Determination of Foveal Contour Change with Optical Coherence Tomography Following Surgery for Epiretinal Membrane

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Background

Epiretinal membrane (ERM) is the result of glial cell proliferation over the internal limiting membrane (ILM) of the retina.

In addition to visual disturbances, ERM causes morphological changes such as retinal thickening, inner retinal wrinkling and loss of the normal foveal depression. These changes may be reversed with surgical removal of the ERM using pars plana vitrectomy (PPV) with membrane peel.

Although ERM is a relatively common retinal condition and PPV is often considered beneficial for visually significant ERM, there is a lack of common description of foveal contour change before and following PPV. Furthermore, factors that determine foveal contour change and associated visual acuity have not been well studied. By better understanding the anatomic changes that may affect visual acuity, better informed preoperative discussion and realistic patient expectations may be achieved.

The aim of this study is to develop quantitative grading of foveal contour to track retinal morphology changes over time and compare with qualitative grading and 2) correlate preoperative and postoperative foveal contour to outcome measures such as Central Subfield Thickness (CST), Central Subfield Volume (CSV), and best corrected visual acuity (BCVA) in order to plan preoperative outcomes using optical coherence tomography (OCT).

Methods

Retrospective study of 47 subjects undergoing PPV with ILM peel for ERM removal.

1. OCT of the retina was taken with a radial line scan protocol
2. OCT images of the fovea were qualitatively graded as with normal depression (Grade 0), flat (Grade 1), or elevated (Grade 2).
3. OCT images were then graded quantitatively: thickness values were recorded at the fovea (central retinal thickness, CRT) and 1mm from the fovea at 30° radial intervals.
   a. The ratio of the thickness 1 mm from the fovea to the CRT was used to characterize the contour
   b. Grade 0: ratios above 1.08, indicating foveal depression
   c. Grade 1: ratios between 0.92 and 1.08
   d. Grade 2: ratios below 0.92, indicating foveal elevation

4. CST and CSV measurements were recorded from ETDRS plots

An example of progressive foveal contour grade changes

Fig. 1a was taken 30 days prior to ERM removal. The ratios are thicker at the fovea (CRT) than at the surrounding retina. The ratios of T1 to CRT and T2 to CRT are 0.84 and 0.80, respectively, and both are considered Grade 2.

Fig. 1b is 32 days following ERM removal. The ratios of T1 and T2 have decreased to approximately the same level (ratios of 0.80 and 0.82, respectively). CST is 0.64 and 0.60, respectively, and are both considered Grade 1.

Fig. 1c is 36 days post-operation. OCT has continued to this thin and T1 and T2 have actually thickened. Ratios of 1.05 and 1.02 are each Grade 1.

Results

Qualitative Grading

Post-op (3 months)

<table>
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<th>Grade 2</th>
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<td>3</td>
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<tr>
<td>1</td>
<td>15</td>
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</table>

Quantitative Grading

Post-op (3 months)

<table>
<thead>
<tr>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-op</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>60</td>
</tr>
</tbody>
</table>

The preoperative foveal contour did not predict the postoperative foveal contour when measured qualitatively (p=0.06) or quantitatively (p=0.30). However, as a group, those that began as grade 0/1 was more likely to end up with 0/1 contour.

Quantitative observer grading of the foveal contour slightly favored Grade 1 over Grade 2 characterization compared to quantitative grading.

Quantitative grading was well suited for distinguishing between borderline Grade 1 and Grade 2 contours when the subjective distinction between the two grades was ambiguous.

Fig. 2: Change in CST with Pre-op CSV

Regression analysis of the change in CST reveals:

• The preoperative foveal contour grade does not predict the change in CST (p=0.04).
• The change in CST is predicted by the preoperative CST (p=0.0001).

Regression analysis of the change in CSV reveals:

• The preoperative foveal contour grade does not predict the change in CSV (p=0.56).
• The change in CSV is predicted by the preoperative CSV (p=0.0001).

Best Corrected Visual Acuity

A predictive model for BCVA was conducted on pseudophakic subjects prior to ERM repair and was thus limited to 17 subjects. A linear mixed model with random person intercept was used to analyze improvements in visual acuity:

\[
y_{i} = a_{i} + b_{i}(\text{days}) + c_{i}
\]

where

- \(a_{i}\) is a random person intercept
- \(b_{i}\) is a daily slope (the same for all subjects)
- \(c_{i}\) is a residual error
- \(j\) is a visits

\[
\beta = 0.0006488 \text{LogMar units} (p=0.001)
\]

Visual acuity improved an average of 0.0006488 LogMar units each day following ERM removal. This corresponds to an average improvement of 0.24 LogMar units—or 2.4 lines on a standardized visual acuity chart—over the course of one year.

Conclusions

• The grading system devised for this study (Grade 0, 1, and 2) appears useful for discussion of foveal contour in eye with epiretinal membranes. It can be applied in a quantitative or qualitative manner.
• The change in central subfield thickness and volume at 3 months is correlated with the preoperative thickness and volume, respectively. The thicker and more voluminous the fovea preoperatively, the greater the decrease in thickness and volume.
• The preoperative foveal contour was not found to predict postoperative foveal contour at 3 months.
• The preoperative foveal contour was not found to predict the change in central subfield thickness or volume at 3 months.
• By controlling for postoperative cataract formation and only analyzing preoperative pseudophakic patients, BCVA improved 2.4 lines on a visual acuity chart per year following ERM removal.
• Future research will continue to analyze the relationship between qualitative and quantitative grading of the foveal contour and to examine the trends of foveal contour resolution and visual acuity improvement.

References


Awards

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Background

Epiretinal membrane (ERM) is the result of glial cell proliferation over the internal limiting membrane (ILM) of the retina.

![OCT image of a healthy retina](image1.png)  
![ERM visible as a thin hyper-reflective line above the ILM](image2.png)

In addition to visual disturbances, ERM causes morphological changes such as retinal thickening, inner retinal wrinkling and loss of the normal foveal depression. These changes may be reversed with surgical removal of the ERM using pars plana vitrectomy (PPV) with membrane peel.

Although ERM is a relatively common retinal condition and PPV is often considered beneficial for visually significant ERM, there is a lack of common description of foveal contour change before and following PPV. Furthermore, factors that determine foveal contour change and associated visual acuity have not been well studied. By better understanding the anatomic changes that may affect visual acuity, better informed preoperative discussion and realistic patient expectations may be achieved.

The aim of this study is to 1) develop quantitative grading of foveal contour to track retinal morphology changes over time and compare with qualitative grading and 2) correlate preoperative and postoperative foveal contour to outcome measures such as Central Subfield Thickness (CST), Central Subfield Volume (CSV), and best corrected visual acuity (BCVA) in order to infer patient postoperative outcomes using optical coherence tomography (OCT).
Methods

Retrospective study of 47 subjects undergoing PPV with ILM peel for ERM removal.

1. OCT of the retina was taken with a radial line scan protocol
2. OCT images of the fovea were qualitatively graded as with normal depression (Grade 0), flat (Grade 1), or elevated (Grade 2).
3. OCT images were then graded quantitatively: thickness values were recorded at the fovea (central retinal thickness, CRT) and 1mm from the fovea at 30° radial intervals
   a. The ratio of the thickness 1mm from the fovea to the CRT was used to characterize the contour
      • Grade 0: ratios above 1.08, indicating foveal depression
      • Grade 1: ratios between 0.92 and 1.08
      • Grade 2: ratios below 0.92, indicating foveal elevation
   b. Twelve ratios and grades were recorded per visit, with the majority grade assigned as the overall contour grade
4. CST and CSV measurements were recorded from ETDRS plots
Results

- The preoperative foveal contour did not predict the postoperative foveal contour when measured qualitatively (p=0.08) or quantitatively (p=0.30). However, as a group, those that began as grade 0/1 was more likely to end with 0/1 contour.

- Qualitative observer grading of the foveal contour slightly favored Grade 1 over Grade 2 characterization compared to quantitative grading.

- Quantitative grading was well suited for distinguishing between borderline Grade 1 and Grade 2 contours when the subjective distinction between the two grades was ambiguous.

An example of progressive foveal contour grade changes

Regression analysis of the change in CST reveals:
- The preoperative foveal contour grade does not predict the change in CST (p=0.54)
- The change in CST is predicted by the preoperative CST (p=0.0001)

Regression analysis of the change in CBV reveals:
- The preoperative foveal contour grade does not predict the change in CBV (p=0.60)
- The change in CBV is predicted by the preoperative CBV (p=0.0001)

Fig. A was taken 30 days prior to DEXM removal. The retina is thinner at the fovea (DCT) than at the surrounding tissue (T1 and T2). The ratio of T1 to DCT and T2 to DCT is 0.84 and 0.86, respectively, and both are considered Grade 2.

Fig. B is 12 days following DEXM removal. CDT, T1, and T2 all have thinned to approximate the same levels (ratio of 0.88 and 0.93, respectively) to be considered Grade 1, while T1 is considered Grade 0.

Fig. C is 66 days post-operation. CDT has continued to thin while T1 and T2 have actually thickened. Ratios of 1.10 and 1.12 are each Grade 0.
Conclusions

- The grading system devised for this study (Grade 0, 1, and 2) appears useful for discussion of foveal contour in eye with epiretinal membrane. It can be applied in a quantitative or qualitative manner.

- The change in central subfield thickness and volume at 3 months is correlated with the preoperative thickness and volume, respectively. The thicker and more voluminous the fovea preoperatively, the greater the decrease in thickness and volume.

- The preoperative foveal contour was not found to predict postoperative foveal contour at 3 months.

- The preoperative foveal contour was not found to predict the change in central subfield thickness or volume at 3 months.

- By controlling for postoperative cataract formation and only analyzing preoperative pseudophakic patients, BCVA improved 2.4 lines on a visual acuity chart per year following ERM removal.

- Future research will continue to analyze the relationship between qualitative and quantitative grading of the foveal contour and to examine the trends of foveal contour resolution and visual acuity improvement.