Longitudinal Changes in Retinal Nerve Fiber Layer Thickness after Vitrectomy for Rhegmatogenous Retinal Detachment

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PURPOSE. To investigate the longitudinal changes in retinal nerve fiber layer (RNFL) thickness after pars plana vitrectomy for rhegmatogenous retinal detachment.

METHODS. This prospective study examined 33 vitrectomy patients who were diagnosed with rhegmatogenous retinal detachment. Optical coherence tomography was conducted 6, 12, and 24 months after vitrectomy to investigate the changes in RNFL thickness. The RNFL thickness in the retinal detached area of the affected eye was compared with its mirror image in the fellow eye.

RESULTS. The respective RNFL thickness in retinal-detached area and its mirror image in the fellow eye was 120.7 ± 13.5 µm and 124.7 ± 21.5 µm at 6 months following vitrectomy (P > 0.05); 114.1 ± 19.6 µm and 124.0 ± 16.6 µm at 12 months (P < 0.05); and 107.5 ± 17.2 µm and 123.8 ± 14.3 µm at 24 months (P < 0.05). A significant difference was detected between the RNFL thickness in the detached area and the fellow eye after 12 and 24 months. The difference in the RNFL thickness in the area of undetached retina in the affected eye and its mirror image in the fellow eye during follow-up did not differ significantly (P > 0.05).

CONCLUSIONS. In patients undergoing vitrectomy for rhegmatogenous retinal detachment, the RNFL was significantly thinner in the area of the detached retina than in the fellow eye 12 and 24 months postoperatively. (Invest Ophthalmol Vis Sci. 2012; 53:5471–5474) DOI:10.1167/iovs.12-9782

Rhegmatogenous retinal detachment is characterized by the presence of a retinal break held open by vitreoretinal traction, which allows the accumulation of liquefied vitreous under the neurosensory retina, separating it from the retinal pigment epithelium (RPE). Retinal detachment involving the macula can cause irreversible visual loss, which can be permanent despite reattachment of the detached retina. With modern diagnostic and surgical techniques, the success of detachment repair is >90%.1,2 Nevertheless, the rate of return of central visual acuity falls short of the success rate of detachment repair, with the return of central visual acuity of 20/50 or better ranging from 42% to 60%.3–5

Animal studies have shown the rapid disorganization and subsequent loss of photoreceptor cells after retinal detachment.5–9 Photoreceptor degeneration is accompanied by marked loss of ganglion cell axons, which cause ganglion cell layer degeneration.10

Few studies, however, have examined the influence of retinal detachment on the retinal nerve fiber layer (RNFL). Ozdek et al.11 have reported the effect of retinal detachment on RNFL thickness by using scanning laser polarimetry after successful sclera buckling surgery for the treatment of rhegmatogenous retinal detachment and concluded that the retinal detachment seemed to cause minimal or no change in RNFL thickness.

Imaging methods used to assess RNFL thickness include scanning laser polarimetry, confocal laser scanning ophthalmoscopy, and optical coherence tomography (OCT). OCT is a noninvasive examination using low-coherence interferometry that gives high-resolution RNFL cross-sectional images. Since OCT is based on near-infrared interferometry, it is affected less by refractive status, the axial length of the eye, nuclear sclerotic cataract density, and media opacity. Consequently, it is widely used to measure RNFL thickness in glaucoma and other optic neuropathies.12

As no longitudinal, prospective studies have examined the effect of retinal detachment on RNFL thickness using OCT, we evaluated this condition in patients who underwent vitrectomy for rhegmatogenous retinal detachment.

METHODS

Patients

This was a prospective cohort study. The protocol was approved by the institutional review board of Chungnam National University Hospital. All participants gave informed consent and the study adhered to the tenets of the Declaration of Helsinki.

The participants were 33 patients who visited Chungnam National University Hospital from January 2007 to December 2007, underwent vitrectomy for rhegmatogenous retinal detachment, and were followed up for 2 years after surgery. Patients with phakic eyes were included only when they underwent vitrectomy with cataract surgery. Patients were excluded if they had retinal disease other than rhegmatogenous retinal detachment, an intraocular pressure (IOP) greater than 22 mm Hg during follow-up, a history or family history of glaucoma, optic neuropathy that could be associated with abnormal RNFL during follow-up, visual acuity of 0.1 or lower, myopia of 6 diopters (D) or higher, or cerebrovascular disease.
Study Protocol

The baseline assessments included the uncorrected visual acuity, best corrected visual acuity with a Snellen chart, IOP measurement, slit lamp examination, funduscopy, fundus photography, and OCT tests. The tests were repeated 6, 12, and 24 months after surgery.

Pars Plana Vitrectomy

All of the surgical procedures were performed by a single surgeon (J.-Y. Kim) under general or local anesthesia. Following a peritomy, three 20-gauge sclerotomies were created in the pars plana of the ciliary body 3.5 mm from the corneal limbus. Surgery was performed by using a vitrectomy machine (ACCURUS Surgical System; Alcon Laboratories, Fort Worth, TX). A wide-field visualization system (Mini Quad XL; Volk Optical, Mentor, OH) was used. As much of the peripheral vitreous as possible was removed by performing scleral depression on the area over the entire 360°. Simultaneously, the traction in the area adjacent to the retinal break was removed. Following fluid-air exchange, perfluorocarbon liquid was infused until it filled the area posterior to the retinal break. In a preexisting retinal break, using a backflush tip, intraocular-subretinal fluid drainage was performed. Following removal of the perfluorocarbon liquid, intraocular laser retinopexy was done for the areas adjacent to the retinal break. If there was a cataract, the cataract was extracted concomitantly. Before the vitrectomy, through a 2.8-mm clear cornea incision, phacoemulsification was carried out. Following the vitrectomy and fluid-air exchange, posterior chamber IOL implantation was performed. Following air-gas exchange with SF6 or C3F8, the sclerotomy was sutured. Scleral buckling was not performed in any case.

Optical Coherence Tomography

OCT was conducted by one experienced operator using a Stratus OCT3 (Carl Zeiss Meditec, Dublin, CA) with pupil dilation 6, 12, and 24 months after surgery. The RNFL thickness was measured with the fast RNFL thickness map protocol. The 3.4-mm-diameter circle surrounding the optic disc was examined. The RNFL was divided into 12 equal parts (Fig. 1). The respective RNFL thickness in the area of detached retina and its mirror image in the fellow eye was 120.7 ± 24.0 μm at 6 months following vitrectomy. It filled the area posterior to the retinal break. In a preexisting retinal break, using a backflush tip, intraocular-subretinal fluid drainage was performed. Following removal of the perfluorocarbon liquid, intraocular laser retinopexy was done for the areas adjacent to the retinal break. If there was a cataract, the cataract was extracted concomitantly. Before the vitrectomy, through a 2.8-mm clear cornea incision, phacoemulsification was carried out. Following the vitrectomy and fluid-air exchange, posterior chamber IOL implantation was performed. Following air-gas exchange with SF6 or C3F8, the sclerotomy was sutured. Scleral buckling was not performed in any case.

Statistical Analysis

Statistical analyses were conducted with SPSS (version 12.0; SPSS Inc., Chicago, IL). The RNFL thickness in the affected and fellow eyes was compared by using a paired t-test. The RNFL thickness 6, 12, and 24 months postoperatively was compared by using analysis of variance (ANOVA). A P value <0.05 was considered to indicate statistical significance.

Results

Sixty-five patients underwent vitrectomy with rhegmatogenous retinal detachment. Thirty-two patients with myopia of 6 D or higher, visual acuity of 0.1 or lower, and less than 2 year follow-up were excluded. The 33 patients in this study included 18 men (55%) and 15 women (45%). The mean patient age was 54.7 ± 20.8 years (range, 18–77 years). Eleven patients were pseudophakic. Preoperatively, the area of retinal detachment was less than half in 19 of the 33 patients and more than half in 14 patients (Table 1).

Total Retinal Area

The RNFL thickness in the affected and fellow eyes was compared. While the difference was not significant between the two eyes at 6 months, it was significant at 12 months and 24 months (Table 2).

Detached Area

The respective RNFL thickness in the area of detached retina and its mirror image in the fellow eye was 120.7 ± 13.5 μm and 124.7 ± 21.5 μm at 6 months following vitrectomy (P > 0.05); 114.1 ± 19.6 μm and 124.0 ± 16.6 μm at 12 months (P < 0.05); and 107.5 ± 17.2 μm and 123.8 ± 14.3 μm at 24 months (Table 2).

Table 1. Patient Demographics (n = 33)

<table>
<thead>
<tr>
<th>Age, x, mean ± SD</th>
<th>54.7 ± 19.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male:female</td>
<td>18:15</td>
</tr>
<tr>
<td>Macula (on-off)*</td>
<td>9:24</td>
</tr>
<tr>
<td>OD:OS</td>
<td>20:15</td>
</tr>
<tr>
<td>Phakic:pseudophakic</td>
<td>22:11</td>
</tr>
<tr>
<td>Type of break</td>
<td></td>
</tr>
<tr>
<td>Horseshoe tear</td>
<td>16</td>
</tr>
<tr>
<td>Round hole</td>
<td>17</td>
</tr>
</tbody>
</table>

*Macula on" means that macular region 6000 μm in diameter was not detached on OCT.

Table 2. Change in the Mean RNFL Thickness as Measured with OCT in the Affected and Fellow Eyes for the Total Retinal Area (n = 33)

<table>
<thead>
<tr>
<th></th>
<th>Affected Eye</th>
<th>Fellow Eye</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(μm ± SD)</td>
<td>(μm ± SD)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>113.9 ± 13.5</td>
<td>115.5 ± 20.8</td>
<td>0.37</td>
</tr>
<tr>
<td>12 months</td>
<td>108.8 ± 15.1</td>
<td>116.1 ± 12.8</td>
<td>0.04</td>
</tr>
<tr>
<td>24 months</td>
<td>104.5 ± 14.2</td>
<td>114.8 ± 10.4</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* Paired t-test.
months ($P < 0.05$). A significant difference was detected between the RNFL thickness in the area of detached retina and its mirror image in the fellow eye after 12 and 24 months (Table 3).

**Undetached Area**

The respective RNFL thickness in the area of undetached retina and its mirror image in the fellow eye was 104.1 ± 20.0 μm and 105.2 ± 18.1 μm at 6 months following vitrectomy ($P > 0.05$); 103.5 ± 15.2 μm and 104.6 ± 14.7 μm at 12 months ($P > 0.05$); and 103.5 ± 17.8 μm and 105.0 ± 13.5 μm at 24 months ($P > 0.05$). The difference in the RNFL thickness in the area of undetached retina in the affected eye and its mirror image in the fellow eye during follow-up did not differ significantly ($P > 0.05$) (Table 4).

**Longitudinal Changes in RNFL Thickness in Affected Eye**

RNFL thickness of total area and detached area was decreased as time went by and it was statistically significant (Fig. 2).

**DISCUSSION**

With modern diagnostic and surgical techniques, the success rate of detachment repair exceeds 90%. Although the anatomic success rates are high, the functional improvement in vision remains disappointing, even if the macula is reattached. Tani et al. have reported that although 96% (100/104) of the primary detachments are repaired successfully with the initial surgery, the return of central visual acuity of 20/50 or better is 37%. The discordance between the anatomic success and functional improvement in vision reflects the histologic changes in the detached retina. Many studies have examined the effect of retinal detachment on the histology of the retina.8–16

The main problem is the loss of nutrition by the outer segments of the retina during retinal detachment, which causes the first visible pathologic changes in the outer segments of the photoreceptors; the outer segments and synaptic terminals of the photoreceptors degenerate, as do the photoreceptor bodies in the outer nuclear layer. The effects of retinal detachment on the RPE cells are partial dedifferentiation, proliferation, and migration to the subretinal area.8,10,17

While many studies have focused on the outer retina, few have examined the inner retinal layers. Lewis et al. have reported lengthening of the horizontal and bipolar cell processes after retinal detachment. Faude et al. have found that the photoreceptor degeneration is accompanied by a considerable loss of ganglion cell axons, and the degeneration of many ganglion cells, in the inner layers of the detached retina. Coblentz et al. have reported the overexpression of protein in the ganglion cells of the detached retina, which is downregulated in normal ganglion cells in an experimental model of retinal detachment. This results in cellular remodeling in the ganglion cell. While most effects of detachment have been explained by effects on photoreceptors, their data strongly suggest that effects beyond the photoreceptors at the level of ganglion cell play a role in some of the visual changes that occur.

Few studies have examined the effect of retinal detachment on RNFL thickness. As mentioned in the introduction, Ozdek et al. have concluded that retinal detachment seems to cause minimal or no change in RNFL thickness. Similarly, we found no significant difference between RNFL thickness in the area of detached retina and its mirror image in the fellow eye after 6 months. While they have evaluated the RNFL thickness only once, 6 months after surgery, we evaluated it 6, 12, and 24 months after surgery. While no significant difference was detected between the RNFL thickness in the area of detached retina and its mirror image in the fellow eye 6 months after surgery, significant decreases occurred at 12 and 24 months.

![Figure 2. Longitudinal changes in the RNFL thickness of the affected eye. *$P < 0.05$ by ANOVA. †RNFL.](image-url)
We postulate that the RNFL thickness in the area of detached retina and its mirror image in the fellow eye are similar within 6 months because of postoperative edema or Müller cell proliferation, while the RNFL thickness subsequently differs because of anterograde degeneration of the second and third neurons in the area of detached retina.

In other words, atrophy of retinal ganglion cell layer occurs with gradual histologic change in the retina, resulting in a gradual decrease in RNFL thickness. Within the initial 6 months, the difference in RNFL thickness in the area of detached retina and its mirror image in the fellow eye is not significant because the change is not big enough owing to postoperative edema or Müller cell proliferation, but the difference grows as atrophy progresses over time.

To exclude the influence of vitrectomy on the RNFL, we compared the RNFL thickness in the area of undetached retina in the affected eye and its mirror image in the fellow eye. The difference was not significant. Therefore, vitrectomy itself does not affect RNFL thickness.

Our study had some limitations. First, it included a small number of patients. Second, although it was a long-term study, following up the subjects for 2 years, it had a limited ability to determine the long-term pattern of the changes in RNFL thickness. To overcome this limitation, prospective long-term studies with more subjects are necessary. Examining the effect of thinning of the RNFL on patients is also necessary.

In conclusion, retinal detachment causes thinning of the RNFL over time. This may be one of the clinical evidence that support the previous report, which suggests the degeneration of inner layers as well as outer layers of the retina in an experimental model of retinal detachment. Also, retinal detachment as well as glaucoma and optic neuropathy could be cause of RNFL thinning.

References