Effect of Visual Sensory Improvement by Amblyopia Treatment on Improvement of Ocular Functions

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Purpose: This study is to investigate if the improvement of visual sensory (VS) by amblyopia treatment affects the ocular functions in refractive errors, accommodative errors and phoria at distance and near.

Methods: 10 subjects (17 eyes, mean age of 10.7 ± 2.9 years) who treated amblyopia completely, were participated for this study. Refractive errors, accommodative errors, and distance and near phoria were compared between before and after treatments of amblyopia. Refractive errors and accommodative errors at 40 cm were measured using open-field auto-refractor (NVision-5001, Shin Nippon, Japan) and using monocular estimated method (MEM) respectively. Phoria was determined at 3 m for distance and at 40 cm for near using Howell phoria card, cover test or Maddox rod.

Results: Mean corrected visual acuity (CVA) significantly increased from 0.46 ± 0.11 (decimal notation) for before amblyopia treatment to a level of 1.03 ± 0.13 for after amblyopia treatment (p < 0.001). For spherical refractive error, hyperopia significantly decreased from +2.29 ± 0.86 D to a level of +1.1 ± 2.38D (p < 0.05) but astigmatism did not significantly change; −1.80 ± 1.41D for before treatment and −1.65 ± 1.30D for after treatment (p > 0.05). Accommodative error significantly decreased from accommodative lag of +1.1 ± 0.75D to a level of +0.5 ± 0.59D (accommodative lag) (p < 0.05). Distance phoria significantly changed from eso 2.9 ± 6.17PD (prism diopters) to a level of eso 0.2 ± 3.49 PD (p < 0.05), and near phoria also significantly changed from eso 0.4 ± 2.32PD to level of eso 2 ± 4.9 PD (p < 0.05). There was a high correlation (r = 0.88, p < 0.001) between improvement of visual acuity and decrease of accommodative lag.

Conclusions: Hyperopic refractive error decreased with improvement of CVA or VS by amblyopia treatment. And the improvement of VS by amblyopia treatment also improved accommodative error, and changed phoria coupled with accommodation.

Key words: Amblyopia, Visual sensory, Ocular functions, Refractive error, Accommodation, Phoria

Introduction

Human’s ocular functions rapidly develop over the few months of life under normal condition. Visual acuity grows from about 20/330 at 1 month old to 20/19 at 5 years old. Accommodation response also improves with increase of age. Haynes et al. reported that before 1 month of age, it showed poor accommodative response to the changing accommodative stimulus and wide range of accommodative response levels was observed, ranging from approximately 3.5 D to 8.75 D. The flexibility of the response improves with increase of age and adult-like response is achieved by 4 months of age. Banks noted three changes with increase of age, namely an increase in the gradient of the stimulus-response function, a decrease in variability within same age group, and decline in the mean accommodative error.

Infants have the ability to converge and diverge in the appropriate direction as early 1 month of age, but they cannot consistently converge to near targets until 2 months age. Moreover, the ability to response appropriately to faster target motion so increases with age increases. Even through under the normal vision condition, ocular functions such as visual acuity, accommodation and eye movement change with increase of age, any visual deprivation for obstacle during early age have an extremely detrimental effect upon

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The most common outcome of abnormal visual experience in early age is sensory disorder or amblyopia which is lower corrective visual acuity. In addition to the lower sensory, previous studies have reported that amblyopia had lower ocular functions than normal vision. Amblyopia has been found to have longer reaction time than normal vision, increased visual evoked potential (VEP) latency, and deficits in velocity discrimination.

If we analogize a cause of lower ocular functions out of previous studies, we can have a result that lower sensory influence on low ocular functions. Banks also formulated 2 hypotheses for mechanism of accommodative development, namely “motor hypothesis”, which is development in the motor component of the accommodative control system accounts for the infant developmental changes observed with his study, and “sensory hypothesis” which programming of accurate accommodative response is dependent on the detection of the consequences of inaccurate accommodation. However, it still remains a question whether there are correlations between sensory and motor in ocular functions of accommodation and phoria. So this study is to investigate using a novel method whether improvement of visual sensory by amblyopia treatment affects ocular functions or not.

Subjects and Methods

10 subjects (17 eyes) (mean age of 10.7 ± 2.9 years) who have treated amblyopia completely, were participated for this study. Amblyopes were 7 subjects for both eyes amblyopia and 3 subjects for one eye amblyopia. Refractive errors, accommodative errors, and distance and near phoria were compared between before and after treatments of amblyopia. For the treatment of amblyopia, it was prescribed with near addition lenses (NAL) to make non-accommodative lag measured by monocular estimated method (MEM) in amblyopic eye, and with NAL to make 0.50 D of accommodative lag in normal eyes. Subjects were asked wearing near glasses for reading at near. Total period of amblyopia treatment was 50 ± 20 months (about 4 years). Refractive errors and accommodative errors at 40 cm were measured using open-field auto-refractor (NVision-5001, Shin Nippon, Japan) and MEM respectively. Phoria was determined at 3 m for distance and at 40 cm for near using Howell phoria card, cover test or Maddox rod. Howell phoria card was used for subjects who phoria could be measured with Howell card, otherwise Maddox rod or cover test was used.

Results

Corrected visual acuity of pre- and post-treatments of amblyopia showed in Fig. 1. Mean corrected visual acuity (CVA) was significantly increased by 0.46 ± 0.11 (decimal notation) for before amblyopia treatment to a level of 1.03 ± 0.13 for after amblyopia treatment (paired t-test, p < 0.001). For spherical refractive error, hyperopia significantly decreased by +2.29 ± 0.86D to a level of +1.1 ± 2.38D (paired t-test: p < 0.05) but astigmatism did not significantly changed; −1.80 ± 1.41D for before treatment and −1.65 ± 1.30D for after treatment (paired t-test: p > 0.05).

Fig. 2 shows accommodative lag at 40 cm of pre-treatment and post-treatment. Accommodative lag significantly decreased by +1.1 ± 0.75D to a level of 0.5 ± 0.59D (paired t-test: p < 0.00). This result means that eyes of post-treatment with distance correction can see clearer than eyes of pre-treatment.

Fig. 3 shows correlation between change of visual acuity and accommodative lag.