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Intraluminal Deposits Found in Glaucoma Tube Shunts via Anterior Segment Ocular Coherence Tomography

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Abstract

Purpose—To describe and characterize a novel observation of intraluminal deposits of glaucoma tube shunts (TS) using spectral domain (SD) ocular coherence topography (OCT).

Patients and Methods—Fifteen TS in 11 patients diagnosed with primary open angle, neovascular, aphakic, and uveitic glaucomas. Both Ahmed (n = 11) and Baerveldt (n = 4) TS were examined with 5-line raster anterior segment SD-OCT imaging.

Results—The exposed tubes of two patients had highly reflective intraluminal deposits in the corresponding exposed areas. Seven tubes without exposure had a thin rim of highly reflective material. Six tubes were clear of luminal deposits. The most common diagnosis in the study was uveitic glaucoma which occurred in 5 of the 15 eyes (33%). The next most common diagnosis was primary open angle glaucoma which occurred in 4 of the 15 eyes (25%). There were 2 non-valved Baerveldt tubes in each group. The mean duration of tube shunt implantation was 15.0 months in the deposit group and 33.7 months in the group without luminal deposits. The majority of patients in each group were using eye drops at presentation (88.9% deposit, 83.3% clear), and the average intraocular pressure was 20.2 mmHg in the deposit group and 19.0 mmHg in the clear group.

Conclusions—Anterior segment OCT imaging may be used to evaluate TS integrity. Intraluminal deposits in tube shunts may occur as a natural response to implanted drainage device, possibly as an inflammatory response.

Keywords

tube shunts; glaucoma drainage implants; anterior segment; OCT

INTRODUCTION

A leading cause of blindness in the world, glaucoma is a heterogeneous disease that causes irreversible damage to the optic nerve. Lowering intraocular pressure remains to be the only proven therapy. [1] Aqueous drainage tube shunts were created as an alternative means from the standard trabeculectomy approach to divert extra-ocular fluid. There are four main

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shunts utilized in the US: Baerveldt® (Advanced Medical Optics, Inc., Santa Ana, CA, USA), Ahmed™ (New World Medical Inc., Rancho Cucamunga, CA, USA), Molteno® (Molteno Ophthalmic Ltd., Dunedin New Zealand), and Krupin (Eagle Vision, Inc., Memphis, TN, USA). [2–3] They contain silicone tubes with an internal diameter of approximately 300 μm, which can be inserted into the anterior chamber or vitreous cavity (in vitrectomized eyes) and are connected to an equatorial plate varying in surface area depending on the model. The equatorial plate is surrounded by a fibrovascular capsule which contain capillaries that will drain the shunted ocular fluid. The ideal tube shunts would improve aqueous outflow with minimal complications. [2] Complications documented are hypotony, choroidal effusion, shallow or flat anterior chamber, corneal decompensation, diplopia, tube obstructions, tube erosion, and increased intraocular pressure. [4] Despite the complications, tube shunts are becoming the first-line surgical option in glaucoma, researched by the randomized, prospective Tube versus Trabeculectomy (TVT) study. [5] Anterior segment SD-OCT has recently been introduced in glaucoma evaluation. This imaging modality is a non-contact, non-invasive method to evaluate the anterior chamber (AC) and is usually used to examine AC depth, cornea, iris, and lens. In glaucoma, anterior segment OCT has been used to evaluate scleral flaps, trabeculectomy blebs, and patent laser iridotomies [6]. Tube shunts buried under tutoplast and/or conjunctiva and coursing into the AC are typically limited to slit lamp examination or a more invasive method. Anterior segment OCT has only been used to determine tube shunt position and patency [7]. This study presents novel findings of intraluminal deposits of tube shunts via anterior segment OCT imaging.

MATERIALS AND METHODS

This was a IRB-approved retrospective chart review conducted during spring 2014, involving 11 patients and 15 eyes of patients diagnosed with glaucoma who had received a tube shunt (Ahmed (AGV; New World Medical, Ranchos Cucamonga, CA)) or (BGI; Abbott Medical Optics, Abbott Park, IL) [8] in one or both eyes. Patients had received their eye care and OCT imaging at Sydney and Lois Eskenazi Eye Clinic in Indianapolis, IN. Glaucoma diagnoses included primary open angle glaucoma, chronic angle closure, aphakic glaucoma, uveitic glaucoma, or neovascular glaucoma. In addition, patients were older than 18 years old, with either Ahmed or Baerveldt tube shunt implantations and light perception or better visual acuity. Patients excluded from the study were younger than 18 years old with no light perception vision, and who had undergone previous retinal surgery with silicone oil. Each patient underwent eye examination, including visual acuity using standard distance Snellen chart, applanation tonometry, and slit lamp examination of anterior segment, including the tube shunt. Additionally, patients underwent imaging with the Carl Zeiss spectral domain 5-line raster HD-OCT of the anterior segment concentrating on the tube beneath the conjunctiva or tutoplast. Patient's demographic data was collected and analyzed using Microsoft Excel 2002, and the standard Chi test was utilized to obtain p-values via Excel.

RESULTS

Of 11 patients with tube shunts, 6 presented with intraluminal deposits, 4 with no deposits, and 1 had deposits in one eye but not in the other. The age of the patients ranged from 41–

83. The range for the deposit group was 41–78 with a mean age of 60.4 years old, and the clear group ranged from 41–83 with a mean of 58.6 years old. Both groups were split fairly evenly between genders, with 3 eyes from males in both groups (42.8% deposit, 60% clear) and 4 eyes from females (57.1%) in the deposit tube group and 2 (40%) in the clear tube group. Both groups were comprised of predominantly African-Americans with only 1 Hispanic American in the deposit group (14.3%).

The 2 eyes with exposed tube shunts exhibited intraluminal deposits on the exposed area, while 7 of 13 eyes without exposure had a thin rim of highly reflective material. The most common diagnosis in the study was uveitic glaucoma, which occurred in 5 of the 15 eyes (3 deposit, 2 clear). The next most common diagnosis was both primary open angle and neovascular glaucoma (NVG), which occurred in 4 of the 15 eyes, respectively (1 deposit, 3 clear; 4 deposit, 0 clear). The predominant tube represented in the study was the valved Ahmed tube with 11 of the 15 eyes (7 deposit, 4 clear). There were 2 non-valved Baerveldt tubes in each group. The mean duration of tube shunt implantation was 15.0 months in the deposit group and 33.7 in the clear tube group. The majority of patients in each group were using eye drops at presentation (88.9% deposit, 83.3% clear), and the average intraocular pressure was 20.2 mmHg in the deposit group and 19.0 mmHg in the clear group.

DISCUSSION

In this study, we are first to report a novel intraluminal deposit in the TS of glaucoma drainage devices using AS-OCT. The two most common aqueous tube shunts examined in the present study are the Ahmed valve and the Baerveldt implant. Once the tube shunt is in place, the slit lamp is the primary means to examine the tube shunt apparatus by verifying presence of bleb, position of tube in anterior chamber or sulcus, and tube coverage with conjunctiva. For instance, a 78-year-old female with uveitic glaucoma who presented with approximately 5 mm of Ahmed tube shunt exposure exhibited unique, white crystalline deposits as depicted in slit lamp photos (Figure 1A). However, there remains no non-invasive way to investigate the tube. This study utilized SD-OCT of the anterior segment to investigate the intraluminal aspect of tube shunts. In previous studies, anterior segment OCT has been used to evaluate the position and patency of tube shunts, but no similar study has been conducted thus far [7]. In this case, SD-OCT confirmed the presence of reflective deposits on the inner aspect (Figure 1B).

The majority of demographic data between the two groups were similar, such as mean age and gender composition, with African-Americans as the predominant race (10/11 patients, 90.9%). In terms of diagnosis and treatment, both groups had a majority of Ahmed tube shunts with only 2 Baerveldts in each group. Similarly, the intraocular pressure was comparable between the two groups (20.2 mmHg vs 19 mmHg, see table 1), and the majority of patients in both groups were on eye drops.

The main difference between the deposit group and the clear tube group was glaucoma diagnosis, with the common diagnosis being NVG (4 deposit, 0 clear) and primary open angle glaucoma (1 deposit, 3 clear). However, due to the small sample size, this difference was not statistically significant (p-value=0.22, 0.19, see Table 1). NVG is characterized by

the breakdown of the blood-aqueous barrier [9], and all patients with NVG in this study exhibited intraluminal deposits. Proteomic studies show inflammatory markers in aqueous humor of patients after tube shunt surgery, suggesting the inserted tubes cause a breach in the blood-aqueous barrier and produce an influx of inflammatory proteins [10]. Deposits may be expected in such cases. Therefore, blood-aqueous barrier breach may be associated with the build-up of these deposits.

Although the intraluminal deposits can be seen, the composition of the material is still unclear. Initially, the patient referred to in Figure 1 was managed on topical antibiotics, but when the exposure did not heal, she was scheduled for tube shunt removal and reinsertion with a tube extender. The extracted tube (Figure 1C) was sent for microbiological analysis with chemical staining, but due to the fragile nature of the tube and cellular material, the results were inconclusive. The leading thoughts on the material are calcification based on the slit lamp appearance of patient 1, who had the largest, most visible deposits. Intraluminal calcium deposits would be consistent with the highly reflective appearance on OCT imaging. Similar hyper-reflective OCT findings have been documented in other disease processes involving calcium deposits, such as idiopathic sclerochoroidal calcification, macular drusen, and calcified intraocular lenses. [11–13].

We discovered that tube shunt deposits are present both in exposed tubes (2 of 2 eyes) and in cases where no exposure occurred (7 of 13 eyes). Interestingly, two months after a new, unexposed tube was implanted in the patient from Figure 1, intraluminal deposits developed again (Figure 1D). Taken together, these findings indicate that deposits are a more general occurrence in tube shunts irrespective of exposure. Additionally, after careful review of AS-OCT images of patients with deposits, it was apparent that overlying conjunctival vascularity and tutoplast thickness, or lack thereof, did not play a role in the prevalence of intraluminal deposits. For instance, OCT imaging depicts patients with exposure and, therefore, no conjunctiva or tutoplast overlying the tube with deposits (Figure 1B). However, similar deposits can be seen in patients with unexposed tube shunts who have tutoplast and conjunctiva in place (Figure 1E). Moreover, intraluminal deposits can be seen in the same patient depicted in Figure 1B after reinsertion of a new, unexposed tube shunt, showing a quite vascular conjunctiva and thick tutoplast overlying the tube (Figure 1D).

Tube shunts are becoming more commonly used as initial surgical treatment of glaucoma [8, 14]. With the development of newer technology, such as SD-OCT with higher speed and scan depth, there are now additional avenues for tube shunt examination in glaucoma. [15–16]. This study demonstrates a novel, non-invasive means to examine the lumen of tubes using OCT imaging. However, the limitations of this study are its retrospective nature, small sample size, and that patients come from an urban, tertiary eye care center, in addition to the homogeneity of the racial demographics and underrepresentation of Baerveldt tubes. Future directions of this study include obtaining more patients and following the tubes long-term to track deposit development; using a non-invasive procedure such as OCT imaging as shown in this study would be ideal for examining the lumen of tubes. Further investigation is required to elucidate the implications of these intraluminal deposits, in particular, identifying the composition of the deposits, the potentially inflammatory effect on patients, and the ultimate implications on surgical efficacy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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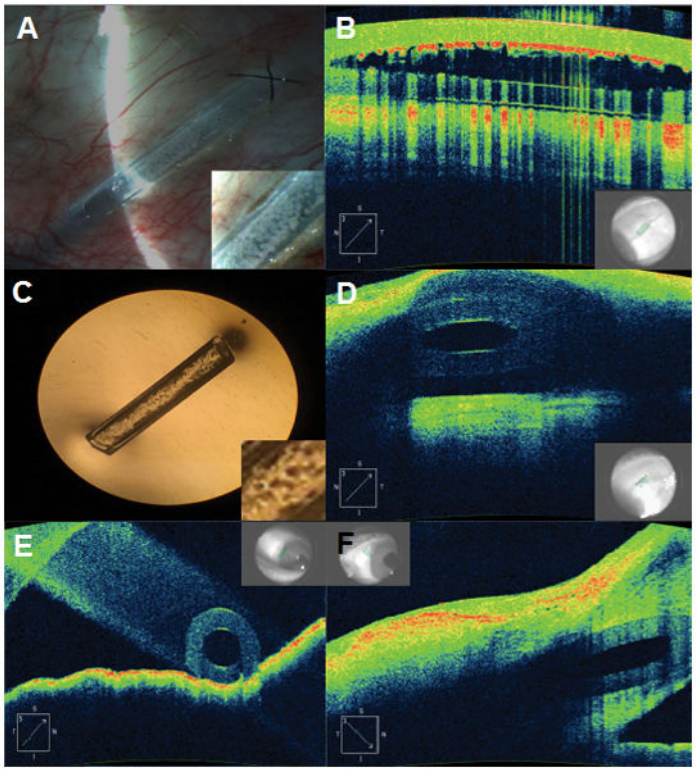

Figure 1.

(A) Intraluminal deposits in 5mm exposed tube shunt as depicted in the slit lamp photos. (B) Deposits were determined to be intraluminal by anterior segment SD-OCT. (C) Excised tube shunt was examined to contain crystalline deposits. (D) Transverse cross-sectional image of new, non-exposed tube shunt showing recurrence of intraluminal deposits. (E–F) OCT imaging of unexposed tube shunts depicting deposits around the rim (E) or no deposits (F).

Table 1

Patient demographics. TS- tube shunt. POAG- primary open angle glaucoma. CACG- chronic angle closure glaucoma. NVG- neovascular glaucoma. AC- anterior chamber. IOP (intraocular pressure) was obtained via applanation.

	Tubes with Deposits		Tubes w/o Deposits	
Patients	7		5	
Demographics				
Age (years old)	41–78		41–83	
Mean	60.4		58.6	
SD	14.55		15.5	
Sex				
Male	3	42.80%	3	60%
Female	4	57.10%	2	40%
Race				
African American	6	85.70%	5	100%
Hispanic	1	14.30%	0	0%
Eyes	9		6	
Diagnosis				
POAG	1	11.10%	3	50%
CACG	1	11.10%	0	0%
NVG	4	44.40%	0	0%
Aphakic	0	0.00%	1	16.70%
Uveitic	3	33.30%	2	33.30%
p-value	0.19		0.22	
Duration of TS				
Mean (mons)	15		33.7	
SD	14.9		34.9	
TS Type				
Ahmed	7	77.80%	4	66.70%
Baeveldt	2	22.20%	2	33.30%
p-value	0.09		0.41	
Using drops	8	88.90%	5	83.30%
AC Inflammation	2	22.20%	3	50%
Intraocular Pressure				
Mean	20.2		19	
SD	4.18		6.24	
Exposure	2	22.20%	0	0.00%