Swept-Source Optical coherence tomography Visualization of Macular Hole Closure in Gas-Filled Eyes

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Objective
To assess the use of swept-source optical coherence tomography (SS-OCT) to visualize early macular hole closure through gas-filled eyes on postoperative day 1 (POD1).

Background
- OCT imaging through gas-filled eyes during the early postoperative periods continues to pose a unique challenge.
- Light scatterers (gas bubbles) cause noticeable image artifacts.
- The recent introduction of swept-source optical coherence tomography (SS-OCT) may offer potential in overcoming this difficulty.
- Preventive OCT SS-OCT has a longer wavelength (1050nm vs. 840-850nm).
- No evidence has been published using this modality and reduced laser scattering between phase transitions.
- This technique may be especially useful for the setting of gas-filled eyes following macular hole surgery.
- Early visualization of hole closure may facilitate a shorter duration of face-down positioning to reduce associated choroidal and complications.

Methods
We examined 30 consecutive patients with full-thickness macular holes (HTM) who underwent standard 25-gauge gas tamponade (SF6) surgery between July 2015 and April 2016 at the Sunnybrook Health Sciences Centre, Toronto, Canada.

SS-OCT
- SS-OCT imaging was performed using horizontal raster scans (6.3 x 6.3 mm with 120 B-scans footing 15-line radial scan). Films to evaluate the hole closure status.

POD 2
- Face-down posturing was discontinued in all patients with no visual disturbance or at least 6/6 vision. OCT images were taken again.

POD 3
- SS-OCT images were taken again to further evaluate and confirm hole closure status.

Interpreting SS-OCT images
SS-OCT images were read by 2 independent OCT readers. POD 1-3.
- Subtreshold: an entirely clear image with complete visualization of all retinal layers at the lesion.
- Consistent MH closure: difference of all retinal layers at the central retinal nerve fiber layer.
- Optic nerve MH closure: objective absence of at least a small fiber layer.
- Optic disk MH closure: objective absence of at least a small fiber layer.

Statistical analysis
Unpaired student’s t-tests used to compare the mean minimum MH diameter between eyes that achieved complete closure by POD 1 and eyes that did not (p < 0.05 was considered significant).

Results
Patient characteristics
- We examined 30 eyes with a mean baseline corrected visual acuity (BCVA) of 69±10 logMAR. Patients ranged from 24 to 77 years of age (mean: 62 ± 14.68). Consenting to 12 men and 18 left eyes.
- The mean postoperative MH diameter was 400±100 µm (range 129-416 µm). Between 25A-400 µm in 13 eyes, 251-500 µm in 12 eyes, >500 µm in 5 eyes.
- Retinal pigment epithelial layer and choroidal thickness were measured.

POD 1: 7/6 eyes achieved MH closure (23%) that could be successfully analyzed. Statistical analysis revealed: 2 had intermediate status, 1 had full closure but with a peripapillary MH.

Discussion
1. Reasons for unsuccessful scan on POD1
- Hyphaema (2/6 eyes)
- Dose constact (1/6 eyes)
- Low gas (≤50%)

2. Advantages of using manual scans
High-quality manual image shows to be substantially mean accurate at detecting and evaluating postoperative macular closure compared to routine volume scans.

3. Advantages of manual focusing and localization

Conclusion
- With the use of SS-OCT, we demonstrated a high degree of consistency, accuracy, and reproducibility in evaluating macular closure.

References

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Methods

- 30 consecutive patients with FTMH underwent standard 25 gauge PPV with ILM peeling & SF6 (25% gas tamponade between July 2015 & April 2016 at the Herzig Eye Institute, Toronto, Canada.

- Dynamic imaging was utilized to maximize image quality: the raster scan was manually shifted to the top or bottom 1/3 of the screen with patient navigation as described by Ehlers et al.

Interpreting SS-OCT images

The SS-OCT images were read by 2 independent OCT readers (NC & DL)

- **Successful scan**: an optically clear image with complete visualization of all retinal layers at the fovea.
- **Complete MH closure**: adherence of all retinal layers at the central hyper-reflective line
- **Partial MH closure**: physical approximation of some retinal layers
- **Open MH**: lack of tissue apposition in all retinal layers
Results

- Mean baseline best-corrected visual acuity (BCVA) of 0.91 logMAR.
- Patients ranged from 44 to 77 years of age (mean 62.9 ± SD 8.3), consisting of 19 women and 11 men corresponding to 11 right eyes and 19 left eyes.
- The mean preoperative MH diameter was 408.8 μm (≤ 200 μm in 2 eyes, between 200-400 μm in 13 eyes, and ≥ 400 μm in 15 eyes).
- 24 underwent concomitant phacoemulsification cataract extraction and intraocular lens implantation, resulting in a total of 27 pseudophakic eyes postoperatively.

<table>
<thead>
<tr>
<th>Day</th>
<th>Successful SS-OCT Scan</th>
<th>Full MH closure</th>
<th>Partial MH closure</th>
<th>Open MH</th>
</tr>
</thead>
<tbody>
<tr>
<td>POD 1</td>
<td>24 of 30 eyes (80%)</td>
<td>17 eyes (67%)*</td>
<td>7 eyes (33%)</td>
<td>None</td>
</tr>
<tr>
<td>POD 7</td>
<td>26 of 30 eyes (87%)</td>
<td>24 eyes (92%)</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>POD 30</td>
<td>30 of 30 eyes (100%)</td>
<td>29 eyes (97%)</td>
<td>None</td>
<td>1 eye (3%)</td>
</tr>
</tbody>
</table>
Results

Figure 1A: SS-OCT of a 'complete' Macular hole closure on POD#1 marked by apposition of all retinal layers

Figure 1B: SS-OCT of a 'partial' Macular hole closure on POD#1 demonstrating physical approximation without complete apposition of all retinal layers
Results

Reasons for Unsuccessful Scan(s)

(A) <80% gas fill with Gas meniscus interference (2 eyes)
(B) Cataract (2 eyes)
(C) Hyphema (2 eyes)

Figure 2: Anterior Segment Images of eyes with unsuccessful scans

Advantages of Radial scans vs. Horizontal raster

(A) Horizontal 9mm scan demonstrating complete hole closure
(B) Radial 9mm scan demonstrating open macular hole in same eye

Figure 3: SS-OCT comparing horizontal to radial scan lines
Conclusions

1. Swept-Source OCT (SS-OCT) enabled consistent early visualization and assessment of macular hole closure through gas-filled eyes.

2. A combination of Radial and Horizontal raster scan protocols with dynamic localization of the fovea assisted in confirmation of the macular hole status following surgery.

3. Examination of macular hole closure status in the early post-operative period using SS-OCT may prove useful in guiding face-down positioning.