatory glaucoma.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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