APPLICATIONS OF ANTERIOR SEGMENT OCT IN GLAUCOMA

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Optical coherence tomography is a novel,three dimensional technology that allows detailed cross-sectional imaging of the eye based on the principle of low- coherence interferometry.[1] Huang et al[2] first described optical coherence tomography of the eye in 1991,and Izatt et al described anterior segment OCT(ASOCT) imaging using the same wavelength of light as in retinal OCT i.e. 830nm but this wavelength was unsuitable for optimal imaging of the anterior chamber angle so a longer wavelength of 1310nm is now used for better penetration through sclera. The current systems available are-

1.Visante™OCT approved by the US FDA in 2005.

2.Slit lamp OCT (SL-OCT) approved by the US FDA in 2006.

3.Optovue (RTVue) commercially available Fourier domain OCT system with a resolution of 5 microns that received marketing clearance from the FDA in2010.Although indicated for posterior segment imaging, a lens is available to allow imaging of the anterior segment.

APPLICATIONS

1)Angle closure glaucoma

-ASOCT allows detailed imaging of anatomy of cornea, iris and sclera.Structures in the anterior chamber angle can be clearlydelineated, such as the scleral spur and the angle recess. Howeverstructures in the posterior chamber are not well delineated due toattenuation of the light beam of OCT by the pigmented epitheliumofiris.

-Quantitative assessment of angle structures

The scleral spur is used as the landmark for measuring anterior

Chamber angle parameters[3]. Itis seen as a highly reflective structure on AS-OCT images. The parameters formeasurement of the angle are

Angle opening distance at 500µm (AOD 500)[4]**:** Defined as theperpendicular distance between the iris and trabecularmeshwork (TM) at a point 500µm away from the scleral spur. This parameter was first described by Pavlinand colleagues for Ultrasound Biomicroscopy(UBM)[5].

Angle opening distance at 750µm (AOD750)[4]: Angle openingdistance is measured 750µm away from the scleral spur insteadof 500µm. It was suggested byRadhakrishnan et al.

Angle Recess area at 500,750 µm (ARA 500, ARA 750)[4]: ARAwas first described by Ishikawa[6] and co-workers for UBM. Itis a triangular area, boundaries of which are AOD 500 orAOD 750 (base), angle recess (apex), the iris surface and theinner corneoscleral wall (sides of the triangle). The ARA maytheoretically be a better parameter than AOD as it takes intoaccount the contour of the iris surface rather than a singlepoint on iris as is the case with AOD.

Trabeculo-iris space area at 500, 750µm (TISA 500, TISA 750)[4]: This parameter was proposed by Radhakrishnan et al.It is a trapezoidal area bounded by AOD 500 or AOD 750anteriorly, a line drawn perpendicular from the scleral spurto the opposing iris, the corneoscleral wall superiorly and theiris surface inferiorly .

Trabeculo-iris contact length (TICL) [4]*:* Defined as the linearlength of contact between the iris and the trabecularmeshwork, beginning at the scleral spur in an anatomicallyapposed or synechially closed angle. It was proposed by Radhakrishnan et al.

All quantitative measurements of the ACA require identificationof scleral spur as the first step. However, according to a recentstudy by Sakata et al, it was not possible to identify the scleral spurin 28% of the eyes on images taken on VisanteOCT(7). This studyalso found that it is more difficult to identify the scleral spur inpatients with narrow angles than in patients with open angles.

Another study reported that interobserver variability in theidentification of scleral spur can lead to 50% variation inmeasurement of angle area (ARA, TISA) and 10% variation inlinear measurements (AOD).

-Angle assessment can be done in corneal opacity and corneal edemaunlike gonioscopy.

-allows the evaluation of efficacy of various treatmentsuch as laser peripheral iridotomy (LPI) [8], effect of cataract surgery on anterior chamber angle.Memarzadeh et al studied the change in anterior segment morphology by ASOCT and gonioscopy before and after LPI(9). They noted a significant increase in AOD500,ARA500, TISA 500 and TISA 750 after PI. On OCT images, theconvex iris configuration flattened after LPI.

2.Pachymetry

The ASOCT allows cross-sectional visualization and measurementof central corneal thickness(CCT). It has a direct influence onintraocular pressure (IOP) measurements. Ocular Hypertension Treatment Study (OHTS) for the first time made a critical discovery regarding corneal thickness and its role in intraocular pressure and glaucoma development.

In clinical practice, intraocular pressure is the only modifiable risk factor in the management of glaucoma. According to manometric data from Ehlersand colleagues(10), 44% of patients with normal-tension glaucomawould be reclassified as having primary open angle glaucoma, and35% of patients with ocular hypertension would be reclassified ashaving normal IOP when CCT is taken into account. Herndon etalfound that as many as 65% of patients with ocular hypertensioncould be reclassified as having normal IOP.

Measuring CCT consistently provides additional knowledge regarding IOP accuracy as well as possible prognosis and future treatment effect.

In guidelines established by the American Academy of Ophthalmology (AAO), CCT was recommended as part of the initial examination for POAG and the glaucoma suspect. The relevance of CCT, as stated by the AAO(11) preferred practice pattern for primary open angle glaucoma(POAG), is based on the fact that it "is a risk factor in that it affectsaccuracy of IOP measurements by all applanation techniques. "

3.Imaging of trabeculectomy blebs

Bleb characteristics like bleb structure,location of scleral flap,presence of cystic spaces,bleb height, size of bleb cavity, bleb wall thickness, scleral flap thickness, tangential and radial dimensions of the bleb. Singh et al(12) studiedthe ASOCT characteristics of trabeculectomyblebs and found that conjunctivalepiscleralthickening in the bleb wall was the hallmark of blebs inwhich IOP was successfully controlled.

OCT is particularly helpful in demonstrating level of failure infailed bleb as it can demonstrate ostial closure, flap fibrosis orepiscleral fibrosis as the cause of bleb failure. It can thus help ininitiating appropriate management in rescuing a failing bleb.

4.Glaucoma drainage implants

AS-OCT provides high resolution images of glaucoma drainage implant and help in assessing position, patency, drainage, intra-luminal stent suture,tube-cornea or tube-iris touch.

AS-OCT VS GONIOSCOPY

Closed angle on gonioscopy is defined as non-visibility of posterior TM, whereas angle closure on ASOCT is defined as any contact between

peripheraliris and angle wall anterior to scleral spur[13]. In comparison to gonioscopy, AS-OCT show less interoperator variabilitydoes not require technical expertise. Angle can be viewed in its natural state without distortion of angle structures as AS-OCT is a non-contact technique.Thus, AS-OCT could be used to screen patients for primary angle closure.But it is unlikely that gonioscopy will ever be completely replaced, as several imaging techniques like AS-OCT are dynamic and does not allow complete(360) visualization of angle.

AS-OCT VS UBM

Ultrasound biomicroscopy, a diagnostic method described in the early1990s , uses a high frequency transducer (50-100 MHz),thus permitting an axial and lateral resolution of around20 to 40 micron, even though at the expense of a reductionin ultrasound penetration (approximately 5 millimeters)[14]. The advantages of the method are the possibilityof evaluating retro iris structures and performingquantitative measurements of the camerular sinus.The benefits of UBM include its utility in identifying nonpupillary block mechanisms for angle closure mechanisms that may contribute to angle closure in the majority of Asian patients[15].Both UBM and AS-OCT can identify narrow and

closed angles with reasonable performance. Neither, however, can reliably differentiate between appositional and synechial closure, an essential distinction prior to surgical intervention.Finally, the identification of the scleral spur can be ambiguous for both UBM and AS-OCT. Without the localization of this landmark, diagnostic uncertainty may remain[16].

Main limitations of UBM are: high cost, the dependence of aqualified examiner, the observation of a restricted regionof the camerular sinus, and the need for dipping the ultrasound probe.

CONCLUSION

Widespread use of anterior segment OCT may permit accurate diagnosis of angle closure cases thus help pick up more cases of angle closure, which constitutes 50% of all glaucoma cases worldwide[17,18]. Ease of image acquisition and noncontact nature may make it a desirable tool for large-scale

screening of patients with narrow angles. Furthermore, it's apotentially valuable tool in glaucoma research and may help usunderstand better the natural history and patho-physiologic mechanism behind different types of glaucoma. However, thereare certain limitations of ASOCT such as limited visualization ofstructures posterior to the iris and difficulty in identification of keylandmarks (e.g. scleral spur) in closed angles.

<u>IMAGES OF VISANTE A-OCT</u>

FIGURE 1:-(A) Anterior segment OCT image with relatively lower ACD (1.64 mm) and higher LV (1.3 mm) at pre LPI. This eye showed greater AOD750 change (255.8%) after LPI (B).

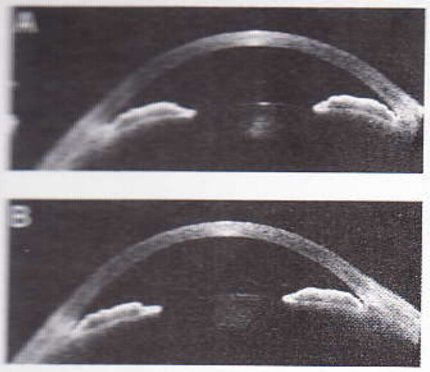


FIGURE 2:-(A) Image of eye with relatively higher ACD (2.20 mm) and lower LV (0.95 mm). (B) A small amount of AOD750 change (64.4%) after LPI

IMAGES OF FOURIER DOMAIN AS-OCT

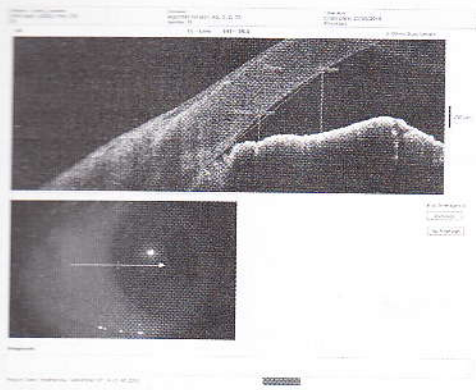


FIGURE 3:-AOD at 1mm and 2mm

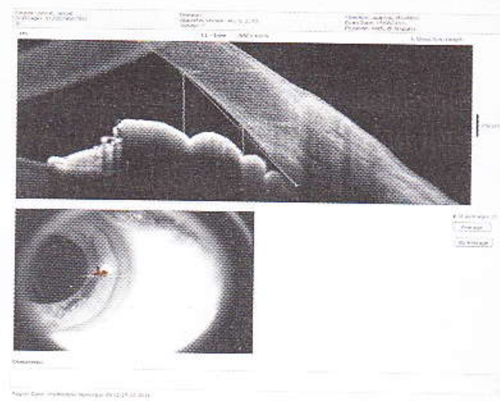


FIGURE 4:-AOD at 1mm and 2mm

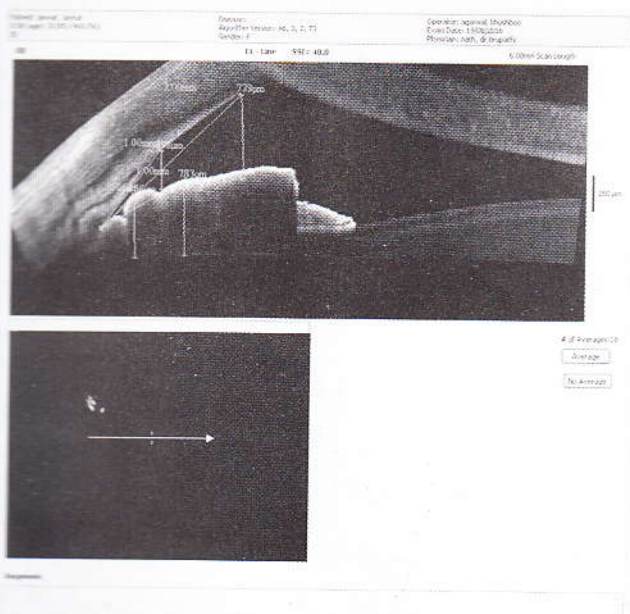


FIGURE 5:- AOD at 1mm and 2mm ; IT at .5mm and 1mm:convex iris curvature

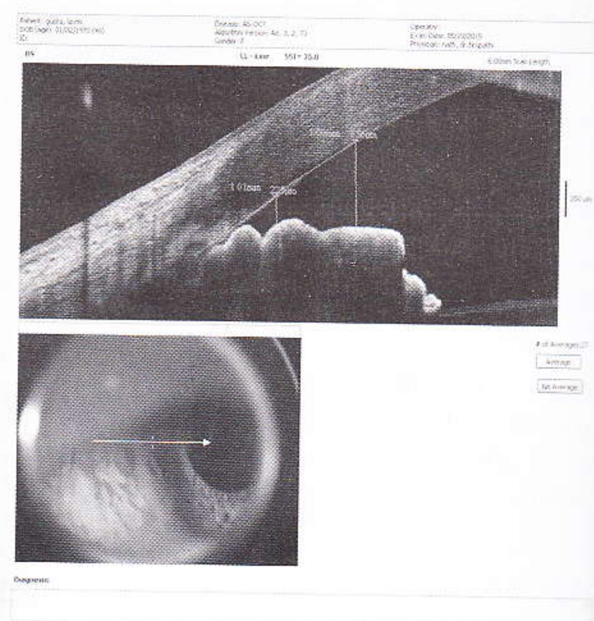


FIGURE 6:-AOD at 1mm and 2mm

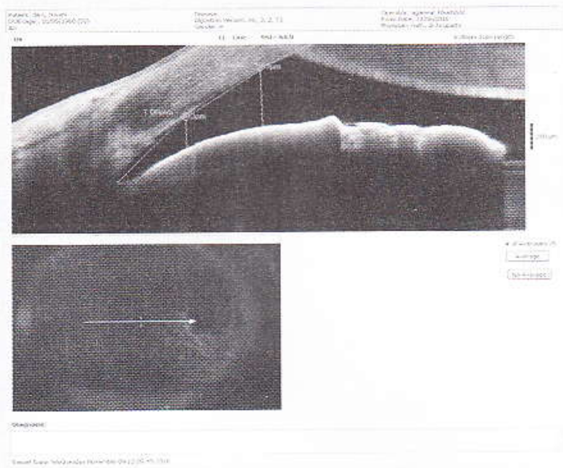


FIGURE 7:-AOD at 1mm and 2mm

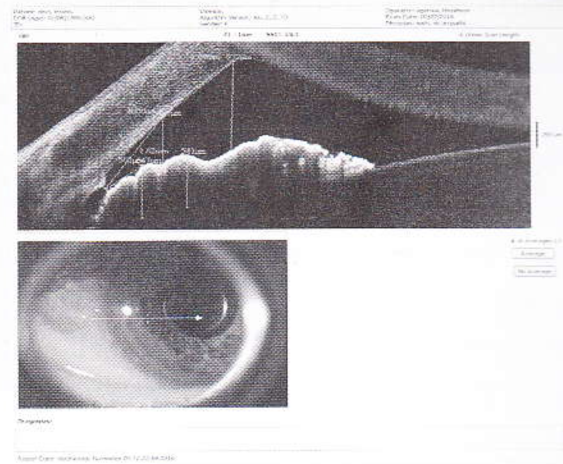
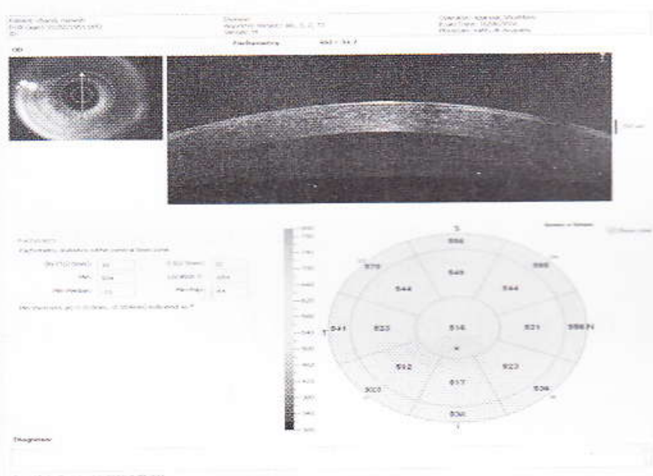
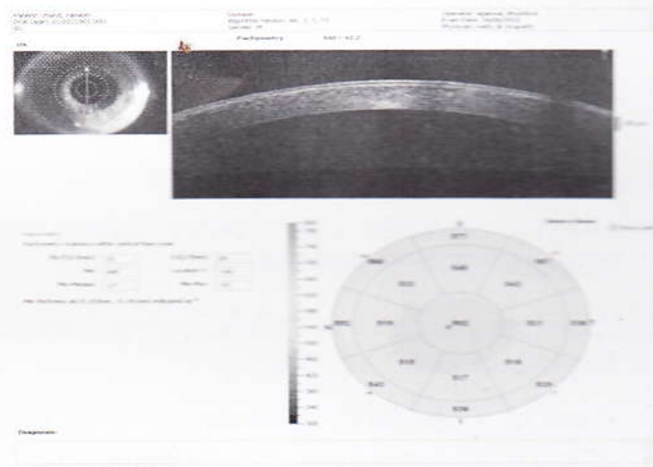


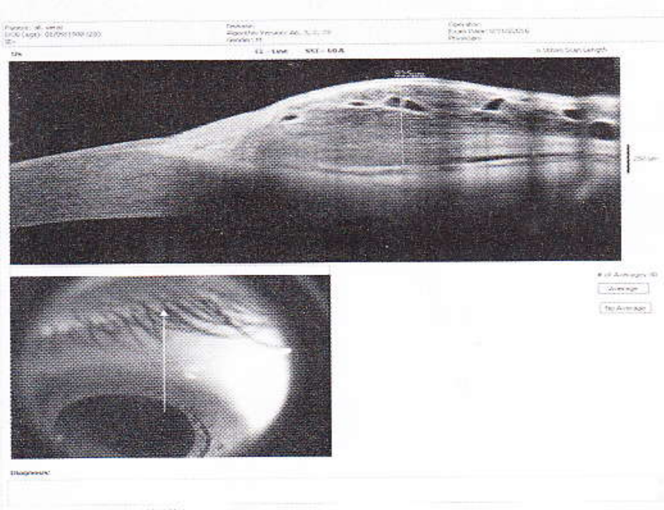
FIGURE 8:- AOD at 1mm and 2mm ;
IT at .5mm and 1mm:convex iris curvature

PACHYMETRY





ASOCT IMAGES OF BLEB



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