Chapter 8
Possibilities in Anterior Segment Imaging for Glaucoma (Gonioscopy, Anterior Segment Optical Coherence Tomography and Ultrasound Biomicroscopy: Advantages and Disadvantages)

Daiva Paulaviciute-Baikstiene and Renata Vaiciuliene

Gonioscopy

Gonioscopy remains the essential diagnostic method for quick estimation of the iridocorneal angle (Fig. 8.1) [1]. This technique is inexpensive and permits dynamic evaluation of each angle quadrant. The block could be revealed as peripheral anterior synechiae, iris configuration into a convex shape or appositional contact with the trabecular meshwork [2]. First should be performed the static examination of the iridocorneal angle and later should be done indentation gonioscopy, which allows differentiating between appositional and synechial angle closure [2]. Gonioscopy can also provide visual information, including color. It will help to rule out neovascularization in the angle and to refuse other abnormalities that can cause an angle to appear closed such as pigmentary, pseudoexfoliation, angle-recession glaucoma [1, 2].

However, this diagnostic method is highly subjective, and the findings may vary dependent on the examiner's skills and experience, the type of lens used, direction of gaze, unintentional compression of the eye during the examination [2]. Amount of slit lamp light is another variable that could influence the results of gonioscopy. The light by constricting the pupil may present the illusion that angle is open in the eye with closed or narrow-angle [3]. Other environmental conditions and cooperation of the patients also have an impact on accurate examination of the angle structures [2].

Gonioscopy is limited in evaluating structures posterior to the iris and does not provide a quantitative investigation of the anterior chamber angle (ACA) structures. All above mentioned conditions can affect the interpretation of the angle anatomy [4, 5].

D. Paulaviciute-Baikstiene (✉) · R. Vaiciuliene
Lithuanian University of Health Sciences, Kaunas, Lithuania

I. Januleviciene, A. Harris (eds.), *Biophysical Properties in Glaucoma*,
https://doi.org/10.1007/978-3-319-98198-7_8

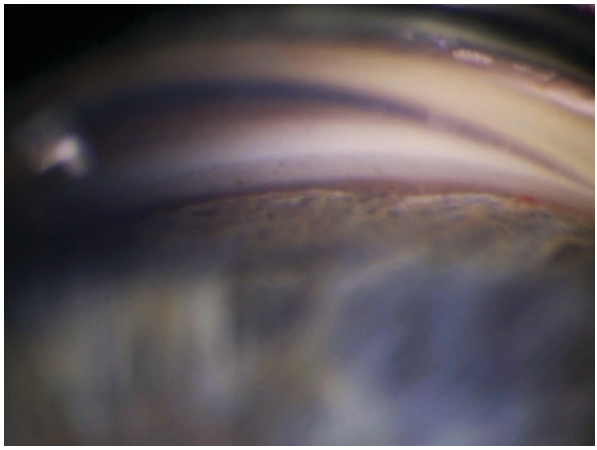

Fig. 8.1 Visualisation of open angle. Normal open angle—mild pigmentation of the posterior trabecular meshwork

Comparison of Anterior Segment Optical Coherence Tomography and Ultrasound Biomicroscopy

Imaging technologies such as anterior segment optical coherence tomography (AS-OCT) and ultrasound biomicroscopy (UBM) play an important diagnostic role and could provide detailed information of anterior segment (AS) structures associated with impaired outflow [6]. Both modalities have advantages and disadvantages (Table 8.1).

AS-OCT is a non-contact, non-invasive technique that uses the principle of low-coherence interferometry to produce high resolution, cross-sectional images of the AS [3, 7, 8]. UBM is a contact procedure and uses high-frequency ultrasound to image the deeper structures of the eye. Topical anesthesia and patient cooperation are very important during this procedure [9–11]. UBM technique might be more time consuming and requires a highly skilled operator to obtain high-quality images [12]. AS-OCT is easier to perform, allows rapid imaging and depicts a more physiological view, because of the sitting position in comparison with UBM. The weakness of AS-OCT, that upper and lower eyelids hamper the imaging of superior and inferior angles. Non-contact modality cannot visualise any structures posterior to the iris, because of blocking wavelength by pigment epithelium [12]. It is known that UBM provides better penetration through cloudy or opaque media. The visualisation behind a clouded cornea in the presence of scars, hyphema or corneal edema is advantageous in the preoperative assessment of AS pathology, to guide in the most effective management. UBM is very useful in cases of plateau iris syndrome and allows improved imaging of ciliary processes [10, 12–15].

Shabana and colleagues reported that the AS-OCT measurements are semi-automated, have good reproducibility [16] and it is not operator dependent like in gonioscopy. Prior studies have noted poor reproducibility in assess of the iris and ACA dimensions with UBM [17–21]. The biometric parameters of outflow

Table 8.1 Advantages and disadvantages of ultrasound biomicroscopy and anterior segment optical coherence tomography

AS-OCT	UBM
Noncontact	Contact and requires a liquid coupling medium
Optical	Ultrasound
Real-time imaging	Real-time imaging
Does not require a skilled operator	Requires skilled operator
Higher axial resolution	Lower axial resolution
Depth of penetration (~1 mm)	Depth of penetration (~6 mm)
Limited ability to visualize structures posterior to the iris pigment epithelium	Can visualize structures posterior to the iris pigment epithelium
Faster acquisition time	Slower acquisition time
Wider field of view	Smaller field of view
Seated upright position	Seated upright or supine positions
Use for clear corneas	Can image through opaque corneas

structures require exact identification of a reference point from which the angle measurements are obtained. Usually, the scleral spur (SS) is used as a reference landmark [22]. A smaller anterior chamber depth (ACD), eye quadrant (especially superior and inferior in AS-OCT), [23] shorter axial length, an eye with a narrow or closed angle or elderly patients [23] may influence the precise identification of the SS. The inability to properly detect this anatomical structure can induce errors and interfere quantitative analysis of ACA parameters. Sakata et al. noted that identification of SS is successful in approximately 72% of images obtained with AS-OCT [11]. Other authors also found difficulties in finding SS from 15 to 28% of AS-OCT images [23, 24]. Reference point such as SS is more distinct on AS-OCT compared with UBM. SS is a landmark for biometric parameters such as: angle opening distance (AOD) [25, 26], angle recess area (ARA) [27], trabecular iris angle [25, 26], trabecular iris space area (TISA) [13], the iris cross-sectional area and volume [28, 29], anterior chamber (AC) width and depth, iris thickness and convexity, lens vault [30].

Imaging devices are valuable not only in AS structures assessment but also for the planning and guidance of glaucoma surgery or laser procedures, as well as the diagnosis and estimation of postoperative complications [31–35]. As a non-contact procedure, AS-OCT is a better option to avoid postoperative complications related to intraocular infection or wound healing. Non-contact device might be performed in the immediate postoperative period to predict the functionality of filtering blebs and may indicate earlier interventions for failing blebs [12]. In some situations it is necessary to evaluate and to monitor changes of ACA structures in the operating room under anesthesia, then is more useful UBM [3].

Both devices are beneficial in assessing glaucoma pathophysiological mechanisms and guide to the most effective management approach. Despite above mentioned advantages in imaging, the clinical examination cannot be replaced.

References

1. European Glaucoma Society. Terminolology and guidelines for Glaucoma. 4th ed. Florence: European Glaucoma Society; 2014.
2. Sun X, Dai Y, Chen Y, et al. Primary angle closure glaucoma: what we know and what we don't know. Prog Retin Eye Res. 2017;57:26–45. https://doi.org/10.1016/j.preteyeres.2016.12.003.
3. Maslin JS, Barkana Y, Dorairaj SK. Anterior segment imaging in glaucoma: an updated review. Indian J Ophthalmol. 2015;63:630–40. https://doi.org/10.4103/0301-4738.169787.
4. Foster PJ, Devereux JG, Alsbirk PH, 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.
5. Aung T, Lim MCC, Chan Y-H, et al. Configuration of the drainage angle, intraocular pressure, and optic disc cupping in subjects with chronic angle-closure glaucoma. Ophthalmology. 2005;112:28–32. https://doi.org/10.1016/j.ophtha.2004.06.033.
6. Singh P, Tyagi M, Kumar Y, et al. Gonioscopy: a review. Open J Ophthalmol. 2013;3:118–21. https://doi.org/10.4236/ojoph.2013.34025.
7. Konstantopoulos A, Hossain P, Anderson DF. Recent advances in ophthalmic anterior segment imaging: a new era for ophthalmic diagnosis? Br J Ophthalmol. 2007;91:551–7. https://doi.org/10.1136/bjo.2006.103408.
8. Huang D, Swanson EA, Lin CP, et al. Optical coherence tomography HHS public access. Science. 1991;22:1178–81. https://doi.org/10.1002/jcp.24872.
9. Quek DTL, Nongpiur ME, Perera SA, Aung T. Angle imaging: advances and challenges. Indian J Ophthalmol. 2011;59(Suppl):S69–75. https://doi.org/10.4103/0301-4738.73699.
10. Pavlin CJ, Harasiewicz K, Sherar MD, Foster FS. Clinical use of ultrasound biomicroscopy. Ophthalmology. 1991;98:287–95.
11. Ishikawa H, Schuman J. Anterior segment imaging: ultrasound biomicroscopy. Ophthalmol Clin N Am. 2004;17:7–20. https://doi.org/10.1016/j.ohc.2003.12.001.
12. Roxana Ursea M, Ronald H, Silverman P. Anterior-segment imaging for assessment of glaucoma Roxana. Expert Rev Ophthalmol. 2010;5:59–74. https://doi.org/10.1586/eop.09.61.
13. Wang N, Ye T, Lai M, et al. Comparison of results of chamber angle examination by ultrasound biomicroscopy and gonioscopy. Zhonghua Yan Ke Za Zhi. 1999;35(10):174–8.
14. Pavlin CJ, McWhae JA, McGowan HD, Foster FS. Ultrasound biomicroscopy of anterior segment tumors. Ophthalmology. 1992;99:1220–8.
15. Foster FS, Pavlin CJ, Harasiewicz KA, et al. Advances in ultrasound biomicroscopy. Ultrasound Med Biol. 2000;26:1–27.
16. Shabana N, Aquino MCD, See J, et al. Quantitative evaluation of anterior chamber parameters using anterior segment optical coherence tomography in primary angle closure mechanisms. Clin Exp Ophthalmol. 2012;40:792–801. https://doi.org/10.1111/j.1442-9071.2012.02805.x.
17. Tello C, Liebmann J, Potash SD, et al. Measurement of ultrasound biomicroscopy images: intraobserver and interobserver reliability. Invest Ophthalmol Vis Sci. 1994;35:3549–52.
18. Urbak SF, Pedersen JK, Thorsen TT. Ultrasound biomicroscopy. II. Intraobserver and interobserver reproducibility of measurements. Acta Ophthalmol Scand. 1998;76:546–9.
19. Wang N, Lai M, Chen X, Zhou W. Quantitative real time measurement of iris configuration in living human eyes. Zhonghua Yan Ke Za Zhi. 1998;34:369–72.
20. de Souza Filho EC, Marigo FDA, Oliveira C, et al. Intraobserver reproducibility in anterior segment morphometry of normal eyes using ultrasound biomicroscopy (UBM). Arq Bras Oftalmol. 2005;68:177–83. S0004–27492005000200005
21. Zhang Q, Jin W, Wang Q. Repeatability, reproducibility, and agreement of central anterior chamber depth measurements in pseudophakic and phakic eyes: optical coherence tomography versus ultrasound biomicroscopy. J Cataract Refract Surg. 2010;36:941–6. https://doi.org/10.1016/j.jcrs.2009.12.038.

22. Marchini G, Pagliarusco A, Toscano A, et al. Ultrasound biomicroscopic and conventional ultrasonographic study of ocular dimensions in primary angle-closure glaucoma. Ophthalmology. 1998;105:2091–8. https://doi.org/10.1016/S0161-6420(98)91132-0.
23. Sakata LM, Lavanya R, Friedman DS, et al. Assessment of the scleral spur in anterior segment optical coherence tomography images. Arch Ophthalmol (Chicago, IL: 1960). 2008;126:181–5. https://doi.org/10.1001/archophthalmol.2007.46.
24. Wang B-S, Narayanaswamy A, Amerasinghe N, et al. Increased iris thickness and association with primary angle closure glaucoma. Br J Ophthalmol. 2011;95:46–50. https://doi.org/10.1136/bjo.2009.178129.
25. Pavlin CJ, Ritch R, Foster FS. Ultrasound biomicroscopy in plateau iris syndrome. Am J Ophthalmol. 1992;113:390–5.
26. Pavlin CJ, Harasiewicz K, Foster FS. Ultrasound biomicroscopy of anterior segment structures in normal and glaucomatous eyes. Am J Ophthalmol. 1992;113:381–9.
27. Ishikawa H, Liebmann JM, Ritch R. Quantitative assessment of the anterior segment using ultrasound biomicroscopy. Curr Opin Ophthalmol. 2000;11:133–9.
28. Quigley HA, Silver DM, Friedman DS, et al. Iris cross-sectional area decreases with pupil dilation and its dynamic behavior is a risk factor in angle closure. J Glaucoma. 2009;18:173–9. https://doi.org/10.1097/IJG.0b013e31818624ce.
29. Aptel F, Denis P. Optical coherence tomography quantitative analysis of iris volume changes after pharmacologic mydriasis. Ophthalmology. 2010;117:3–10. https://doi.org/10.1016/j.ophtha.2009.10.030.
30. Jiang Y, He M, Huang W, et al. Qualitative assessment of ultrasound biomicroscopic images using standard photographs: the Liwan eye study. Investig Ophthalmol Vis Sci. 2010;51:2035–42. https://doi.org/10.1167/iovs.09-4145.
31. Dada T, Gadia R, Sharma A, et al. Ultrasound biomicroscopy in glaucoma. Surv Ophthalmol. 2011;56:433–50. https://doi.org/10.1016/j.survophthal.2011.04.004.
32. Surgery R, People N, Guanghua S, et al. Comparison of ultrasound biomicroscopy and spectral-domain anterior segment optical coherence tomography in evaluation of anterior segment after laser peripheral iridotomy. Int J Ophthalmol. 2016;9:417–23. https://doi.org/10.18240/ijo.2016.03.16.
33. Lin Z, Li S, Fan S, et al. Alteration of anterior chamber and angle structure in eyes with primary angle closure after laser peripheral iridotomy. Zhonghua Yan Ke Za Zhi. 2011;47:881–6.
34. Mansouri K, Burgener ND, Bagnoud M, Shaarawy T. A prospective ultrasound biomicroscopy evaluation of changes in anterior segment morphology following laser iridotomy in European eyes. Eye (Lond). 2009;23:2046–51. https://doi.org/10.1038/eye.2008.395.
35. Nutzi C, Orgul S, Schotzau A, Grieshaber MC. Predictability of morphological changes of the anterior chamber angle after laser iridotomy by ultrasound biomicroscopy. Klin Monatsbl Augenheilkd. 2015;232:419–26. https://doi.org/10.1055/s-0035-1545793.