Effect of Neural Vision therapy on uncorrected pseudophakic visual acuity

Krishna Vaitheeswaran (krish704@gmail.com)
Ikshana Nethralaya

Preetinder Kaur
Ikshana Nethralaya

Monika Nadar
Ikshana Nethralaya

Research Article

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Abstract

Purpose

The present study was conducted to investigate the effect of neural vision therapy using perceptual learning on near and distance visual acuity in pseudophakic patients with mono-focal intraocular lenses.

Methods

The prospective interventional non-comparative study was conducted on 30 pseudophakic patients who had received mono-focal intraocular lenses and required corrective lenses for optimal visual acuity for distance, near or both. Perceptual learning was performed using Gabor gratings of varying spatial frequency and contrast. The distance and near visual acuity as well as contrast sensitivity was assessed before and after the training. The visual function was monitored for a period of three months after intervention.

Results

The mean age of patients in the study was 68.6 ± 11.05 years and included 16 women and 14 men. There was a significant improvement in distance (0.15 ± 0.13 to 0.05 ± 0.06) and near visual acuity (0.4 ± 0.09 to 0.09 ± 0.07) as well as contrast sensitivity function after the intervention (1.35 ± 0.24 to 1.83 ± 0.13). (P < 0.05).

Conclusions

Neural vision therapy using perceptual learning, significantly improved distance and near acuity, as well as contrast sensitivity in pseudophakic patients. With no alteration in the refractive status, perceptual training improved visual function by enhancing neural processing at low signal-noise ratios seen in uncorrected pseudophakic eyes. Neural vision therapy may be an alternative for enhancing visual function across a range of distances without the need for corrective lenses.

Introduction

Good distance acuity is a realistic expectation after cataract surgery today[1]. However, spectacle free near and intermediate visual improvement requires modified interventions such as the use of multifocal and extended depth of focus lenses[2, 3] or mono-vision strategies[4].

Neural vision therapy using perceptual learning is a process of learning skills of perception which may range from a simple sensory discrimination to complex categorizations of spatial and temporal patterns[5].
The improvement in visual performance after training has been well established and though usually task specific[6], generalizes for complex tasks[7]. Training to improve a fundamental function may contribute to enhance performance along a wide range of more complex functions. This may be functionally utilized for improving visual resolution across a range of depth[8–11].

The present case series describes the visual results following neural vision therapy with perceptual training using varying contrast Gabor gratings in patients with reduced vision.

**Patients and Methods**

The study was a prospective study on 30 pseudophakic patients who received neural vision therapy using perceptual learning. The research was performed according to the tenets of the declaration of Helsinki after institutional board review and ethics committee clearance. Informed consent was taken from all participants.

The visual results of 30 patients who underwent neural vision therapy using varying contrast Gabor gratings after cataract surgery were evaluated.

All patients had uncomplicated cataract surgery using monofocal hydrophobic foldable lenses with stable visual function with refractive correction for at least 6 months prior to the commencement of the study. All patients required corrective lenses for near and intermediate tasks. A baseline examination of visual function was performed consisting of unaided visual acuity at distance and near, refraction and contrast sensitivity. Visual acuity was measured using LogMAR charts and the contrast sensitivity was measured using the Pelli Robson chart.

Perceptive learning sessions were commenced using Gabor gratings with varying contrast (100% contrast to 1%). The spatial frequency of the target was increased as the session progressed. Flankers for peripheral stimulation were employed using Gabor gratings surrounding the target. The distance and number of these flankers were varied with the separation being reduced progressively as training progressed.

Each session, lasting 30–40 minutes consisting of eight blocks of 150 trials each. In all, 8000 trials were given over seven sessions in three weeks for each patient. No alterations in orientation of presentation was used for patients with astigmatism. This technique has been previously described by the authors[12].

The visual acuity, distance and near, contrast sensitivity were evaluated at each visit using the same charts as the pre-intervention evaluation and the final visual status compared with that of the postoperative pre-intervention status.

Post intervention the visual function was monitored for a period by regular follow-up for 3 months.
The average age of the patients in the study was 68.6 ± 11.05 years. There were 16 females and 14 males in the study.

The preoperative characteristics are summarized in Table 1.

<table>
<thead>
<tr>
<th>SNo</th>
<th>Characteristic</th>
<th>Median</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age (years)</td>
<td>68</td>
<td>68</td>
<td>11.05</td>
<td>48–89</td>
</tr>
<tr>
<td>2</td>
<td>Preoperative distance vision (LOGMAR)</td>
<td>0.1</td>
<td>0.15</td>
<td>0.13</td>
<td>0-0.5</td>
</tr>
<tr>
<td>3</td>
<td>Preoperative Near Vision (LOGMAR)</td>
<td>0.4</td>
<td>0.37</td>
<td>0.09</td>
<td>0.2–0.6</td>
</tr>
<tr>
<td>4</td>
<td>Contrast Sensitivity</td>
<td>1.35</td>
<td>1.41</td>
<td>0.24</td>
<td>1.05–1.65</td>
</tr>
</tbody>
</table>

The mean preoperative uncorrected distance visual acuity was 0.15 ± 0.13 (Range 0-0.5 LogMAR). The uncorrected near visual acuity was 0.37 ± 0.09 (Range 0.2–0.6 LogMAR). The preoperative contrast sensitivity was 1.41 ± 0.24 (Range 1.05–1.65). None of the patients used the pre-intervention prescribed refractive correction for distance or near.

All patients were followed up for 3 months and the visual function at the end of this period was collated and analysed.

No change in the refractive status of the patients was noted after the intervention.

There was no drop in uncorrected vision in any of the patients during the follow up period.

The post-intervention characteristics and change statistics are summarized in Table 2.

<table>
<thead>
<tr>
<th>SNo</th>
<th>Characteristic</th>
<th>Pre-intervention (mean)</th>
<th>Post-intervention (mean)</th>
<th>Change (mean)</th>
<th>p value</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distance Acuity (LOGMAR)</td>
<td>0.15 ± 0.13</td>
<td>0.05 ± 0.06</td>
<td>0.09 ± 0.11</td>
<td>0.0009</td>
<td>Significant</td>
</tr>
<tr>
<td>2</td>
<td>Near Acuity (LOGMAR)</td>
<td>0.4 ± 0.09</td>
<td>0.09 ± 0.07</td>
<td>0.28 ± 0.09</td>
<td>0000</td>
<td>Significant</td>
</tr>
<tr>
<td>3</td>
<td>Contrast Sensitivity</td>
<td>1.35 ± 0.24</td>
<td>1.83 ± 0.13</td>
<td>0.42 ± 0.19</td>
<td>0000</td>
<td>Significant</td>
</tr>
</tbody>
</table>
Wilcoxon rank sum test was performed on the parameters. A significant improvement in the uncorrected distance (Fig. 1) and near acuity (Fig. 2) as well as the contrast sensitivity was noted after the neural vision therapy using perceptual learning ($p < 0.001$). The change was more marked for near visual acuity than distance acuity ($p << 0.001$) (Fig. 3).

**Discussion**

Perceptual learning has been shown to enhance visual function in a variety of ocular disorders presenting with optical blur by increasing the efficiency of neural processing [10–12]. The present study describes the effect of perceptual learning on the postoperative visual function after cataract surgery with implantation of a mono-focal intraocular lens.

Blur adaptation has been proposed as the mechanism of the action of perceptual learning [13]. However, being a transient phenomenon, adaptation to blur may not be entirely responsible for the beneficial effect on a long term. The enhancement of neural sensitivity so as to enable image processing at low signal-noise ratios has been proposed and may account for the improvement following perceptual learning [11, 12]. Blur detection and discrimination of single blurred edges have been demonstrated to be contrast detection tasks [14] and improvement of contrast detection through perceptual learning may enhance the processing of blurred images. Contrast sensitivity improved in all patients who underwent perceptual learning in this study.

Gabor gratings are sinusoidal gratings with a gaussian envelope, which can be varied in contrast, spatial frequency, size, orientation and phase as also background contrast. The present study utilized flankers at varying distances from the target. These flankers were brought closer to the target as training progressed and resolution improved. The use of flankers at different distances from the target has been proposed to modify lateral interactions and improve crowding [14, 15]. These improvements in lateral interactions may improve resolution of letters and objects through an enhanced range of depth. Visual acuity is improved both for distance and for near with a lower dispersion of acuity regardless of distance.

The study describes the use of Gabor gratings of varying contrast and spatial frequency with flankers for perceptual training. This enhanced both blur discrimination by enhanced contrast detection and reduced effects of crowding due to alterations in the lateral interactions of neurons involved in image processing. Clinically both may have contributed to a better visual function across a range of distance. The improvement in resolution even in patients with astigmatism without use of customized orientation patterns demonstrates a top down effect of the training using varying contrast gratings in the first order refractive error.

The case study illustrates the beneficial effect of perceptual learning in the postoperative period after cataract surgery to improve visual function including near vision. The patients had improved distance and near acuity with enhanced range of perception despite having been implanted with monofocal lenses. No alteration in refractive correction was induced by the therapy.
Conclusions

Neural vision therapy appears to improve vision as well as depth of focus in patients without impacting the refractive error. This is the first reported use of perceptual learning tasks to improve vision as part of post-cataract rehabilitation. The promising results of this limited study needs to be replicated and assessed for perceptual alterations in the presence of documented higher order aberrations as well as its effects on scotopic function. The use of intensive perceptual learning based neural vision therapy also needs to be evaluated in refractive errors and presbyopia, in addition to disorders of visual development such as amblyopia and in neuro-visual rehabilitation.

Declarations

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Competing interest statement: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References


Figures

![Uncorrected Distance Visual Acuity (LOGMAR), pre & post intervention](image)

**Figure 1**

Pre and Post intervention Distance acuity in LOGMAR
Figure 2

Pre and post intervention near acuity in LOGMAR
Figure 3

Change in Acuity after intervention, distance versus near