Original Article

The Diagnostic Value of Ultrasound Biomicroscopy in Anterior Segment Diseases

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Abstract

Objectives: The purpose of this study was to analyze the use of ultrasound biomicroscopy (UBM) in the diagnosis and follow-up anterior segment diseases

Materials and Methods: The records of patients who presented to our clinic for UBM between January 1, 2004, and December 31, 2018 were reviewed retrospectively. Demographic characteristics, indications for UBM imaging and findings of the patients were recorded. Also, the change in clinical indications over the years were analyzed.

Results: The study included 1.256 eyes of 917 patients, of whom 723 (57.6%) were female and 533 (42.4%) were male. The mean age was 48.7±14.8 years (range: 12-85 years). Indications for UBM imaging were to evaluate glaucoma pathogenesis and surgical outcomes (n=764, 60.8%), iris and ciliary body masses (n=263, 20.9%), congenital anomalies of the crystalline lens and complications of cataract surgery (n=86, 6.8%), the etiology of hypotony (n=57, 4.5%), corneal diseases (n=46, 3.7%), anterior segment findings after trauma (n=22, 1.8%), conjunctival pathologies (n=11, 0.9%), and scleral pathologies (n=7, 0.6%). In patients with glaucoma, the most common reason for requesting UBM according to years was to investigate the plateau iris configuration.

Conclusion: UBM is an important imaging method used in the determination of the pathophysiology of anterior segment diseases, clinical evaluation, planning of surgical treatment and analyzing the outcomes.

Keywords: Ultrasound biomicroscopy, anterior segment diseases, glaucoma

Introduction

Ultrasound biomicroscopy (UBM) is high-frequency B-mode ultrasound that allows imaging of the anterior segment, pars plana, and peripheral retina at microscopic resolution. When using an ultrasonic signal at a frequency of 50 mHz during anterior segment imaging, detailed images at a resolution of about 40-50 µm and up to a depth of 4-5 mm can be obtained.[1] UBM enables detailed imaging of the posterior iris, posterior chamber, ciliary body, zonules, and the relationships among all of these structures, which cannot be visualized biomicroscopically. The development of UBM by Pavlin et al.[2] brought about advances in our understanding of the pathogenesis of anterior segment diseases.

Since its introduction into clinical use, UBM has provided guidance in the diagnosis of plateau iris and pupillary block in glaucoma patients. UBM is a very useful method for elucidating the pathogenesis of glaucoma, as well as evaluating treatment efficacy. Quantitative measurement of the anterior segment structures with UBM is important in the classification of the various types of angle-closure and open-angle glaucoma.[3]

The aim of this study was to examine the demographic characteristics of patients who underwent UBM imaging in our clinic, the indications for the clinical use of UBM, and the frequency of these indications by year.

Materials and Methods

The records of patients who underwent UBM imaging in the Ophthalmology Department of Ankara University between January 2004 and December 2018 were reviewed retrospectively. The patients' demographic data such as age, sex, race, and affected side were recorded. Indications for the use of UBM

Cite this article as: Biçer Ö, Hoşal MB. The Diagnostic Value of Ultrasound Biomicroscopy in Anterior Segment Diseases. Turk J Ophthalmol 2023;53:213-217

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Received: 08.06.2022 **Accepted:** 14.11.2022

DOI: 10.4274/tjo.galenos.2022.58201

and the frequency of these indications by year were examined. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ankara University Faculty of Medicine Ethics Committee.

All patients were examined using a Model P40 ultrasonic biomicroscope (Paradigm Medical Industries, USA). With the patient lying in supine position, topical anesthesia was provided by instilling 0.5% proparacaine HCl drops. An appropriate size immersion container was then placed in the palpebral fissure and filled with artificial tear gel. Clock quadrants were scanned in the primary gaze position and by giving appropriate gaze positions without the probe contacting the cornea. All UBM imaging was performed by the same physician (M.B.H.).

Results

The study included 1,256 eyes of 917 patients, all of whom were Caucasian. Seven hundred twenty-three (57.6%) of the patients were females and 533 (42.4%) were males. UBM was performed on the right eye in 629 patients (50.1%) and the left eye in 627 patients (49.9%). The mean age was 48.7±14.8 years (range: 12-85 years). Indications for UBM imaging included the evaluation of glaucoma pathogenesis and surgical outcomes (n=764, 60.8%) (Figure 1a-c), iris and ciliary body masses (n=263, 20.9%) (Figure 1d), congenital anomalies of the crystalline lens and complications of cataract surgery (n=86, 6.8%), the etiology of hypotony (n=57, 4.5%) (Figure 1e), corneal diseases (n=46, 3.7%), post-traumatic anterior segment findings (n=22, 1.8%), conjunctival pathologies (n=11, 0.9%), and scleral pathologies (n=7, 0.6%) (Table 1).

In cases of glaucoma, UBM was most frequently performed to evaluate plateau iris (n=517, 41.2%), pigment dispersion syndrome/pigmentary glaucoma (n=96, 7.6%), or angle-closure glaucoma (n=75, 6%), to evaluate the results of filtering surgery (n=56, 4.5%), cyclodestruction (n=8, 0.6%), or minimally invasive glaucoma surgery (n=6, 0.5%), and to assess post-YAG laser iritomy patency (n=6, 0.5%). Of the iris and ciliary body masses, the most common in UBM were primary iris pigment epithelial cyst (n=136, 10.8%), malignant melanoma of the ciliary body (n=45, 3.6%), malignant melanoma of the iris (n=42, 3.3%), iris nevus (n=28, 2.2%), scleral/corneal metastasis of ciliary body malignant melanoma (n=6, 0.5%), primary iris stromal cyst (n=2, 0.2%), ciliary body medullaepithelioma (n=2, 0.2%), iris pigment epithelial adenoma (n=1, 0.1%), and iris melanocyoma (n=1, 0.1%). Under the crystalline lens and cataract surgery indications, UBM was used to evaluate intraocular lens (IOL) position (n=69, 5.5%), the posterior capsule (n=5, 0.4%), residual cortex (n=5, 0.4%), Descemet detachment (n=3, 0.2%), lenticonus (n=2, 0.2%), and microspherophakia (n=2, 0.2%). In cases of hypotony, UBM findings included ciliary body detachment (n=31, 2.5%), ciliary body atrophy (n=9, 0.7%), cyclitic membrane (n=5, 0.4%), both cyclitic membrane and ciliary body atrophy (n=5, 0.4%), both cyclitic membrane and ciliary body detachment (n=5, 0.4%), and both ciliary body atrophy and ciliary body detachment (n=2, 0.2%). In cornea

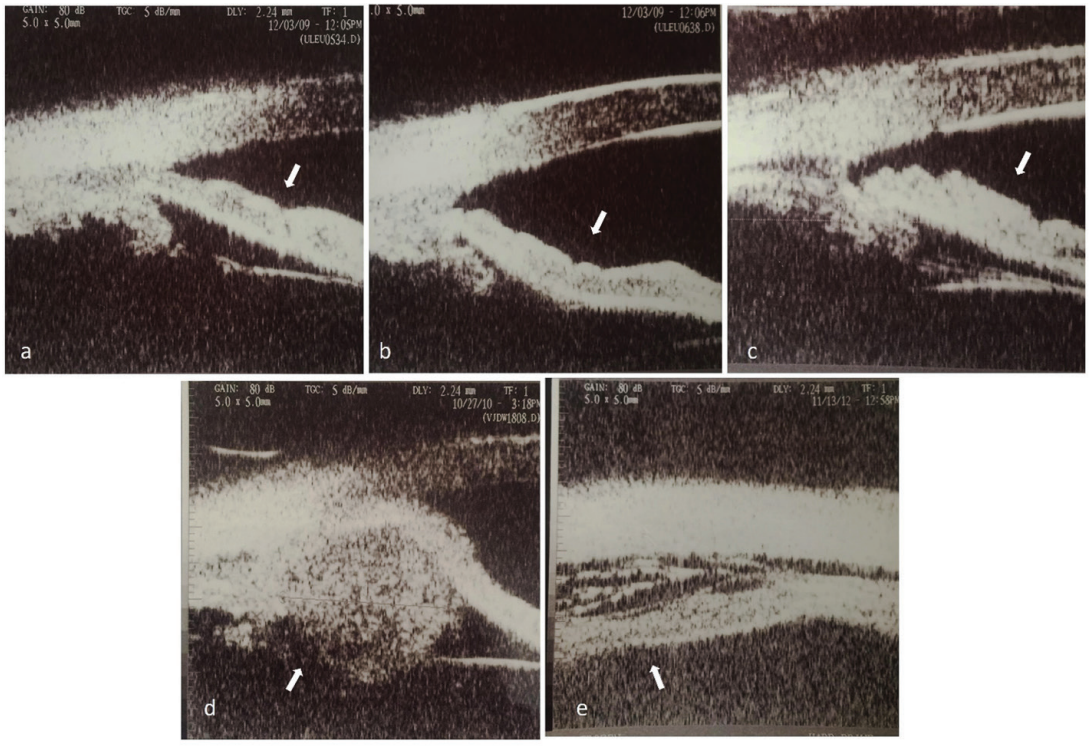

Figure 1. a) Iris imaging of a patient with pigmentary glaucoma while not accommodating (arrow). b) Increased iris concavity with accommodation (arrow). c) Ultrasound biomicroscope (UBM) appearance of the plateau iris configuration (arrow). d) UBM appearance of malignant melanoma of the ciliary body (arrow). e) UBM appearance of ciliary body detachment (arrow)

Table 1. Indications and findings of ultrasound biomicroscopy imaging of the cases	
Corneal diseases, n=46 (3.7%)	
• Anterior segment evaluation in opaque corneas	25 (2%)
• Cogan epithelial basal membrane dystrophy	1 (0.1%)
• Corneal stromal dystrophies	16 (1.3%)
• Corneal disorders secondary to metabolic diseases (cystinosis, hypercalcemia)	4 (0.3%)
Conjunctival masses, n=11 (0.9%)	
• Pterygium/pinguecula	5 (0.4%)
• Limbal dermoid	2 (0.2%)
• Conjunctival nevus	1 (0.1%)
• Squamous cell carcinoma	2 (0.2%)
• Conjunctival lymphoma	1 (0.1%)
Scleral diseases, n=7 (0.6%)	
• Episcleritis	3 (0.2%)
• Scleritis	4 (0.3%)
Glaucoma, n=764 (60.8%)	
Investigation of glaucoma pathogenesis	
• Plateau iris	517 (41.2%)
• Pigment dispersion syndrome/Pigmentary glaucoma	96 (7.6%)
• Angle-closure glaucoma	75 (6.0%)
Evaluation of glaucoma surgery outcomes	
• Filtering surgery (trabeculectomy)	56 (4.5%)
• Cyclodestruction (diode laser cyclophotocoagulation)	8 (0.6%)
• Minimally invasive glaucoma surgery (gel stent implantation)	6 (0.5%)
• Evaluation of iridotomy patency after YAG laser	6 (0.5%)
Iris and ciliary body masses, n=263 (20.9%)	
• Iris nevus	28 (2.2%)
• Primary iris pigment epithelium cyst	136 (10.8%)
• Primary iris stromal cyst	2 (0.2%)
• Iris pigment epithelial adenoma	1 (0.1%)
• Iris melanocytoma	1 (0.1%)
• Iris malignant melanoma	42 (3.3%)
• Ciliary body malignant melanoma	45 (3.6%)
• Ciliary body medullaepithelioma	2 (0.2%)
• Scleral/corneal metastasis of ciliary body malignant melanoma	6 (0.5%)
Lens, n=86 (6.8%)	
Evaluation of congenital anomalies of the crystalline lens	
• Lenticonus	2 (0.2%)
• Microspherophakia	2 (0.2%)
Evaluation of cataract surgery complications	
• Evaluation of the posterior capsule	5 (0.4%)
• Residual cortex	5 (0.4%)
• Descemet detachment	3 (0.2%)
• Evaluation of intraocular lens position	69 (5.5%)
Evaluation of hypotony etiology, n=57 (4.5%)	
• Ciliary body detachment	31 (2.5%)
• Ciliary body atrophy	9 (0.7%)
• Cyclitic membrane	5 (0.4%)
• Cyclitic membrane + ciliary body atrophy	5 (0.4%)
• Cyclitic membrane + ciliary body detachment	5 (0.4%)
• Cyclic membrane + ciliary body atrophy + ciliary body detachment	2 (0.2%)
Post-traumatic anterior segment findings, n=22 (1.8%)	
• *Intraocular foreign body*	
Cornea	2 (0.2%)
Anterior chamber	4 (0.3%)
Lens	6 (0.5%)
Anterior vitreous	8 (0.6%)
• Hyphema	2 (0.2%)

patients, UBM was most commonly used for evaluation of the anterior segment in eyes with opaque corneas (n=25, 0.2%), followed by assessment of stromal dystrophies (n=16, 1.3%), corneal disorders secondary to metabolic diseases (n=4, 0.3%), and Cogan epithelial basement membrane dystrophy (n=1, 0.1%). In trauma cases, UBM revealed intraocular foreign body (n=20, 1.6%) and hyphema (n=2, 0.2%). The conjunctival masses most commonly detected in UBM were pterygium/pinguecula (n=5, 0.4%), limbal dermoid (n=2, 0.2%), squamous cell carcinoma (n=2, 0.2%), conjunctival nevus (n=1, 0.1%), and conjunctival lymphoma (n=1, 0.1%). Scleral diseases detected in UBM included scleritis (n=4, 0.3%) and episcleritis (n=3, 0.2%) (Table 1).

The frequencies of the clinical indications for UBM imaging by year are shown in Figure 2, which shows a decrease in the evaluation of corneal, conjunctival, and lens pathologies by UBM since 2008.

Discussion

UBM is used to understand the pathophysiology of anterior segment diseases, evaluate them clinically, plan surgical treatment, and assess the outcomes. In our study, we determined that UBM was frequently used to investigate the presence of plateau iris in glaucoma patients. Second most common was the evaluation of iris and ciliary body masses.

In most patients undergoing keratoplasty, the anterior segment cannot be examined in detail due to corneal opacity. In these cases, preoperative examination of the anterior segment with UBM is important in preventing intraoperative complications. After cataract surgery, lens remnants that cause ongoing inflammation and might be confused with retroirideal masses can be imaged with UBM.[4] Evaluation of the presence and integrity of the posterior capsule with UBM prior to secondary implantation may allow selection of the appropriate IOL during

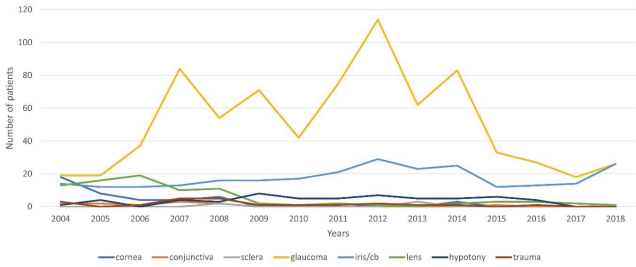

Figure 2. Frequency of clinical indications for ultrasound biomicroscopic imaging by year (cb: Ciliary body)

surgery.[5] In our study, it was observed that UBM was performed to evaluate IOL position in 5.5% and visualize anterior segment structures behind opaque corneas in 2% of the cases.

UBM can show the posterior margins of conjunctival lesions in more detail than anterior segment optical coherence tomography (AS-OCT).[6] In addition, tumor shadowing is rare in UBM compared to AS-OCT. UBM is a more useful method for determining the borders and measuring the size of conjunctival lesions before surgical excision. For lesions such as limbal dermoid, UBM is the preferred technique because it can accurately measure the depth of invasion and enables differential diagnosis.[7] Although AS-OCT better demonstrates the internal structure of conjunctival nevi, UBM is more preferred for highly pigmented and raised nevi.[8] Conventional 10-MHz ultrasound is an important imaging method for the diagnosis of posterior scleritis, but its use in anterior scleritis is limited. With UBM, the differential diagnosis of scleritis and episcleritis can be made easily, and diffuse and nodular scleritis can be distinguished.[9] In our study, it was found that UBM was performed to evaluate conjunctival masses in 0.9% and scleral diseases in 0.6% of the cases.

Our findings demonstrated a marked decrease in the evaluation of corneal, conjunctival, and lens pathologies with UBM after AS-OCT was introduced in our clinic. However, the use of UBM for the evaluation of iris and ciliary body tumors did not change much over the years. This is because despite the high resolution of AS-OCT, it provides inadequate imaging of the posterior face of the iris due to the absorption of infrared light by pigmented tissues.

In a prospective study utilizing UBM, the prevalence of plateau iris configuration was found to be 25.2% in American Caucasians, 24.1% in American Chinese, and 20.9% in mainland Chinese.[10] The fact that our patient series is from Türkiye supports that plateau iris configuration is an important cause of angle closure in the Caucasian population. Parc et al.[11] compared AS-OCT and UBM in the detection of eyes with plateau iris and determined that UBM could directly show the position of the ciliary body and processes and the structures anterior and posterior to the iris root. The authors noted that AS-OCT can only show indirect signs because it cannot detect structures behind the iris.[11] Therefore, AS-OCT may not allow the differentiation of factors that contribute to the development of angle closure such as plateau iris, ciliary body cyst, tumor, or ciliary effusion.

In our study, UBM was used to evaluate increased iris concavity and the presence of iridozonular contact upon accomodation in patients with pigment dispersion. Pillunat et al.[12] reported that iridozonular contact was not present in every patient with pigmentary glaucoma and observed that intraocular pressure decreased with laser iridotomy only in pigmentary glaucoma cases with iridozonular contact. In our study, it was observed that UBM was frequently used to evaluate glaucoma cases (60.8%). Within this group, it had the most important role in evaluating the presence of plateau iris (41.2%), followed by the examination of secondary glaucoma types such as pigmentary glaucoma (7.6%).

In 4.5% of the patients, UBM was used to assess the success of filtering surgery. UBM enables the qualitative assessment of internal osteum and subscleral drainage pathway patency and the quantitative assessment of bleb height and drainage pathway length. It has been reported that intraocular pressure is controlled in eyes with low bleb reflectivity, high bleb elevation, and a visible intrascleral pathway.[13] Bleb height on UBM may influence the decision to perform laser suturolysis after trabeculectomy.[14]

In the literature, UBM has been used to determine the anatomical location of the ciliary body to ensure correct laser probe placement and to determine the scleral damage after the procedure.[15,16] In our study, UBM was performed in 0.6% of the patients to observe early and late ciliary body changes after transscleral cyclophotocoagulation. Although it was infrequent in our study (0.5%), UBM was also used to evaluate the relationship between the Xen implant and anterior segment structures after minimally invasive glaucoma surgery.

In our study, the most common indication for UBM after glaucoma was the evaluation of iris and ciliary body tumors (20.9%). This method enables assessment of tumor size, the iridocorneal angle, and tumor invasion of the ciliary body and sclera. UBM helps diagnose iris pigment epithelial cysts, determine their type, and distinguish them from iris-ciliary body melanoma.[17] Although medium-sized ciliary body tumors can be visualized on low-frequency B-mode ultrasonography, UBM plays an important role in the early diagnosis of small masses.[18] Determining the size and borders of the tumor is valuable in treatment planning. It can assist in determining the appropriate dose in potential radiotherapy and in the planning of an excisional surgery.

Ocular hypotony can occur from many causes, including eye trauma, ophthalmic surgery, and as a complication of uveitis. Cyclitic membrane-related ciliary body traction, ciliary body detachment, ciliary body atrophy, cyclodialysis, or choroidal effusion can lead to hypotony.[19] In our study, UBM was used for a detailed assessment of the underlying mechanism in 4.5% of patients with hypotony. After closed globe injuries, UBM can be used to detect hyphema, iridodialysis, cyclodialysis, peripheral choroidal detachment, and IOL dislocation.[20] UBM is contraindicated in patients with open globe injury. Intraocular foreign bodies that cannot be detected with computed tomography and B-scan ultrasonography can be visualized in

UBM.[21] In our study, UBM was most frequently performed to evaluate the location of intraocular foreign bodies in trauma patients.

Conclusion

In conclusion, UBM has an important role in the diagnosis, follow-up, and evaluation of the efficacy of interventional procedures performed on patients with glaucoma. It aids in the differential diagnosis, treatment planning, and follow-up of anterior segment tumors. In addition, UBM is widely used to determine the pathogenesis other anterior segment pathologies, as well as hypotony.

Ethics

Ethics Committee Approval: Ankara University Human Research Ethics Committee (no: İ1-50-20/date: 13.02.2020).

Informed Consent: Obtained.

Peer-review: Externally peer reviewed.

Authorship Contributions

Concept: Ö.B., M.B.H., Design: Ö.B., M.B.H., Data Collection or Processing: Ö.B., M.B.H., Analysis or Interpretation: Ö.B., M.B.H., Literature Search: Ö.B., M.B.H., Writing: Ö.B., M.B.H.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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