Optical Coherence Tomography to Predict the Post-operative Functional and Anatomical Outcome of Macular Hole Surgery

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Abstract

Background:
Idiopathic macular holes can cause visual loss and metamorphopsia. Vitrectomy combined with gas tamponade and face down positioning is currently the treatment of choice to close the hole and improve vision. The current study was designed to identify predictive factors for postoperative outcome by using optical coherence tomography (OCT) in patients with idiopathic macular holes.

Methods:
Forty two patients with idiopathic macular holes were included. OCT radial line scans were performed before and 4 weeks after macular hole surgery. Images were used to calculate various macular hole parameter. Those parameter were correlated to postoperative visual and morphological outcome.

Results:
The calculated quotient of maximum retinal thickness to minimum hole size (Traction-hole-index;THI) was significantly smaller in eyes with persistent macular holes after surgery (THI in patients with closed holes: 1.02 ± 0.35 vs. 0.84 ± 0.26 in persistent holes; p=0.014). The baseline minimal hole diameter was significantly bigger in patients that had persistent macular holes after surgery (469.7 ± 130 μm in patients with closed holes vs. 560.5 ± 141.3 μm in persistent holes; p=0.014). No significant OCT value was found to predict functional outcome.

Conclusion:
OCT parameters such as the THI or the minimal hole diameter can help to predict the postoperative morphological outcome of macular hole surgery. These parameters might also help to predict outcomes of new emerging pharmacological treatments for macular holes in the future.

Keywords: Optical Coherence Tomography; Macular hole; Retinal thickness; Vitrectomy; Visual outcome

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1. Introduction

Idiopathic macular holes (MH) are full-thickness defects of retinal tissue involving the anatomic fovea. MHs are affecting central visual acuity and cause metamorphopsia. Gass (1988) has described an updated biomicroscopic classification of macular holes and postulated that tangential vitreous traction may play a role. Cellular components surrounding the rim of macular holes may also contribute tangential traction forces and elevate the rim.

Newer imaging technology, such as optical coherence tomography, helps distinguish true macular holes from pseudoholes or other macular conditions and may provide additional insight into the pathogenesis. Optical coherence tomography (OCT) was first introduced in 1991 as a non-invasive, crosssectional imaging technique (Huang et al 1991). In 1995, time-domain OCT was used first for imaging macular disease (Hee et al 1995, Puliafito et al 1995). Tanner and Williamson (2000) used OCT to confirm the predictive value of the Watzke-Allen test in macular holes. OCT technology was also used to define postoperative foveal structure after macular hole surgery to correlate findings with visual function (Chalam et al. 2010, Kang et al. 2010). Since the first descriptions of pars plana vitrectomy (PPV) and gas for its treatment by Kelly and Wendell (1991), macular hole has become one of the commonest reasons for vitrectomy surgery. Success rates can be very high if the patients are operated upon early, but vary from 47 % to 100 % for hole closure depending on the mix of stages of macular hole and the duration of the symptoms (Jaycock et al 2005, Da Mata et al 2001, Da Mata et al 2004, Dori D et al. 2003, and Ezra and Gregor 2004).

In this study, OCT was used to calculate various parameters of preoperative scans from idiopathic macular holes in order to predict functional and anatomical outcome of MH surgery.

2. Methods

Charts of all patients diagnosed with idiopathic MH between 2004 and 2006 at the Department of Ophthalmology, University Hospital Leipzig, Germany were retrospectively reviewed. Patients that had a full thickness MH were included if no prior other ocular surgery (beside cataract surgery) was performed in study eyes. All patients received good quality baseline OCT (Stratus OCT 3000, Carl Zeiss Meditec AG) radial line scans (consisting of 6 single line scans) centered on the MH. Patients agreed to schedule a follow up visit to re-perform OCT four weeks after surgery. Best corrected Snellen visual acuity (VA) was tested at baseline and last visit. VA values were converted into logMAR values for statistical analysis. Figure 1 shows a fundus photograph of a typical case of idiopathic MH prior to surgery. OCT scans were used to calculate various MH parameters. Out of the six single line OCT scans, the mean minimal hole diameter and mean maximum hole diameter were calculated. In addition, the Macular Hole Index (MHI) and Tractional Hole Index (THI) were calculated. Figure 2 explains how MHI and THI were calculated.

For statistical analysis data was tested for normal distribution using the Kolmogorov-Smirnov test. Differences in OCT parameter or visual acuity change within patient groups with closed MH or persistent MH have been tested by Mann-Whitney U test.
3. Results

Seventy-Two patients with idiopathic MH were identified. Only 42 patients were included into the study. The other patients were not willing to participate in follow up examinations or had to be excluded due to other reasons. All 42 eyes received pars plana vitrectomy, peeling of the inner...
limiting membrane and SF6 gas tamponade. Face down positioning was performed for 5 days after surgery. Out of 42 eyes, 21 MHs (50%) were closed after vitrectomy, whereas 21 MHs (50%) remained open. Out of the 21 patients with persistent MH after surgery, 11 patients decided to reoperate. Out of these 11 patients, 8 eyes had finally closed MHs after the second vitrectomy and 3 eyes had persistent MHs even after the second surgery. Both surgeries combined, 91% of MHs have been successfully closed (29 out of 32 patients that received 2 surgeries). Table 1 shows the change in VA from baseline to 4 weeks post 1st surgery and from baseline to 4 weeks post 2nd surgery.

**Table 1** Visual acuity change from baseline to 4 weeks post 1st surgery and 4 weeks post 2nd surgery.

<table>
<thead>
<tr>
<th></th>
<th>Baseline to 4 weeks post 1st surgery (n= 42)</th>
<th>Baseline to 4 weeks post 2nd surgery (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>logMAR-VA</td>
<td>0.88 ± 0.39</td>
<td>0.75 ± 0.38</td>
</tr>
<tr>
<td>Mean change in VA</td>
<td>-0.03 ± 0.37</td>
<td>-0.13 ± 0.39</td>
</tr>
<tr>
<td>VA improvement</td>
<td>-0.35 ± 0.24 (45%)</td>
<td>-0.4 ± 0.26 (53%)</td>
</tr>
<tr>
<td>VA unchanged</td>
<td>8 (19%)</td>
<td>8 (25%)</td>
</tr>
<tr>
<td>VA worsening</td>
<td>0.36 ± 0.14 (36%)</td>
<td>0.39 ± 0.27 (22%)</td>
</tr>
</tbody>
</table>

Visual acuity= VA

OCT parameters such as the MHI, THI, minimal hole diameter and maximum hole diameter have been calculated at baseline. Data showed significant differences for THI and minimal hole diameter between patients with closed MHs and patients with persistent MHs 4 weeks after 1st surgery (Table 2).

**Table 2** Differences in OCT parameters between patients with closed macular holes and persistent macular holes 4 weeks after 1st surgery.

<table>
<thead>
<tr>
<th></th>
<th>closed MH</th>
<th>persistent MH</th>
<th>P -value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHI</td>
<td>0.51 ± 0.18</td>
<td>0.44 ± 0.1</td>
<td>0.126</td>
</tr>
<tr>
<td>THI</td>
<td>1.02 ± 0.35</td>
<td>0.84 ± 0.26</td>
<td><strong>0.041</strong></td>
</tr>
<tr>
<td>Minimal hole diameter</td>
<td>469.7 ± 130</td>
<td>560.5 ± 141.3</td>
<td><strong>0.014</strong></td>
</tr>
<tr>
<td>Maximum hole diameter</td>
<td>1031 ± 343.7</td>
<td>1231 ± 739.2</td>
<td>0.379</td>
</tr>
</tbody>
</table>

MH=macular hole
No significant correlation was found between any OCT parameter and postoperative VA change.
4. Discussion


Our study revealed some OCT parameters that have predictive value regarding the anatomical closure rate after surgery. The minimal hole diameter was significantly smaller in eyes with successful surgery. Minimal hole diameter > 500 μm might have an unfavorable anatomical outcome. These findings are in agreement with other previous studies, showing that smaller MHs have better prognosis in regard to postoperative anatomical closure (Haritoglou et al 2007, Ullrich et al 2002, and Yamamoto and Hori 2011). We found no significant correlation between VA change and minimal hole diameter. In contrast, Haritoglou et al (2007) found significantly better functional outcome in patients with smaller MHs. Also Ruiz-Moreno et al (2008) found a weak correlation between hole size and functional outcome, whereas Ullrich et al (2002) found no correlation between MH size and functional outcome. One can conclude that the correlation between functional outcome and MH size still remains matter of controversy.

Another significant predictive parameter was the THI. This parameter was first introduced by Ruiz-Moreno et al (2008). The THI parameter might be a factor that represents the amount of traction at the edges of the macular hole. THI is calculated out of the maximum retinal thickness at the edge of the hole divided by the minimal hole diameter. In the study of Ruiz-Moreno et al. (2008) the THI was a significant predictive factor for postoperative visual outcome. In our study the THI was a predictive factor for successful MH closure (1.02 ± 0.35 in closed MHs vs. 0.84 ± 0.26 in persistent MHs; p = 0.041).

We also calculated the MHI index that was first introduced by Kusuhara et al in 2004. Our data found no significant predictive value of the MHI. In contrast, Kusuhara et al (2004) found a significant correlation between MHI and postoperative visual outcome. Authors stated that MHI ≥ 0.5 was a positive predictive factor for a favorable postoperative outcome. In our patient group, the mean MHI of patients with closed MHs was 0.51 ± 0.18 vs 0.44 ± 0.1 in patients with persistent MHs. However, our study cohort was very different from the Kusuhara study cohort; therefore results cannot be directly been compared. In the Kusuhara study, 83% of patients had a stage 2 and 17 % a stage 3 MH (Gass-staging, Gass (1988). No stage 4 MHs were included. In addition, mean MH diameter was relatively small with only 268 μm, compared to our study (mean minimal hole diameter = 515.1 μm; and mean maximum hole diameter = 1131 μm). Ip et al (2002) could show that MH closure rates show great variation depending of the initial MH size. MHs with a diameter of > 400 μm had a closure rate of only 56% whereas MHs with a diameter of < 400 μm showed a closure rate of 92%.
The current study has some limitations. Data is based on observations made between 2004 and 2006 with Stratus OCT, which is now considered outdated. All surgeries have been performed with ICG and ILM peeling and surgical techniques have not changed much since 2004. However, smaller gauge vitrectomy (23, 25 or even 27G) is now considered standard, rather than 20 G vitrectomy systems. One might say that our results are still important from a historical point of view. More recent data with spectral Domain OCT systems seem to support our observation that hole size remains one of the most important prognostic factors for surgical success rate.

In conclusion, we found two OCT factors (minimal hole diameter and THI) with predictive value for anatomical outcome after MH surgery. No significant predictive factor regarding functional outcome was found. Up to this point, published data on this topic remains inconclusive since very heterogeneous study groups make it difficult to compare results between studies. Our study data suggests, that OCT might provide useful information for the surgeon to decide whether macular hole surgery has a good or bad prognosis.

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