Evaluation of Early Glaucoma Filtering Blebs using 3-Dimensional Anterior-segment Optical Coherence Tomography

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Purpose
This study is aimed to identify cross-sectional characteristics of early glaucoma filtering blebs associated with good intraocular pressure (IOP) control 6 months after surgery using 3-dimensional cornea and anterior segment optical coherence tomography (3-D CAS-OCT).

Methods
We examined 40 eyes of 36 patients who had undergone a trabeculectomy at Okayama Saiseikai General Hospital, Japan. All patients were Japanese. There were 19 eyes with primary open-angle glaucoma, 9 eyes with exfoliation glaucoma, 4 eyes with normal tension glaucoma, 8 eyes with secondary glaucoma and 2 eyes with primary angle-closure glaucoma. Any patients with neovascular glaucoma, previous glaucoma surgery or any other type of ocular surgery that may have affected the conjunctival integrity were excluded in this study. All eyes had a fornix-based trabeculectomy. A 3 x 3 mm limbus-based scleral flap of approximately two-thirds of the scleral depth was created. Under the first scleral flap, a 3 x 2 mm second scleral flap of approximately one-quarter of the sclera depth, which works as a tunnel for aqueous humor was created. 0.4mg/ml mitomycin-C was applied for 3 minutes under the scleral flap and subconjunctival Tenon tissue. The filtering blebs were examined with 3-D CAS-OCT (Tomey Corporation, Nagoya, Japan). The maximum possible measurements with 3-D CAS-OCT were 16 x 16 mm in tissue width and 6mm in tissue depth. The mean axial resolution with 4mm depth was 11μm. The internal features of the blebs: subconjunctival microcysts, multiple low-reflective layers within Tenon’s capsule (striping phenomenon) and the loss of visualization of the sclera below the filtering bleb (shading phenomenon) were observed 2 weeks after surgery. The patients were followed up at 6 months or more and classified into three categories according to the IOP 6 months postoperatively: good (IOP ≤14mmHg without glaucoma medication), fair (14mmHg≤IOP ≤18mmHg without glaucoma medication) and poor (18mmHg≤IOP ≤18mmHg with glaucoma medication). The Wilcoxon rank-sum test and the Kruskal-Wallis test were used for the analyses.

Results

Table 1. Demographic and clinical characteristics of trabeculectomised eyes

<table>
<thead>
<tr>
<th>Patients with Glaucoma</th>
<th>Number of patients</th>
<th>Number of eyes</th>
<th>Mean age (years)</th>
<th>Sex (Male/Female)</th>
<th>Operation (Phaco+Trab/Trab)</th>
<th>Preoperative mean IOP (mmHg)</th>
<th>Mean follow-up period (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>36</td>
<td>40</td>
<td>71.3 ±10.4</td>
<td>20 / 17</td>
<td>18 / 22</td>
<td>28.0 ±11.2</td>
<td>20.6 ±11.4</td>
</tr>
</tbody>
</table>

Table 2. Association of IOP and internal features of the blebs 2 weeks following surgery with IOP control at 6 months

<table>
<thead>
<tr>
<th>IOP control at 6 months</th>
<th>Good (n=27)</th>
<th>Fair (n=4)</th>
<th>Poor (n=9)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOP at 2 weeks (mmHg)</td>
<td>5.9±3.0</td>
<td>8.7±7.5</td>
<td>6.9±5.2</td>
<td>0.959</td>
</tr>
<tr>
<td>IOP at 6 months (mmHg)</td>
<td>8.4±2.8</td>
<td>17.1±1.0</td>
<td>16.1±3.8</td>
<td></td>
</tr>
</tbody>
</table>

Internal features of the blebs with 3-D CAS-OCT

- **Subconjunctival microcysts**
  - microcyst

- **Striping phenomenon**
  - multiple low-reflective layers within Tenon’s capsule

- **Shading phenomenon**
  - loss of visualization of the sclera below the filtering bleb

Discussion
CAS-OCT is a non-invasive technique and can provide high-resolution images of filtering blebs to visualize the internal structures of the bleb after surgery. Theellen T et al. demonstrated poor visualization of the sclera below the bleb (“shading” phenomenon) and multiple hypo-reflective layers within Tenon’s capsule (“striping” phenomenon) in successful blebs in the first operative week using slit lamp-adapted OCT [1]. In our study, early filtering blebs of eyes with good IOP control (n=27) had striping phenomenon in 12/27 (44.4%), shading phenomenon in 9/27 (33.3%) and subconjunctival microcysts in 23/27 (85.2%) and with fair IOP control (n=4) had striping phenomenon in 1/4 (25%), subconjunctival microcysts in 4/4 (100%) and no shading phenomenon, whereas those with poor IOP control (n=9) had neither striping nor shading phenomenon and had subconjunctival microcysts in 8/9 (88.9%). Early filtering blebs with striping and shading phenomena were associated with good IOP control 6 months following surgery (p=0.016, 0.023, respectively). We found no association between IOP values 2 weeks postoperatively and IOP control at 6 months (p=0.959). The studies using confocal microscopy and the histological results of filtering blebs showed that striping phenomena represents collections of aqueous humor with loosely arranged subepithelial connective tissue [2-5]. Shading phenomenon seems to represent the absorption profile of water that significantly worsens tissue transparency and limits light backscatter of deeper structures [6]. Further studies are needed to find out what kinds of surgical manipulations and post-surgical intervention can contribute to the development of striping and shading phenomena using 3-D CAS-OCT.

Conclusion
Striping and shading phenomena of early glaucoma filtering blebs may predict a good IOP control 6 months after surgery.

<References>
4) Guthoff R et al. 2006;J Glaucoma 15:552-558
5) Messier GM et al. 2006;Arch Ophthalmol 2006; 124:1095-1103