Accuracy of Swept-Source Optical Coherence Tomography and Ultrasound Biomicroscopy for Evaluation of Posterior Lens Capsule in Traumatic Cataract

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• PURPOSE: To assess the efficacy of swept-source optical coherence tomography (SS-OCT) and ultrasound biomicroscopy (UBM) in detecting posterior capsule (PC) defect in patients with traumatic cataract.

• DESIGN: Observational case-series.

• METHODS: Sixty-seven eyes from 67 patients, with traumatic cataract severe enough to prevent slit lamp evaluation of the PC, were included in a simple sequence without randomization. Patients underwent both 50-MHz UBM and SS-OCT evaluation of the PC by different operators. Cataract surgery was then performed using a single technique.

• RESULTS: Sixty-seven eyes from 67 patients including 60 men and 7 women were studied. The mean age was 34 ± 14 years and the mean logarithm of minimal angle of resolution of visual acuity was 1.89 ± 0.71. The calculated sensitivity, specificity, and accuracy values for SS-OCT were 96.8% (95% confidence interval [CI] 83.81-99.43), 66.7% (95% CI 48.78-80.77), and 82% (95% CI 70.53-89.62), respectively. For UBM, sensitivity, specificity, and accuracy values were 82.6% (95% CI 62.86-93.02), 57.9% (95% CI 36.28-76.86), and 71.4% (95% CI 56.43-82.83), respectively. Positive predictive and negative predictive values for SS-OCT were 75% (95% CI 59.81-85.81) and 95.2% (95% CI 77.33-99.15) and for UBM were 70.4% (95% CI 51.52-84.15) and 73.3% (95% CI 48.05-89.1), respectively.

• CONCLUSION: Although both imaging techniques are effective, SS-OCT appears to be at least comparable, or superior in special circumstances, to UBM in detecting preoperative posttraumatic PC rupture. We recommend preoperative assessment of all traumatic cataracts with SS-OCT as a part of surgical planning. (Am J Ophthalmol 2020;216:55–58. © 2020 Elsevier Inc. All rights reserved.)

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OCULAR TRAUMA, EITHER BLUNT OR PENETRATING, is a recognized cause for cataract formation at any age. Although the diagnosis of a traumatic cataract is usually straightforward, its management requires an individualized approach. Some patients may demonstrate cataract despite the preservation of good visual acuity (VA). Others may show a rapidly progressive course with total lens opacity and severe reduction of VA. The former group is usually followed for progression, while the latter is considered for cataract extraction and intraocular lens implantation.

Surgical management of traumatic cataract requires several considerations.[1] The assessment of cataract (per se or its effect on VA), may be hampered by concomitant complications, such as corneal laceration, anterior chamber reaction and hyphema, and swollen cortical material. Open posterior capsule (PC) may also precipitate the process of cataract formation. On the other hand, if the cataract surgery is inevitable, knowledge about the integrity of the PC is extremely helpful to avoid unintended extension of the PC tear and lens particle drop into the vitreous cavity.

Several imaging modalities have been proposed for assessment of the PC before cataract surgery. These include ultrasound biomicroscopy (UBM), Scheimpflug imaging with Pentacam, and spectral-domain optical coherence tomography (OCT).[2–5] In this study, we present the findings of a series of patients who underwent anterior segment evaluation with a swept-source OCT (SS-OCT) device and ultrasound biomicroscopy (UBM); then we try to determine the predictability of SS-OCT for the preoperative assessment of PC integrity.

METHODS

THIS IS A CASE SERIES OF 67 PATIENTS WHO SUFFERED FROM traumatic cataract. The study took place in Farabi Eye Hospital, Tehran, Iran, from January 2018 to December 2019. The design of the study was approved by the Clinical Ethics Committee of Farabi Eye Hospital in accordance with the tenets of the Declaration of Helsinki and attested by Tehran University of Medical Sciences Clinical Ethics Review

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TABLE 1. General Characteristics of Patients with Traumatic Cataract According to Posterior Capsule Status

	Capsule Status					
	Intact		Open		Total	
Parameter	n (%)	Mean ± SD	n (%)	Mean ± SD	n (%)	*P* Value
Age (y)		37 ± 14		31 ± 14		.059[a]
<30	11 (32.4%)		16 (48.5%)		27 (40.3%)	
31-60	21 (61.8%)		17 (51.5%)		38 (56.7%)	
>60	2 (5.9%)		-		2 (3%)	
Sex						.259[b]
Male	32 (94.1%)		28 (84.8%)		60 (89.6%)	
Female	2 (5.9%)		5 (15.2%)		7 (10.4%)	
Visual acuity (logarithm of minimal angle of resolution)		1.92 ± 0.63		1.85 ± 0.8		.885[c]
Light perception	2 (5.9%)		5 (15.2%)		7 (10.4%)	
Hand motion	14 (41.2%)		11 (33.3%)		25 (37.3%)	
Finger count	18 (52.9%)		17 (51.5%)		35 (52.2%)	

SD = standard deviation.
[a]Based on the *t* test.
[b]Based on the Fisher exact test.
[c]Based on the Mann-Whitney *U* test.

Board. Informed consent was obtained from each patient or their surrogate decision-makers where appropriate.

Patients were included in a simple sequential sample of anyone with blunt or penetrating trauma to the eye or periocular area, whose lens opacity prohibited evaluation of the PC. Only those with clinically significant cataract necessitating surgical intervention were included. Patients that had sufficient cooperation to do these tests were included. All eyes with open globe injury were repaired primarily. Patients with iatrogenic cataract (for example, after intravitreal injections or postvitrectomy) were excluded.

The anterior segment and the lens of each patient were evaluated after maximal pupillary dilation using a single SS-OCT device (CASIA SS-1000, Tomey, Nagoya, Japan). The lens was delineated into 4 quadrants and images were obtained for each quadrant separately. An operator was present during image acquisition to see any part of open PC. A different operator, masked to the results of OCT, evaluated patients with UBM (50 MHz) (Quantel Medical, Clermont-Ferrand, France) to look for the evidence of PC rupture. A surgeon familiar with the management of traumatic cataract and blind to the findings of the images, accomplished operations from the beginning to the end with the same technique. The status of the PC during surgery was revealed and documented for the analysis. Each image was evaluated by 2 independent examiners.

The analysis of the study was accomplished using SPSS software (version 23; IBM Corp., Chicago, Illinois). In addition to descriptive statistics, we present the following values: sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratio (LR), and diagnostic accuracy. The latter is defined as total correct diagnoses (true positive plus true negative) divided by the total number of patients. The Cohen kappa index, indicating agreement of the findings, was also calculated. Values <0.40 and >0.75 indicate low and high agreement, respectively. The statistical significance was considered <0.05.

RESULTS

A TOTAL OF 67 EYES FROM 67 PATIENTS, INCLUDING 60 (90%) men and 7 (10%) women, were analyzed. The mean age was 34 ± 14 years distributed into 3 age groups: <30 years (n = 27 [40.3%]), 31-60 years (n = 38 [56.7%]), and >60 years (n = 2 [3%]). The mean VA was 1.89 ± 0.71 logarithm of minimal angle of resolution with 32 (47%) patients with hand-motion (HM) or worse and 35 (52%) patients had finger-count (FC). Those with intact PC and open PC demonstrated no significant difference in terms of age, gender, and VA. Table 1 shows the general features of the study population.

The calculated sensitivity and specificity values for SS-OCT were 96.8% (95% CI 83.81%-99.43%) and 66.7% (95% CI 48.78%-80.77%), respectively. For UBM, sensitivity and specificity values were 82.6% (95% CI 62.86%-93.02%) and 57.9% (95% CI 36.28%-76.86%), respectively.

Accordingly, positive and negative predictive values for SS-OCT were 75% (95% CI 59.81%-85.81%) and 95.2% (95% CI 77.33%-99.15%) and for UBM were 70.4% (95% CI 51.52%-84.15%) and 73.3% (95% CI 48.05%-

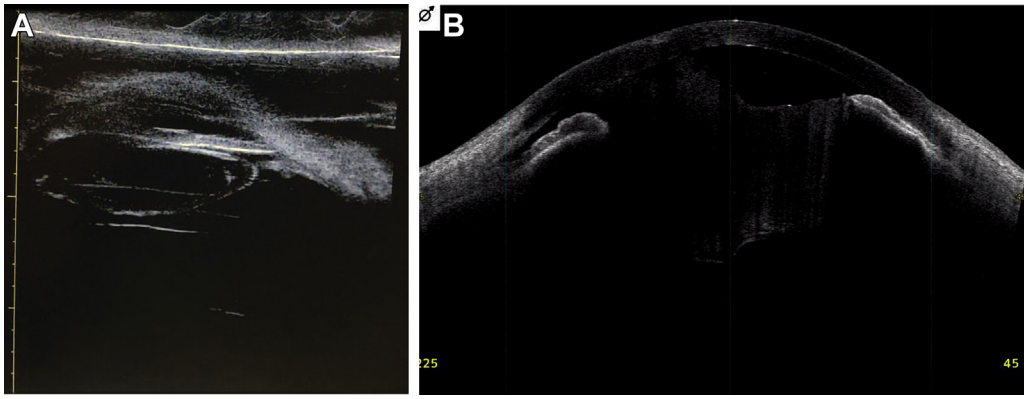

FIGURE 1. A 32-year-old man with repaired penetrating injury of the left eye. (A) Ultrasound biomicroscopy demonstrating the lens borders. It seems that the posterior capsule is intact. (B) The same eye imaged with optical coherence tomography illustrating posterior capsule rupture.

89.1%), respectively. We also calculated the LR of a positive and a negative test for both SS-OCT and UBM. The LR of positive and negative SS-OCT were 2.90 (95% CI 2.38-3.54) and 0.05 (95% CI 0.006-0.360), respectively. The LR of positive and negative UBM were 1.96 (95% CI 1.50-2.50) and 0.3 (95% CI 0.16-0.55), respectively.

The overall diagnostic accuracy of the SS-OCT was more than UBM, but it was not statistically significant (82% [95% CI 70.53%-89.62%] vs 71.4% [95% CI 56.43%-82.83%], respectively).

As a measure of agreement, we calculated the Cohen kappa index for SS-OCT and UBM separately. The kappa index was 0.64 for SS-OCT and 0.41 for UBM.

DISCUSSION

THE GOAL OF THIS STUDY WAS TO INVESTIGATE THE ROLE of SS-OCT and UBM in the diagnosis of PC rupture in patients with traumatic cataract. We found that SS-OCT was a sensitive and a relatively specific technique in the evaluation of the PC before considering cataract surgery. It was comparable to UBM or may provide some advantages in specific circumstances in yielding defective PCs (Figure 1).

Although a forceful blunt trauma may cause cataract with or without PC rupture, many traumatic cataracts follow a penetrating injury. Less frequently, isolated PC rupture has been reported in blunt trauma even in the absence of clinically evident lens opacity.[6,7] The trouble arises when an opacified lens, severe enough to impair vision, requires surgical removal and the PC is already defective. A surgeon aware of the PC status may be better equipped for devising an appropriate surgical plan and therefore prevent complications during surgery.

Although Scheimpflug imaging has been successful in the assessment of PC, its low quality, especially in patients with significant lens opacity, restricts its clinical application.[5,8,9] Magnetic resonance imaging may also imply PC rupture, especially if the lens material is herniated. However, the acquisition of high-quality images is time-consuming and not all clinical ophthalmology centers have a magnetic resonance imaging facility.[10]

Among several imaging modalities that can delineate orbital structures, UBM and OCT have been used more frequently. UBM is effective in demarcating anterior eye segment. As the ultrasound frequency increases, the resolution is increased at the cost of depth of penetration. In 2012, we published the results of 20-MHz UBM in the evaluation of PC in 43 patients with traumatic cataract. We showed that this technique was 88% accurate in the detection of PC defects.[3] In 2013, Kucukevcilioglu[2] found that 35-MHz UBM was able to delineate PC defects of as small as 1 mm.

Despite its value, UBM requires great operator skill, contact with the ocular surface, and patient cooperation. However, Wu and associates[11] have recently shown that 14-MHz UBM combined with tissue harmonic imaging may accurately reveal the PC defect without the need for surface contact. Although their overall results were similar to our UBM findings, this technique may be extremely valuable in a subset of patients with penetrating eye injury whose wound integrity is in doubt or the risk of intraocular infection is high. In addition, children may benefit from this technique because of enhanced cooperation.[11]

In the past 30 years, OCT technologies have evolved from time-domain (TD) through spectral-domain machines and now SS devices are available. From a technical standpoint, SS-OCT differs from spectral-domain OCT by using a tunable swept laser instead of a diode light source, and a higher wavelength (1050 nm vs 840 nm). These specifications result in increased scanning speed, number, and area compared with spectral-domain OCT. The longer the wavelength used in SS-OCT, the deeper the light penetration and

therefore the higher the resolution.[12] Although none of these technologies have been implied to damage intraocular structures, higher wavelengths are proposed to be safer for the eye, theoretically favoring the use of SS-OCT.[13]

In recent years, SS-OCT has been used for evaluating the crystalline lens of no-traumatic patients. In separate works, de Castro and associates[14] and Grulkowski and associates[15] showed that lens opacities and PC were demarcated well in 2- and 3-dimensional images, implying its usefulness for evaluating PC status in traumatic cataract. Our study showed that the sensitivity and specificity of SS-OCT technology were superior to UBM in PC defects. This is interesting because, in 2014, we compared 20-MHz UBM, spectral-domain OCT, and Scheimpflug imaging of the PC in 21 patients with traumatic cataract and found that UBM was superior to spectral-domain OCT in terms of sensitivity, specificity, and diagnostic accuracy.[4] However, the limitation of OCT in detecting structures behind the iris remains a challenge for interpretation of OCT images.

Despite these findings, we admit that the sample size of our study is relatively small for extracting undoubted specificity and sensitivity values. A larger sample may change these statistical measures. The kappa index demonstrated low and moderate agreement in the UBM and OCT findings, respectively. This indicates that more consistent results will be expected if SS-OCT is used instead of UBM to detect PC defects.

Another important consideration that may limit our findings is the unpredictable and highly dynamic nature of posttraumatic cataract surgery. Though the rate of intraoperative PC rent is low in experienced hands, it may be hard to tell if a PC ruptured before or during surgery in some cases because of unusual fluidics, unstable zonules, opaque media, and the presence of synechiae. Finally, there may be a natural surgeon bias to attribute capsule failure to an existing defect rather than to a mistake made during the procedure.

In conclusion, although both techniques are helpful, SS-OCT appears to be at least comparable (and may be superior in special circumstances) to UBM in detecting preoperative posttraumatic PC rupture. This technology is invaluable in patients with opaque media severe enough to make slit lamp examination unyielding. We recommend preoperative assessment of all patients with traumatic cataract by SS-OCT as a part of surgical planning.

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