Primary angle closure glaucoma (PACG) is a major form of glaucoma in large populous countries in East and South Asia. The high visual morbidity from PACG is related to the destructive nature of the asymptomatic form of the disease. Early detection of anatomically narrow angles is important and the subsequent prevention of visual loss from PACG depends on an accurate assessment of the anterior chamber angle (ACA). This review paper discusses the advantages and limitations of newer ACA imaging technologies, namely ultrasound biomicroscopy, Scheimpflug photography, anterior segment optical coherence tomography and EyeCam, highlighting the current clinical evidence comparing these devices with each other and with clinical dynamic indentation gonioscopy, the current reference standard.

Key words: Anterior chamber angle imaging, anterior segment optical coherence tomography, EyeCam, gonioscopy, Scheimpflug photography, ultrasound biomicroscopy

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**Angle Imaging: Advances and Challenges**

Glaucoma is the second leading cause of blindness worldwide, affecting 60.5 million people in 2010, increasing to 79.6 million by 2020.[3] Asians will represent 47% of those with glaucoma and 87% of those with primary angle closure glaucoma (PACG). Bilateral blindness will be present in 3.9 million people with PACG in 2010, rising to 5.3 million people in 2020.[1] PACG has a mean annual age-and-sex-adjusted incidence of up to 8.3 per 100,000,[4] and is a major form of glaucoma in East and South Asia.[5] Aggressive and visually destructive, it is responsible for the majority of bilateral glaucoma blindness in Mongolia.[6] Singapore,[5] China,[7] and India.[8] In China, an estimated 28 million have appositional angle closure, the anatomical trait predisposing to PACG, which blinds more people than open angle glaucoma in China.[7] The high prevalence of PACG in the populous nations like China and India ranks it as a major cause of significant visual morbidity on a global scale.

There exists a spectrum of stages in the PACG disease process. At the earliest stage (termed primary angle closure suspect, PACS), eyes have narrow or occludable angles without raised intraocular pressure (IOP) or glaucomatous optic neuropathy. Primary angle closure (PAC) is said to occur in eyes with narrow angles and the sequelae of apposition, peripheral anterior synchiae (PAS) and/or raised IOP but without glaucomatous optic neuropathy. PACG is reserved for cases of PAC with glaucomatous optic neuropathy. Although the natural history and clinical course of eyes with angle closure are not well established, PACS are anatomically predisposed and considered the “precursor” to PAC and PACG. It has been estimated that 22% of the eyes with PACS progress to PAC[9] and 28.5% progress from PAC to PACG over 5–10 years.[10] Prophylactic laser iridotomy performed as the first-line treatment for narrow angles may halt the progression of the angle closure process and prevent development of PACG,[11] but it is less effective in controlling IOP if optic nerve damage with PAS has already occurred.[12,13]

Many cases of PACG are asymptomatic and often present with severe to end-stage visual field loss at the time of the first presentation. The high visual morbidity from PACG is related to the destructive nature of the asymptomatic form of the disease.[14] Hence, early detection of anatomically narrow angles is important and the subsequent prevention of visual loss from PACG depends on an accurate assessment of the anterior chamber angle (ACA).

**Gonioscopy**

Dynamic indentation gonioscopy is the current reference standard for assessing ACA structures and their configuration. The identification of regions of apposition of the iris to the trabecular meshwork enable the diagnosis of angle closure to be sought. However, gonioscopy is unfortunately plagued by subjectivity, with only moderate agreement reported among the observers.[3,4,15] The varying annotation of angle findings across different grading schemes,[16,17] varying gonioscopic findings with different gonioscopic lenses and the alteration of the angle configuration by light, placement of the lens and/or mechanical compression of the eye lead to significant variability in the assessments.[3,4,16,19-23] The definition of what constitutes an occludable angle also ranges from 180 to 270 degrees of angle, in which the trabecular meshwork is not visible.[24]

**Ultrasound biomicroscopy**

Ultrasound biomicroscopy (UBM), a technique first developed in the 1990s, is an objective alternative for ACA assessment. Electric signals are converted, by a radiofrequency signal generator coupled to a piezoelectric transducer, into 50 MHz
frequency ultrasonic sound waves, which are transmitted to
the eye via saline solution that is held in a cup reservoir or
within the end of a probe on which the transducer is mounted.
These sound waves travel at different speeds through the eye
as they encounter tissues of varying acoustic impedance and
are reflected at differing time intervals. A computer system
collates and magnifies these reflected sound waves, providing
a high-resolution B scan image.

Studies comparing UBM to gonioscopy have found a
high agreement between the two modalities when both are
performed in a completely dark room.[26] UBM is sufficiently
sensitive such that significant differences among the mean
UBM measurements (angle-opening distances at 250 µm and
500 µm from the scleral spur and trabecular meshwork–ciliary
process distance) of each angle grade estimated by gonioscopy
can be detected [Fig. 1].[34] Although subjective gonioscopic
assessment occasionally resulted in an overestimation of the
angle width as compared with the UBM values in eyes with occludable angles,[27] angle dimensions measured by UBM
correlated significantly with gonioscopy in general.[28]

UBM allows for the acquisition of real-time images, with
lateral and axial resolutions of 50 µm and 25 µm, respectively.[28,29]
In addition, its ability to visualize posteriorly located structures
such as the ciliary body, lens zonules and anterior choroid
puts it at an advantage over other modalities, especially for
the investigation of the mechanisms behind angle closure.
This includes anterior rotation of the ciliary body in plateau
iris, iridociliary masses causing secondary angle closure or
choroidal effusions.[33,35] Additionally, UBM may also play a
role in the evaluation of certain types of secondary glaucoma,
such as pigment dispersion[31] (posteriorly bowed, causing iris
pigment shuffling) and assessing for a tilted or subluxed lens
in the exfoliation syndrome.[32]

When performing UBM, the requirement for a saline bath,
through which sound waves are transmitted, necessitates
contact with the eye, usually in the form of a scleral cup or a
conical probe [Fig. 2]. This introduces discomfort, the need
for a supine position, risks of mechanical corneal abrasion
and infection and the likelihood of angle distortion due to
inadvertent indentation.[30] Optimal UBM imaging requires a
skilled operator and cooperative subject and, even then, the
process can be time consuming.

Scheimpflug photography
The Scheimpflug principle describes the change in focal plane
that occurs when the film plane is tilted, such that the focal, lens
and film planes are not parallel, shifting the plane of sharp focus
to the intersection point of the film and lens planes and allowing
slit images of the anterior segment of the eye that retain depth
to be obtained. Commercial devices based on this principle
now take up to 50 images in 2 s, using a rotating camera, which
are reconstructed into a 3-dimensional image, enabling a rapid
assessment of the anterior chamber. Semi-automated analysis
of angle width requires the user to determine the iris plane and
plane of corneal curvature by placing up to 10 marks on the
corneal endothelium, from which the angle width is measured.
Although subjective, this fast and non-contact method of
ACA assessment has been previously reported to be highly
reproducible, at least in eyes with open angles.[34-38]

Scheimpflug photographic techniques, however, have not
been documented to reliably image a variety of angle
configurations. In addition, the ACA cannot be entirely
visualized and only the angle approach can be photographed as
light is unable to penetrate to the angle recess. User definition
of the iris plane necessarily uses a straight line to describe a curved
plane, leading to inaccuracies in angle width measurement.
Comparing ACA width measurements using Scheimpflug
photography and UBM revealed only moderate correlation,[39]
with Scheimpflug images being of a much lower resolution.
In addition, one study found that angle measurements
from Scheimpflug images were less sensitive to changes in
illumination compared with those obtained using UBM.[40]
In a recent study, Scheimpflug photography was reported to
provide insufficient detail of the angle for assessment of angle
anatomy, with limited agreement existing between gonioscopy,
Scheimpflug photography and UBM.[41]

Anterior segment optical coherence tomography
Anterior segment optical coherence tomography (AS-OCT)
is a rapid, non-contact imaging device that acquires high-
resolution cross-sectional images of the anterior segment
structures and allows for their objective and quantitative
evaluation. This imaging technology uses low-coherence
interferometry to measure the delay and intensity of light
reflected from tissue structures and comparing it with light
that has traversed a known reference path length by using a
Michelson-type interferometer.[42] The A-scan in this time-
domain OCT technology are produced by varying the position
of the reference mirror. Although this principle was originally
employed for the retinal OCT using light of wavelength 830
nm,[43,44] it was later modified and refined to image the anterior
segment[45] by altering the light to a longer wavelength of 1310
nm.[46] This increases the depth of penetration by reducing the
amount of light scattered by the sclera and limbus, allowing
for visualization of the ACA morphology in greater detail.
In addition, the 1310 nm light incident on the cornea is strongly
absorbed by water in the ocular media, with only 10% reaching
the retina.[47] This enables the AS-OCT to utilize higher power,
enhancing imaging speed and eliminating motion artefacts.

Visante and slit-lamp AS-OCT
The Visante AS-OCT (Carl Zeiss Meditec Inc., Dublin, CA,
USA) obtains scans at a rate of 2000 A-scans per second,
with an axial and transverse resolution of 18 µm and 60
µm, respectively. It requires minimal experience for image
acquisition [Fig. 3]. Slit-lamp OCT (SL-OCT) (Heidelberg
Engineering, Heidelberg, Germany) is the other commercially
available AS-OCT device that is incorporated into a modified
slit-lamp biomicroscopy system. Compared with the Visante
OCT, the SL-OCT has a slower image acquisition speed and
a lower axial and transverse resolution of <25 µm and 20–100
µm, respectively. Furthermore, the SL-OCT requires manual
rotation of the scanning beam.

The AS-OCT devices provide anterior segment, angle and
corneal scans and pachymetry maps and can also be used to
calculate the depth, width and angle of the anterior chamber.
Customized software devices have also been developed to
quantitatively assess, in greater detail, angle parameters,
namely trabeculo-iris space area (TISA), angle recess area
(ARA) and angle opening distance (AOD).
Comparison studies between Visante AS-OCT and gonioscopy found the AS-OCT detected greater closed angles than gonioscopy [Fig. 4], particularly in the superior and inferior quadrants.[48,49] Using gonioscopy as the reference standard, the sensitivity and specificity of AS-OCT to identify angle closure were 98% and 55.4%, respectively, using a definition of one or more quadrants of non-visibility of the trabecular meshwork.[48] Several explanations have been suggested for the disparate findings between gonioscopy and AS-OCT. Inadvertent pressure on the globe and too much exposure of the pupil to visible light during gonioscopy may alter the configuration of the angle, leading to spurious widening of the angle. Another reason could be a difference in the definition and description of the landmarks used to define angle closure. On gonioscopy, angle closure was defined as the apposition between the iris and the posterior trabecular meshwork, whereas on the AS-OCT, it was defined as any contact between the iris and the angle structures anterior to the sclera spur.

Comparison of ACA dimensions by SL-OCT and Visante AS-OCT found a poor correlation, suggesting that angle measurements obtained by the two devices cannot be used interchangeably.[50] The authors attributed the poor agreement to differences in the choice of refractive indices in the calculation of anterior segment dimensions, differing algorithms for image dewarping, software for image analysis, exact scan location and use of internal fixation in Visante OCT and external fixation in SL-OCT. Another study comparing the two AS-OCT devices found that both detected more closed angles than gonioscopy.[51] However, there was a better agreement between SL-OCT and gonioscopy, which can be attributed to the use of visible light during both examinations. The study also found discrepancies in the ACA quantification with each device, confirming the findings of Leung et al.[50] that the measurements are not interchangeable.

In a comparison between low-resolution (20 µm) and high-resolution (8 µm) AS-OCT, Wang et al. found that higher-resolution OCT produced larger-angle width measurements, which they attributed to the different image-processing algorithms, where dewarping procedures were not implemented for the high-resolution images.[52] Moreover, sclera spur location was more accurately determined in the images obtained by the higher-resolution mode.

The major advantages of the AS-OCT devices include
ease of operation and rapidity of image acquisition. The non-contact method eliminates patient discomfort and inadvertent compression of the globe, which is especially useful in the immediate post-operative period or after trauma. The incorporation of automated analysis software allows for rapid estimation of the various anterior segment parameters, including corneal thickness, anterior chamber depth and ACA indices. In addition, customized image analysis software can be also be used to quantify other angle parameters.

The main disadvantage of these devices is the inability to distinctly detect and measure structures posterior to the iris as well as peripheral anterior synechiae. Currently available software analysis programs require the manual localization of the scleral spur, which can at times be difficult, especially in closed angles or where there is a smooth transition from cornea to sclera. Sakata et al. found that the sclera spur could not be detected in approximately 30% of the ACA quadrants, this problem being worse in the superior and inferior quadrants. While gonioscopy allows concurrent and dynamic visualization of the entire angle quadrant, AS-OCT images should only be interpreted for the particular section of the ACAs scanned. Lastly, the high cost of these devices may be a limiting factor for their use in routine clinical set-up or screening purposes.

Spectral domain OCT

Fourier or Spectral domain OCT (SD-OCT) differs from time domain OCT (TD-OCT) by utilizing light of shorter wavelength (830 nm) and having a fixed reference mirror, which allows higher scanning speed and more images to be taken in a single pass. It scans at a rate of 26,000 A-scans per second, producing detailed cross-sectional images of structures at an axial resolution of 5 µm and a transverse resolution of 15 µm. However, the shorter wavelength of the SD-OCT reduces the depth of penetration of the anterior segment structures, making it useful for imaging the corneal region and less useful for the iris and more posterior areas. The RTVue (Optovue Inc., Fremont, CA, USA) is an SD-OCT system that can be used for either retinal or anterior segment imaging (when used with a corneal adaptor module, CAM).

The Cirrus high-definition OCT (HD-OCT) 4.0 (Cirrus; Carl Zeiss Meditec Inc.) is used for in vivo viewing, axial cross-sectional and three-dimensional imaging and measurement of the anterior and posterior ocular structures.

Stehouwer and colleagues recently described a novel technique of integrating a combined anterior and posterior segment SD-OCT (SLSCAN-1) onto a slit-lamp, with the aim of improved efficiency in the clinical evaluation of a patient. With regards to anterior segment scan, the authors acknowledge that the images were not comparable to the commercially available TD-OCT devices.

In a recent study, Wong and colleagues modified a commercially available SD-OCT device with a 60 diopter lens to acquire high-resolution images of the ACA. In addition to the sclera spur, they were able to identify new angle imaging landmarks such as the Schwalbe’s line in 93.3% and trabecular meshwork in 62.2% of the images. Although the device also showed a good correlation with gonioscopy findings (kappa = 0.65), better than that obtained by AS-OCT (ACI = 0.35–0.47), it detected fewer closed angles compared with gonioscopy.
Wylegala and colleagues compared anterior segment imaging and measurements obtained by the TD- and SD-AS-OCT systems.[56] Quantitatively, they found no statistical difference between the mean TISA and AOD values measured by the two devices.

The SD-OCT devices seem to allow better structural delineation and visualization of novel ACA landmarks such as Schwalbe’s line, trabecular meshwork and Schlemm’s canal.[55,56]

EyeCam™

The EyeCam™ (Clarity Medical Systems, Pleasanton, CA, USA) is a new technology originally designed to yield wide-field photographs of the pediatric fundus for the diagnosis and management of posterior segment diseases.[57] With modifications in the optical technique and the inclusion of a 130 degree lens, the device can be used to visualize angle structures in a manner similar to direct gonioscopy.

For imaging, patients are positioned supine and the lens probe is placed on a coupling gel without direct contact onto the cornea, minimizing alteration of angle configuration due to compression artefact and causing less discomfort than gonioscopy [Fig. 6]. To image a particular angle quadrant, the patient is instructed to look in the direction of that angle. The probe is positioned at the opposite limbus to the angle being photographed and light from the fiber optic probe is directed toward the angle of interest and then tilted downward, to bring the angle structures into view while minimizing pupillary constriction.

The EyeCam™ is thus a new and objective way of documenting angle configuration, using a photographic method similar to goniophotography. The images produced are easy for clinicians to interpret as the angle appears similar to what is seen during gonioscopy [Fig. 7]. Images recorded by the EyeCam™ can be saved on a computer thus allowing comparisons to be made over time. Such “goniographic” documentation by EyeCam™ allows for monitoring of angle changes over time, tracking of angle changes with disease progression as well as treatment effects[58] and use as patient education tools.

A preliminary study comparing EyeCam™ “gonio-graphy” with conventional gonioscopy in 60 eyes, with angles ranging from a Shaffer grading of 0 to 4 on clinical gonioscopy, demonstrated that results from the EyeCam™ are accurate and reliable.[59] In another study comparing these two modalities, Perera et al. (2009, in press) found that the agreement between EyeCam™ and gonioscopy in detecting closed quadrants in the superior, inferior, nasal and temporal quadrants based on ACI statistics was 0.73, 0.75, 0.76 and 0.72, respectively. EyeCam™ had 76% sensitivity and 81% specificity for detecting eyes with angle closure using the two-quadrant definition of angle closure to categorize each eye.

Although the EyeCam™ is as yet unable to provide quantitative measurements of anterior chamber depth like the AS-OCT or UBM, it provides a 360-degree visualization of the entire ACA compared with the ASOCT and UBM, which provide only cross-sectional views.

The device has some limitations: imaging of the ACA using EyeCam™ takes longer than gonioscopy (about 5–10 min per eye). The device is more expensive than gonioscopy and additional space is required for supine examination. It is not known if supine positioning would widen the angle due to the effect of gravity on the lens–iris diaphragm. The light source from the EyeCam™, delivered via a fiber optic cable, may cause pupil constriction, artificially altering ACA configuration. Unlike with dynamic gonioscopy, it is difficult to discern the presence of PAS due to the inability to indent the angle. Similarly, determination of iris configuration is difficult with the two-dimensional EyeCam™ images. Reproducibility may also be compromised as, with repeat imaging, each photograph may be slightly rotated and images may not be obtained over the exact same location, unless certain landmarks on the iris are used as anchors.

Conclusions

New methods of imaging the angle have been introduced, offering advantages of being more objective, reproducible and non-contact, rapid image requisition and storage, quantitative analysis and the ability for anterior segment imaging despite corneal opacities results in their easy incorporation into clinical practice and research. While none of these new devices, singly, can replace conventional slit-lamp biomicroscopy and gonioscopy, these new techniques of anterior segment and ACA imaging are useful in complementing clinical practice, particularly when gonioscopy is difficult. While attempting to address the shortfalls of gonioscopy, these devices are not without their own limitations and, until the ultimate imaging tool is invented, clinical dynamic indentation gonioscopy remains the current reference standard.

References

1. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. Br J Ophthalmol 2006;90:262-7.
2. Erie JC, Hodge DO, Gray DT. The incidence of primary angle-closure glaucoma in Olmsted County, Minnesota. Arch Ophthalmol 1997;115:177-81.
3. Foster PJ, Baasanhu J, Alsabik PH, Munkhbayar D, Uranchimeg D, Johnson GJ. Glaucoma in Mongolia. A population-based survey in Hovsgol province, northern Mongolia. Arch Ophthalmol 1996;114:1235-41.
4. Foster PJ, Oen FT, Machin D, Ng TP, Devereux JG, Johnson GJ, et al. The prevalence of glaucoma in Chinese residents of Singapore: a cross-sectional population survey of the Tanjong Pagar district. Arch Ophthalmol 2000;118:1105-11.
5. Dandona L, Dandona R, Mandal P, Srinivas M, John RK, McCarty CA, et al. Angle-closure glaucoma in an urban population in southern India. The Andhra Pradesh eye disease study. Ophthalmology 2000;107:1710-6.
6. Jacob A, Thomas R, Koshi SP, Braganza A, Muliyil J. Prevalence of primary glaucoma in an urban south Indian population. Indian J Ophthalmol 1998;46:81-6.
7. Foster PJ, Johnson GJ. Glaucoma in China: how big is the problem? Br J Ophthalmol 2001;85:1277-82.
8. Hu CN. An epidemiologic study of glaucoma in Shunyi County, Beijing. Zhonghua Yan Ke Za Zhi 1989;25:115-9.
9. Thomas R, George R, Parikh R, Muliyil J, Jacob A. Five year risk of progression of primary angle closure suspects to primary angle closure: a population based study. Br J Ophthalmol 2003;87:450-4.
10. Thomas R, Parikh R, Muliyil J, Kumar RS. Five-year risk of progression of primary angle closure to primary angle closure glaucoma: A population-based study. Acta Ophthalmol Scand
2003;81:480-5.
11. Nolan WP, Baasanhu J, Undraa A, Uranchimeg D, Ganzorig S, Johnson GJ. Screening for primary angle closure in Mongolia: a randomised controlled trial to determine whether screening and prophylactic treatment will reduce the incidence of primary angle closure glaucoma in an east Asian population. Br J Ophthalmol 2003;87:271-4.
12. Nolan WP, Foster PJ, Devereux JG, Uranchimeg D, Johnson GJ, Baasanhu J. YAG laser iridotomy treatment for primary angle closure in east Asian eyes. Br J Ophthalmol 2000;84:1255-9.
13. Alsagoff A, Aung T, Ang LP, Chew PT. Long-term clinical course of primary angle-closure glaucoma in an Asian population. Ophthalmology 2000;107:2300-4.
14. Ang LP, Aung T, Chua WH, Yap LW, Chew PT. Visual field loss from primary angle-closure glaucoma: a comparative study of symptomatic and asymptomatic disease. Ophthalmology 2004;111:1636-40.
15. Aung T, Lim MC, Chan YH, Rojanapongpun P, Chew PT; EXACT Study Group. Configuration of the drainage angle, intraocular pressure, and optic disc cupping in subjects with chronic angle-closure glaucoma. Ophthalmology 2005;112:28-32.
16. Scheie HG. Width and pigmentation of the angle of the anterior chamber; a system of grading by gonioscopy. AMA Arch Ophthalmol 1957;58:510-2.
17. Spaeth GL. The normal development of the human anterior angle chamber: a new system of descriptive grading. Trans Ophthalmol Soc U K 1971;91:709-39.
18. Foster PJ, Devereux JG, Alshirk PH, Lee PS, Uranchimeg D, Machin D, et al. Detection of gonioscopically occludable angles and primary angle closure glaucoma by estimation of limbal chamber depth in Asians: modified grading scheme. Br J Ophthalmol 2000;84:186-92.
19. He M, Foster PJ, Ge J, Huang W, Wang D, Friedman DS, et al. Gonioscopy in adult Chinese: the Liwen Eye Study. Invest Ophthalmol Vis Sci 2006;47:4772-9.
20. He M, Friedman DS, Ge J, Huang W, Jin C, Lee PS, et al. Laser peripheral iridotomy in primary angle-closure suspects: biometric and gonioscopic outcomes: The Liwen Eye Study. Ophthalmology 2007;114:494-500.
21. Schirmer KE. Gonioscopy and artefacts. Br J Ophthalmol 1967;51:50-3.
22. Hoskins HD Jr. Interpretive gonioscopy in glaucoma. Invest Ophthalmol 1972;11:97-102.
23. Forbes M. Gonioscopy with corneal indentation. A method for distinguishing between appositional closure and synechial closure. Arch Ophthalmol 1966;76:488-92.
24. Weinreb N, Friedman D. Angle closure and angle closure glaucoma. The Hauge, The Netherlands: Kugler Publications; 2006.
25. Barkana Y, Dorairaj SK, Gerber Y, Liebmann JM, Ritch R. Agreement between gonioscopy and ultrasound biomicroscopy in detecting iridotrabeal apposition. Arch Ophthalmol 2007;125:1331-5.
26. Kauschik S, Jain R, Pandav SS, Gupta A. Evaluation of the anterior chamber angle in Asian Indian eyes by ultrasound biomicroscopy and gonioscopy. Indian J Ophthalmol 2006;54:159-63.
27. Narayanaswamy A, Vijaya L, Shantha B, Baskaran M, Sathidevi AV, Balaswamy S. Anterior chamber angle assessment using gonioscopy and ultrasound biomicroscopy. Jpn J Ophthalmol 2004;48:44-9.
28. Pavlin CJ, Harasiewicz K, Sherar MD, Foster FS. Clinical use of ultrasound biomicroscopy. Ophthalmology 1991;98:287-95.
29. Pavlin CJ, Sherar MD, Foster FS. Subsurface ultrasound microscopic imaging of the intact eye. Ophthalmology 1990;97:244-50.
30. Ritch R, Liebmann JM. Role of ultrasound biomicroscopy in the differentiation of block glaucomas. Curr Opin Ophthalmol 1998;9:39-45.
31. Mora P, Sangermano C, Ghiardini S, Carta A, Ungaro N, Gandolfi S. Ultrasound biomicroscopy and iris pigment dispersion: a case-control study. Br J Ophthalmol 2010;94:428-32.
32. Sbeta Z, Dorairaj SK, Reddy S, Tello C, Liebmann JM, Ritch R. Ultrasound biomicroscopy of zonular anatomy in clinically unilateral exfoliation syndrome. Acta Ophthalmol 2008;86:565-8.
33. Ishikawa H, Inazumi K, Liebmann JM, Ritch R. Inadvertent corneal indentation can cause artifactitious widening of the iridocorneal angle on ultrasound biomicroscopy. Ophthalmic Surg Lasers 2003;31:342-5.
34. Baez KA, Orenso S, Gandham S, Spaeth GL. Intraobserver and interobserver reproducibility of the Nidek EAS-1000: Anterior Eye Segment Analysis System. Ophthalmic Surg 1992;23:426-8.
35. Lam AK, Chan R, Woo GC, Pang FC, Chiu R. Intra-observer and inter-observer repeatability of anterior eye segment analysis system (EAS-1000) in anterior chamber configuration. Ophthalmic Physiol Opt 2002;22:552-9.
36. Lee TT, Lam AK, Chan BL. Anterior chamber angle measurement with Anterior Eye Segment analysis system Nidek. EAS-1000: improving the repeatability. Ophthalmic Physiol Opt 2003;23:423-8.
37. Bosem ME, Morsman D, Lusky M, Weinreb RN. Reproducibility of quantitative anterior chamber angle measurements with Scheimpflug video imaging. J Glaucoma 1992;1:254-7.
38. Rabsilber TM, Khoramnia R, Auffarth GU. Anterior chamber angle measurements using Pentacam rotating Scheimpflug camera. J Cataract Refract Surg 2006;32:456-9.
39. Boker T, Sheqem J, Rauwolff M, Wegener A. Anterior chamber angle biometry: A comparison of Scheimpflug photography and ultrasound biomicroscopy. Ophthalmic Res 1995;27 Suppl 1:104-9.
40. Friedman DS, Gazzard G, Foster P, Devereux J, Broman A, Quigley H, et al. Ultrasonographic biomicroscopy, Scheimpflug photography, and novel provocative tests in contralateral eyes of Chinese patients initially seen with acute angle closure. Arch Ophthalmol 2003;121:633-42.
41. Friedman DS, Gazzard G, Min CB, Broman AT, Quigley H, Tielisch J, et al. Age and sex variation in angle findings among normal Chinese subjects: a comparison of UBM, Scheimpflug, and gonioscopic assessment of the anterior chamber angle. J Glaucoma 2008;17:5-10.
42. Brezinski M, Fujimoto J. Optical coherence tomography: high resolution imaging in non-transparent tissue. IEEE J Select Top Quantum Electron 1999;5:1185-92.
43. Swanson EA, Izatt JA, Hee MR, Huang D, Lin CP, Schuman JS, et al. In vivo retinal imaging by optical coherence tomography. Opt Lett 1993;18:1864-6.
44. Hee MR, Izatt JA, Swanson EA, Huang D, Schuman JS, Lin CP, et al. Optical coherence tomography of the human retina. Arch Ophthalmol 1995;113:325-32.
45. Izatt JA, Hee MR, Swanson EA, Lin CP, Huang D, Schuman JS, et al. Micrometer-scale resolution imaging of the anterior eye in vivo with optical coherence tomography. Arch Ophthalmol 1994;112:1384-9.
46. Wirbelauer C, Karandish A, Haberle H, Pham DT. Noncontact gonioscopy with optical coherence tomography. Arch Ophthalmol 2005;123:179-85.
47. van den Berg TJ, Spekreijse H. Near infrared light absorption in the human eye media. Vision Res 1997;37:249-53.
48. Nolan WP, See JL, Chew PT, Friedman DS, Smith SD, Radhakrishnan S, et al. Detection of primary angle closure using anterior segment optical coherence tomography in Asian eyes. Ophthalmology 2007;114:33-9.
49. Sakata LM, Lavanya R, Friedman DS, Aung HT, Gao H, Kumar RS, et al. Comparison of gonioscopy and anterior segment ocular coherence tomography in detecting angle closure in different quadrants of the anterior chamber angle. Ophthalmology
50. Leung CK, Li H, Weinreb RN, Liu J, Cheung CY, Lai RY, et al. Anterior chamber angle measurement with anterior segment optical coherence tomography: A comparison between slit lamp OCT and Visante OCT. Invest Ophthalmol Vis Sci 2008;49:3469-74.

51. Sakata LM, Wong TT, Wong HT, Kumar RS, Htoon HM, Aung HT, et al. Comparison of Visante and slit-lamp anterior segment optical coherence tomography in imaging the anterior chamber angle. Eye (Lond) 2010;24:578-87.

52. Wang D, Pekmezci M, Basham RP, He M, Seider MI, Lin SC. Comparison of different modes in optical coherence tomography and ultrasound biomicroscopy in anterior chamber angle assessment. J Glaucoma 2009;18:472-8.

53. Wojtkowski M, Bajraszewski T, Gorczyńska I, Targowski P, Kowalczyk A, Wasilewski W, et al. Ophthalmic imaging by spectral optical coherence tomography. Am J Ophthalmol 2004;138:412-9.

54. Stehouwer M, Verbraak FD, de Vries H, Kok PH, van Leeuwen TG. Fourier Domain Optical Coherence Tomography integrated into a slit lamp; a novel technique combining anterior and posterior segment OCT. Eye (Lond) 2010;24:980-4.

55. Wong HT, Lim MC, Sakata LM, Aung HT, Amerasinghe N, Friedman DS, et al. High-definition optical coherence tomography imaging of the iridocorneal angle of the eye. Arch Ophthalmol 2009;127:256-60.

56. Wylegala E, Teper S, Nowińska AK, Milka M, Dobrowolski D. Anterior segment imaging: Fourier-domain optical coherence tomography versus time-domain optical coherence tomography. J Cataract Refract Surg 2009;35:1410-4.

57. Erraguntla V, MacKeen LD, Atenafu E, Stephens D, Buncic JR, Budning AS, et al. Assessment of change of optic nerve head cupping in pediatric glaucoma using the RetCam 120. J AAPOS 2006;10:528-33.

58. Ahmed I, MacKeen L. A new approach to imaging the angle. Glaucoma Today 2007;4:1-3.

59. Calafati J, Naqi A, Ahmed I. Digital imaging system an alternative to traditional process. US ed. Ocular Surgery News 2009.

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