Status of center point thickness and correlation between anatomic and best corrected visual acuity changes after photocoagulation in diabetic macular edema

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Abstract

Background: Center point thickness in diabetic macular edema varies after photocoagulation according to its baseline status. It is unknown whether this variation reduces the correlation between anatomic and visual acuity changes. We undertook this study to identify the contribution of baseline center point thickness to the correlation between anatomic and visual acuity changes after photocoagulation in eyes with diabetic macular edema.

Methods: We carried out a nonexperimental, prospective, longitudinal, analytical study in diabetic patients with macular edema treated with photocoagulation and stratified by groups: visual acuity <0.5 with (group 1) or without central thickening (group 2), and visual acuity ≥0.5 with (group 3) or without central thickening (group 4). The correlations between changes of center point thickness, macular volume, and visual acuity were identified (Spearman).

Results: There were 79 eyes, 17 in group 1 (21.5%), 21 in group 2 (26.6%), 14 in group 3 (17.7%) and 27 in group 4 (34.2%). Center point thickness increased in groups 2 and 4, visual acuity decreased in group 3 and macular volume decreased in all groups. The correlations between center point thickness and best corrected visual acuity changes in group 3 and between macular volume and visual acuity in group 1 were negative. The correlations between anatomic variables and visual acuity were low in the sample (r = 0.14).

Conclusion: The increase of center point thickness in eyes without baseline central thickening produced opposite correlations between groups, which reduced the correlations in the sample. Stratification according to baseline center point thickness would make it easier to evaluate other variables that modify the functional outcome after photocoagulation.

Key words: correlation, diabetic retinopathy, diabetic macular edema, macular volume, retinal thickness.

Introduction

The most common cause of blindness worldwide during the productive age is diabetic retinopathy.1 The most common types of diabetic retinopathy that threaten vision are proliferative retinopathy and macular edema, with a prevalence of 6.9 and 6.8% worldwide, respectively.2

In diabetic macular edema, interstitial fluid accumulates in the region of the retina with higher resolution due to damage to the blood-retinal barrier. The fluid separates the photoreceptors and may permanently reduce visual capacity (auxiliary corrected visual acuity). The fluid can come from specific alterations such as microaneurysms (focal edema) or from a wide area of blood-retinal barrier dysfunction (diffuse edema).3

The Early Treatment of Diabetic Retinopathy Study (ETDRS) identified characteristics of diabetic macular edema that would confer risk of moderate visual loss (duplication of the visual angle, loss of three lines on a logarithmic visual acuity scale), which include retinal thickening up to 500 μm from the center of the macula, exudates up to 500 μm from the center of the macula if they are accompanied by thickening of the adjacent retina, or a zone or zones of retinal thickening larger than one disc area any part of which is less than one disc diameter from the center of the macula.4

The ETDRS denominated edema as “clinically significant” edema when any of these characteristics existed and found that treating it with photoacoagulation reduced the incidence of moderate visual loss from 33 to 13% over a 3-year period. For clinically significant macular edema with
focal filtration, photocoagulation is the standard treatment; its objective for most eyes is to stabilize visual acuity.4

Eyes with involvement of the center of the macula have a greater risk of visual loss. It has been identified that eyes with clinically significant macular edema (CSME) and visual acuity <20/40 have a greater probability of improving visual function,4 an outcome that in recent studies has been identified in >30% of eyes treated with photocoagulation.5,7

In eyes with CSME, visual acuity decreases as the center point thickness increases as measured by optical coherence tomography, but the correlation between visual acuity and center point thickness varies between -0.46 in the study by Nunez et al.8 and 0.52 in the DRCR.net study.9 After photocoagulation, stability of the center point thickness has been described, whose correlation with the modification of the visual acuity has been 0.3310 and 0.36.7 The early anatomic response after photocoagulation varies depending on the state of the center point prior to the treatment,11 which could explain the correlation reported with the change in visual acuity, but this association has not been evaluated.

A study to identify the correlation between the anatomic changes and early visual acuity after photocoagulation was carried out in patients with CSME with focal filtration, with stratification according to the visual acuity and center point thickness prior to treatment so as to determine any modification due to the different anatomic response.

**Patients and Methods**

We carried out an observational, prospective, longitudinal, analytical study with the target population being patients with type 2 diabetes from Mexico City and its metropolitan area. The sample was obtained from patients treated at a general hospital in Mexico City between January 1, 2008 and December 31, 2011. The study was conducted from January 1, 2008 to January 31, 2012 and was approved by the Research and Ethics Committees of the hospital where the study was carried out.

We included patients with type 2 diabetes scheduled for focal photocoagulation for CSME, of either gender, between 40 and 70 years of age, with any duration of diabetes, any degree of diabetic retinopathy. Subjects had to have focal filtration on the fluorescein angiography and a fast macular map of adequate quality before treatment and 3 weeks after treatment.

We excluded patients with myopia over -6.00 diopters, thickening of the posterior vitreous, vitreous traction on the macula and other retinal diseases at the time of treatment and eliminated patients with any other macular disease or who required panretinal photocoagulation before the second evaluation, as well as eyes whose maps had measurement errors.

CSME was diagnosed by biomicroscopy, by a single retinal specialist according to the ETDRS criteria. Visual acuity was measured under subjective refraction (decimal equivalent) on the day of treatment (prior to application) and 3 weeks later.

The same retinal specialist treated all patients according to the ETDRS guidelines. A different investigator obtained all the fast macular mapping using the following standardized procedure: midriasis ≥6 mm, inclusion of spherical equivalent and anteroposterior axis, tracking for dark eyes, identification of the retinal plane with an acoustic alarm and optimization of the Z-axis and polarization.

All maps were obtained with flash between 8 a.m. and 11:00 a.m. using the Stratus optical coherency tomography equipment (Zeiss) after evaluating visual acuity; to verify that the maps were adequately centered; it was assured that the center point thickness was less than the center field thickness, and that the zone of less thickness was within the central circle. Any deviation of the line of the optical coherence tomography with respect to the actual limits of the retina, a standard deviation relationship of the center point thickness of the central point >0.113 or a signal intensity <4 were considered measurement errors.

The sample was divided into four groups: eyes with visual acuity <0.5 (20/40) with center point thickening (group 1) or without center point thickening (group 2), and eyes with visual acuity ≥0.5 with center point thickening (group 3) or without center point thickening (group 4). Center point thickening was defined as a value of center point thickness higher than the average reported in diabetic patients without retinopathy from our population (158 µm) by more than 2 standard deviations (30 µm, SD ± 15 µm).13

The variables studied were visual acuity, center field thickness, center point thickness, and macular volume. Visual acuity was measured in decimal equivalents; center field thickness and center point thickness (in µm) and macular volume (in mm³) were recorded as per the macular fast map automatic calculation.14 The averages of the variables were compared before and after treatment by Wilcoxon t test, and correlations were calculated between the absolute and percentage changes of the variables (Spearman rho). The average of the changes was compared between groups using the Kruskal-Wallis test.

To calculate the absolute change of the variables, the baseline value was subtracted from that found 3 weeks after photocoagulation. To obtain the percentage change, the absolute change was divided between the baseline values and multiplied by 100.15 In this manner, an increase generated positive values and a decrease generated negative values.
The proportion of eyes that presented significant changes, defined as duplication of the visual angle for visual acuity, a change >11% of the center field thickness, >17% of the center point thickness or >3% of the macular volume, were identified. A p value <0.05 was considered statistically significant. The information was stored and analyzed with the SPSS program for Windows, v.19.

**Results**

Seventy nine 79 eyes of 69 patients were evaluated, with an age range of 34-78 years (average 58.1 ± 8.2 years), 52 eyes were of females (65.8%). Duration of the diabetes had a range of 1-35 years (average 14.1 ± 7.2 years). In 56 eyes the patients were treated with oral hypoglycemics (70.9%) and in 23 eyes patients were treated with insulin (29.1%); 48 eyes corresponded to patients with arterial hypertension (60.8%).

Blood glucose before treatment showed an average of 179.7 ± 87.2 mg/dL and glycosylated hemoglobin of 8.75 ± 1.7%. Diabetic retinopathy level was mild nonproliferative in five eyes (6.3%), moderately nonproliferative in 37 (46.8%), severe nonproliferative in 8 (10.1%) and proliferative in 29 (36.7%).

Prior to treatment, 39 eyes had visual acuity <0.5 (49.4%) and 31 had center point thickening (39.2%); 17 eyes were classified as group 1 (21.5%), 21 as group 2 (26.6%), 14 as group 3 (17.7%) and 27 as group 4 (34.2%). The proportion of eyes with center point thickening did not vary among the eyes with visual acuity <0.5 (groups 1 and 2) and those who had visual acuity ≥0.5 (groups 3 and 4, p = 0.3).

After treatment, visual acuity decreased in 26 eyes (32.9%), did not change in 16 (20.3%) and increased in 37 eyes (46.8%); nine eyes duplicated their visual angle (11.4%). The proportion of eyes whose visual acuity increased was greater in group 2 (76.2%) than in the remaining groups (36%, p <0.001, relative risk [RR] 2.1, 95% CI 1.39-3.19). Although this proportion did not differ significantly from that of group 1 (58.8%, p = 0.2), it did for group 3 (7.1% p <0.001) and group 4 (37%, p <0.007).

The proportion of eyes whose visual acuity decreased in group 3 (64.3%) surpassed that of the remaining eyes (23.3%, p = 0.01, RR 2.46, 95% CI 1.40-4.33 (Figure 1), and that of groups 1 (p = 0.007) and 2 (p = 0.002). Fourteen eyes significantly increased center point thickness (17.7%), 10 increased center field thickness (12.7%) and seven increased macular volume (8.9%). One eye significantly decreased center point thickness (1.3%), five decreased center field thickness (6.3%) and 32 decreased macular volume (40.5%).

The average of center point thickness according to group is shown in Table 1. In group 4 it significantly increased, changing the sample average from 177.5 ± 30.1 µm to 182.1 ± 30.3 µm (p = 0.05). The average of the absolute change in the sample showed an increase of 4.6 ± 20.7 µm and of the percentage an increase of 3.4 ± 12.1%. The average of the absolute change differed significantly between groups (p = 0.007, Kruskall-Wallis).

The average of the center field thickness according to group is shown in Table 2; that of group 4 also increased significantly, but the sample average only changed from 211.5 ± 30.2 µm to 213.3 ± 27.4 µm (p = 0.2). The average of the absolute change showed an increase of 1.8 ± 16.5 µm and that of the percentage showed an increase of 1.3 ± 7.9%. The average of the absolute change differed significantly between groups (p = 0.03, Kruskall-Wallis).

The average of the macular volume is shown in Table 3. In all groups it decreased statistically and in groups 1 to 3 the difference was clinically significant. The sample average decreased from 7.9 ± 0.63 mm³ to 7.7 ± 0.55 mm³ (p <0.001), average of the absolute change was a reduction of 0.25 ± 0.35 mm³, the percentage corresponded to 3.0 ± 4.3%, a clinically significant modification (>3%). The average of the absolute change did not differ between groups (p = 0.4, Kruskall-Wallis). The average of the visual acuity according to group is shown in Table 4. In groups 1 and 2 it was increased and in group 3 was significantly decreased.
Table 1. Change of center point thickness in the studied groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Average before treatment</th>
<th>Average after treatment</th>
<th>p*</th>
<th>Average of absolute change</th>
<th>Average of percentage change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ( (n = 17) )</td>
<td>208.1 ± 13.5 µm</td>
<td>201.8 ± 21.9 µm</td>
<td>0.3</td>
<td>-6.4 ± 15.2 µm</td>
<td>-3.1 ± 7.3</td>
</tr>
<tr>
<td>2 ( (n = 21) )</td>
<td>157.2 ± 17.2 µm</td>
<td>166.3 ± 27.6 µm</td>
<td>0.09</td>
<td>9.1 ± 22.7 µm</td>
<td>6.0 ± 14.5</td>
</tr>
<tr>
<td>3 ( (n = 14) )</td>
<td>211.2 ± 14.4 µm</td>
<td>208.0 ± 29.9 µm</td>
<td>0.7</td>
<td>-3.2 ± 22.3 µm</td>
<td>-1.7 ± 10.4</td>
</tr>
<tr>
<td>4 ( (n = 27) )</td>
<td>156.4 ± 16.1 µm</td>
<td>168.6 ± 20.5 µm</td>
<td>0.003</td>
<td>12.1 ± 17.4 µm</td>
<td>8.1 ± 11.2</td>
</tr>
</tbody>
</table>

*Wilcoxon t.

Table 2. Change in center field thickness in the study groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Average before treatment</th>
<th>Average after treatment</th>
<th>p*</th>
<th>Average of absolute change</th>
<th>Average of percentage change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ( (n = 17) )</td>
<td>237.9 ± 14.9</td>
<td>233.0 ± 17.5</td>
<td>0.3</td>
<td>-4.8 ± 12.6</td>
<td>-1.9 ± 5.2</td>
</tr>
<tr>
<td>2 ( (n = 21) )</td>
<td>194.9 ± 21.8</td>
<td>199.7 ± 23.2</td>
<td>0.2</td>
<td>4.8 ± 16.3</td>
<td>2.7 ± 8.7</td>
</tr>
<tr>
<td>3 ( (n = 14) )</td>
<td>243.2 ± 19.9</td>
<td>236.3 ± 28.1</td>
<td>0.3</td>
<td>-6.9 ± 20.1</td>
<td>-2.8 ± 8.1</td>
</tr>
<tr>
<td>4 ( (n = 27) )</td>
<td>191.3 ± 19.7</td>
<td>199.6 ± 19.3</td>
<td>0.006</td>
<td>8.2 ± 13.7</td>
<td>4.5 ± 7.2</td>
</tr>
</tbody>
</table>

*Wilcoxon t.

Table 3. Change of macular volume in the study groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Average before treatment</th>
<th>Average after treatment</th>
<th>p*</th>
<th>Average of absolute change</th>
<th>Average of percentage change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ( (n = 17) )</td>
<td>8.31 ± 0.47</td>
<td>8.01 ± 0.29</td>
<td>0.007</td>
<td>-0.30 ± 0.38</td>
<td>-3.43 ± 4.44</td>
</tr>
<tr>
<td>2 ( (n = 21) )</td>
<td>7.75 ± 0.62</td>
<td>7.45 ± 0.54</td>
<td>0.001</td>
<td>-0.29 ± 0.32</td>
<td>-3.72 ± 4.08</td>
</tr>
<tr>
<td>3 ( (n = 14) )</td>
<td>8.16 ± 0.47</td>
<td>7.91 ± 0.44</td>
<td>0.003</td>
<td>-0.25 ± 0.27</td>
<td>-3.03 ± 3.18</td>
</tr>
<tr>
<td>4 ( (n = 28) )</td>
<td>7.72 ± 0.66</td>
<td>7.53 ± 0.62</td>
<td>0.02</td>
<td>-0.18 ± 0.39</td>
<td>-2.29 ± 4.95</td>
</tr>
</tbody>
</table>

*Wilcoxon t test.

Table 4. Change of visual acuity in the study groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Average before treatment</th>
<th>Average after treatment</th>
<th>p*</th>
<th>Average of absolute change</th>
<th>Average of percentage change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ( (n = 17) )</td>
<td>0.28 ± 0.11</td>
<td>0.32 ± 0.12</td>
<td>0.04*</td>
<td>0.05 ± 0.10</td>
<td>32.1 ± 53.6</td>
</tr>
<tr>
<td>2 ( (n = 21) )</td>
<td>0.30 ± 0.10</td>
<td>0.43 ± 0.21</td>
<td>0.01*</td>
<td>0.12 ± 0.16</td>
<td>43.1 ± 59.7</td>
</tr>
<tr>
<td>3 ( (n = 14) )</td>
<td>0.70 ± 0.13</td>
<td>0.55 ± 0.23</td>
<td>0.04*</td>
<td>-0.15 ± 0.21</td>
<td>-21.4 ± 31.1</td>
</tr>
<tr>
<td>4 ( (n = 27) )</td>
<td>0.69 ± 0.19</td>
<td>0.63 ± 0.25</td>
<td>0.2</td>
<td>-0.06 ± 0.23</td>
<td>-4.17 ± 39.3</td>
</tr>
</tbody>
</table>

*Wilcoxon t.
The sample average changed from \(0.50 \pm 0.25\) to \(0.49 \pm 0.24\) \((p = 0.8)\), and there was a significant difference between the groups according to the modifications already described \((p < 0.001\), Kruskall-Wallis\). The correlations of absolute change are shown in Table 5. The only one that showed significance was that of the absolute changes of the volume and that of the visual acuity in group 3, where both variables decreased. Correlations between the percentage changes were not significant (Table 6). The correlation between the percentage changes of center point thickness and visual acuity was greater in the eyes without central point thickening before treatment (groups 2 and 4, Figure 2). There was no correlation in the eyes with visual acuity \(\geq 0.5\). The correlation between the percentage changes of the center field thickness and of visual acuity was negative only in group 1 (Figure 3). The correlation between the percent change of the macular volume and of the visual acuity was positive in groups 2 and 3 (Figure 4). Group 3 had the highest correlations of absolute change in the sample. The combination of the responses in the groups generated a low correlation between the percent modifications of the visual acuity and the center point thickness \((r = 0.14)\), center field thickness \((r = 0.09)\), and macular volume \((r = 0.02)\) in the sample (Figure 5).

### Table 5. Correlation between absolute changes of the anatomic variables and of visual acuity in the groups

<table>
<thead>
<tr>
<th>Group</th>
<th>CPT-VA</th>
<th>(p^*)</th>
<th>CFT-VA</th>
<th>(p^*)</th>
<th>Volume-VA</th>
<th>(p^*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n = 17)</td>
<td>0.02</td>
<td>0.9</td>
<td>-0.28</td>
<td>0.3</td>
<td>-0.09</td>
<td>0.7</td>
</tr>
<tr>
<td>2 (n = 21)</td>
<td>0.25</td>
<td>0.3</td>
<td>0.15</td>
<td>0.5</td>
<td>0.11</td>
<td>0.6</td>
</tr>
<tr>
<td>3 (n = 14)</td>
<td>-0.09</td>
<td>0.7</td>
<td>0.00</td>
<td>1.0</td>
<td>0.55</td>
<td>0.04</td>
</tr>
<tr>
<td>4 (n = 27)</td>
<td>0.09</td>
<td>0.6</td>
<td>0.04</td>
<td>0.8</td>
<td>0.001</td>
<td>0.99</td>
</tr>
</tbody>
</table>

CPT, center point thickness; CFT, center field thickness; VA, visual acuity.

* Spearman rho.

### Table 6. Correlation between percentage changes of the anatomic variables and of visual acuity in the groups

<table>
<thead>
<tr>
<th>Group</th>
<th>CPT-VA</th>
<th>(p^*)</th>
<th>CFT-VA</th>
<th>(p^*)</th>
<th>Volume-VA</th>
<th>(p^*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n = 17)</td>
<td>0.06</td>
<td>0.8</td>
<td>-0.13</td>
<td>0.6</td>
<td>0.002</td>
<td>0.9</td>
</tr>
<tr>
<td>2 (n = 21)</td>
<td>0.33</td>
<td>0.1</td>
<td>0.19</td>
<td>0.4</td>
<td>0.15</td>
<td>0.5</td>
</tr>
<tr>
<td>3 (n = 14)</td>
<td>-0.11</td>
<td>0.7</td>
<td>-0.05</td>
<td>0.8</td>
<td>0.47</td>
<td>0.09</td>
</tr>
<tr>
<td>4 (n = 27)</td>
<td>0.14</td>
<td>0.4</td>
<td>0.10</td>
<td>0.6</td>
<td>-0.01</td>
<td>0.9</td>
</tr>
</tbody>
</table>

CPT, center point thickness; CFT, center field thickness; VA, visual acuity.

* Spearman rho.

**Discussion**

The correlation between the anatomic and visual acuity changes 3 weeks after focal photocoagulation was low. Most anatomic modifications were located in ranges considered as measurement variables or were not statistically significant.

It is expected that macular edema would decrease clinically 3 weeks after treatment. Biomicroscopy finds a partial reduction of the thickness and, occasionally, new exudates as a result of the removal of the fluid component of the edema. The decrease of macular volume, that represents the entire macula, indicates that the edema has been reduced. In the sample this decrease was clinically significant 3 weeks after the treatment (>3%).

Although the decrease of the macular volume showed the effectiveness of the treatment to reduce the thickness, average visual acuity did not change statistically. Visual acuity increased in 46.8% of the eyes studied, but the macular volume decreased significantly only in 40.5% of eyes whose vision improved.

Visual recovery was more frequent in groups 1 and 2 (with visual acuity <0.5, 16/25, \(p < 0.001\), RR 3.0, 95% CI
The response of the center point thickness also varied between groups, a characteristic that has been previously described, although its contribution to the correlation with the change of visual capacity had not been analyzed. Using optical coherence tomography, Shimura et al. identified that scatter photocoagulation increased the center point thickness, and 2 weeks after treatment, Sandhu et al. found a significant reduction in retinal thickness at the site of photocoagulation, but not in the center point thickness. In the groups without baseline involvement of the center point (2 and 4), center point thickness significantly increased after treatment. In group 4, the macular volume was minimally affected by the increase in the center point thickness, so the latter may not interfere in reaching the goal of reducing edema.

1.4-6.2), and visual loss in groups 3 and 4 (with visual acuity ≥0.5, 11/26, \( p = 0.04 \), RR 2.6, 95% CI 0.96-7.2). These results are consistent with those reported by the ETDRS where eyes with visual acuity <20/40 had a greater probability of presenting visual improvement. The proportion of improvement in group 2 requires further evaluation because 52% of the eyes showed center point thickening after treatment; therefore, the absence of this characteristic is insufficient to explain the functional outcome.

In the groups with greater reduction in volume, visual outcome was different: group 2 had the highest proportion of visual improvement (75%). In group 3 there was no visual improvement and this group had the highest proportion of visual loss (62.5%), opposite to the expected result.

The proportion of improvement in group 2 requires further evaluation because 52% of the eyes showed center point thickening after treatment; therefore, the absence of this characteristic is insufficient to explain the functional outcome.

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**Figure 2.** Dispersion graph between percentage changes of center point thickness and visual acuity in the groups. cpt, center point thickness, va, visual acuity, ○ paradoxical response.
Anatomic-functional correlation in diabetic macular edema

The center point thickness, center field thickness and macular volume most commonly increased in eyes without prior center point thickening than in the eyes with it. The correlation of the changes of the central point and of visual acuity had the expected result only in group 1; the correlations in groups 2 and 4 had an opposite direction to group 1 according to the increase of the center point thickness found in eyes without prior center point thickening.

The proportion of eyes whose visual acuity improved did not differ between the groups with and without prior center point thickening, because there were responses which the DRCR.net calls paradoxical visual: improvement on the face of an increase of the center point or visual loss in the presence of a decrease in center point thickness or of macular volume. This type of change of the center point thickness was more frequent in group 2 than in the remaining groups \((p = 0.02, \text{RR 1.76, 95\% CI 1.12-2.75})\). The frequency of paradoxical changes of the macular volume was low in groups 1 and 2 (18 and 24\%, respectively), but surpassed one third of the cases in group 4 (37\%) and two thirds in group 3 (71\%). The proportion of eyes with this response was greater if the prior visual acuity was \(\geq 0.5\) (48.8 vs. 21.1\%, \text{RR 2.32, 95\% CI 1.16-4.62}). When these eyes had center point involvement, the majority presented visual loss even if the macular volume decreased.

Figure 3. Dispersion graph between changes of center field thickness and visual acuity in the groups. cft, center field thickness; va, visual acuity, ○paradoxical response.
Various studies have found correlation values above 0.3 between the changes of center point thickness and visual acuity, but have evaluated eyes with diffuse and cystoid edema whose center point thickness modifies the slope. The ranges of center point thickness reported by Alkuraya et al.\(^1\) (230-720 µm), Okada et al.\(^2\) (210-1052 µm), Maalej et al.\(^3\) (235-1056 µm), and Kakinoki et al.\(^4\) (203-712 µm) are above those of the present sample (127-238 µm); in the study of the DRCR.net,\(^5\) 45% of the eyes had a center point thickness ≥300 µm.

All eyes in the present study had biomicroscopic characteristics of CSME, focal or multifocal filtration on angiography with fluorescein and diffuse thickening on optical coherence tomography. Patients with diffuse leakage, cystoid thickening or vitreous traction whose center point thickness values were above those in this sample were not evaluated.

It has been reported that the retinal thickness of diabetic patients with macular edema and renal insufficiency decreases after a dialysis procedure, which

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**Figure 4.** Dispersion graph between percentage changes of macular volume and visual acuity in the groups. va, visual acuity; ○paradoxical response.
Anatomic-functional correlation in diabetic macular edema

could represent a confounding variable.\textsuperscript{23,24} None of the patients in the study sample had dialysis treatment during the evaluation period; although patients with renal insufficiency who require treatment with dialysis could present focal edema, it is common that they have diffuse edema and that their retinal thickness surpasses that of the sample.

Preoperative correlation between visual acuity and center point thickness in the sample was low as a result of the distribution of the former in a range of center point thickness between 150 and 300 µm ($r = -0.06$). The correlation between the modifications of the variables was low in each group and the differences between groups resulted in a low correlation between the changes of the sample ($r = 0.13$).

\textbf{Figure 5.} Dispersion graph between percentage changes of center point thickness, center field thickness, macular volume and visual acuity in the sample. cpt, center point thickness; cft, center field thickness; va, visual acuity; o, paradoxical response.
Nunes et al.\textsuperscript{8} reported that retinal thickness as measured by optical coherence tomography cannot be used in isolation as a reliable indicator of visual loss, because it represents a single component of the disease progression. Other factors such as the presence of ischemia and extent of thickening may contribute to visual loss; in addition, data of neural dysfunction prior to visual loss may be present, which will require future evaluation.

Regardless of the factors that modify the visual evolution after photocoagulation, the status of the center point prior to the procedure should be taken into consideration. In samples with a high proportion of eyes without center point thickening, the correlation between changes in the center point thickness and visual acuity would have a greater chance of being paradoxical due to the increase of the former that treatment may induce.

Subsequent evaluations of the response to photocoagulation could better identify contaminant and intervening variables if the evaluated samples are stratified according to the baseline center point and visual acuity.

In conclusion, the correlation of the changes in the center point thickness and visual acuity had opposite directions in eyes with and without prior center point thickening caused by different anatomic responses, which reduced the sample correlation between variables.

References