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Research Article

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Impact of Strabismus Management on the Retinal Microstructure

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Abstract

To examine whether change in retinal structure can improve vision and stereoacuity following strabismus management

Keywords: Retinal nerve fiber layer (RNFL), SD-OCT, CMT

Intruduction

A crucial dimension of vision is stereoacuity [1, 2, 3]. It is a vital type of binocular vision responsible for depth perception [2]. In aniseikonia, stereoacuity is affected [4]. Stereopsis is absent in strabismus [5, 6] and refractive errors [7, 8]. Numerous factors affect stereopsis including literacy, poor vision, age, amblyopia, and deprivation [9, 10]. Stereoacuity can be improved by treating its cause including refraction, strabismus, or cataract [11, 12, 13].

This study explored whether strabismus management can improve alignment. The aligned eye may exhibit improved stereopsis and thus binocular vision (ref). We explored the association of functional improvement with retina structure changes. We evaluated whether functional improvement leads neuroanabolism.

Methods

Both the study protocol and informed consent form were approved by the Hospital Ethical Committee of Drashti Netralaya and were according to the guidelines of the Helsinki Declaration. We obtained written informed consent from the legal guardian or parents of each child, and each patient provided consent before study participation. This prospective cohort study recruited patients visiting the motility department who were diagnosed as having strabismus requiring surgical correction from 2018 to 2020. We excluded those with other pathology or neurological diseases that can affect the retinal nerve fiber layer (RNFL), optic nerve head (ONH), or central macular thickness (CMT).

All patients received comprehensive eye assessments, which included slit lamp biomicroscope or handheld slit lamp evaluation for ocular alignment, A-scan ultrasound biometry, and tests for refraction and visual acuity (VA). Assessments were conducted under anesthesia in younger children who were unable to cooperate. We examined intraocular pressure by employing Perkins applanation tonometer. For children aged <3 years, monocular distance VA was tested. For nonverbal children, VA was examined based on a child's ability to fix and follow objects. Fixation was determined by examining each eye's ability to fixate on an object, maintain the fixation, and subsequently follow the object through varying gaze positions. Children aged 3–6 years were shown wall charts containing Snellen letters and numbers and subjected to the tumbling E test and HOTV as per the standard VA assessment. For

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children, single optotypes of ETDRS acuity charts with surrounding bars were presented. We examined cycloplegic refraction for all children.

An indirect ophthalmoscope with +20 D lens was employed to examine the posterior segment. We assessed near stereopsis using the Titmus circle (Titmus, Optical Co, Inc., Chicago, IL, USA) and the Randot circle (Stereo Optical Co). We examined distance stereopsis by employing the B-VAT II BVS contour circle of the Mentor B VAT II video acuity tester (Mentor O & O, Inc., Norwell, MA, USA). Motor and sensory adoption were assessed using various tests for all patients. All patients underwent surgery.

We measured distance stereopsis after strabismus and refractive error correction. An arc of 240 s was used with patients wearing liquid-crystal shutter glasses at a 6-m distance. A correct result indicated a successful test. However, for an incorrect result, patients were again shown the circle in different directions more than two consecutive times. If the patients obtained a correct result, they were administered next tests. However, in case of an incorrect result, patients were considered to have high stereopsis. If stereopsis was undetermined, previous steps were repeated again. When correct results were obtained for more than two consecutive times, we used the obtained result as the final finding. If 240 s were not perceived, patients were not included in statistical analysis. Moreover, we performed intraocular pressure and slit lamp, alternate prism cover, and fundus and refraction examinations.

All OCT measurements (Cirrus Spectral Domain OCT 4000; Carl Zeiss Meditec, Dublin, CA) were performed after dilating patients' pupils to at least 5-mm diameter. A single skilled ophthalmologist conducted all measurements. SD-OCT was employed to measure ONH parameters, central macular thickness (CMT), and RNFL. CMT is the average macular thickness in the 1-mm diameter in the center. The signal strength for all scans was set to six. Patients were followed on the postoperative third day, first month, second month, and third month and then every 6 months.

Patients with strabismus were followed on the third day postoperatively, first month, third month, and then every six months. Patients underwent comprehensive examination during each follow-up. All patients received stereoacuity tests and SD-OCT during all follow-up visits as a standard protocol. Details regarding patient characteristics, strabismus surgery, and HD-OCT were collected from hospital records. During follow-up visits, data were entered online using a pretested format and exported to an Excel spread sheet (Microsoft Corp.). Data were audited periodically to ensure complete data collection. Statistical analyses were conducted using SPSS (version 22.0; SPSS Inc., Chicago, IL, USA). Cross tabulation and descriptive statistics were employed to compare cause and effect among different variables. Differences in mean MCT values were observed using Student's t test and one-way ANOVA. The Pearson correlation was used to evaluate agreements between the variables. $P < 0.05$ indicated statistical significance.

Results

Our cohort comprised 54 patients (median: 20 years; mean age: 19.74 ± 9.26 years). Of the 54 patients, 25 (46.3%) were women and 29 (53.7%) were men (Table). The mean stereopsis was −700 ± 792.84 (median: 400) preoperatively and −573.15 ± 708.76 (median: 200; Table 2) postoperatively during the last visit. Of the 54 patients, 24 (44.4%) had amblyopia. Of the 54 patients, 25 (46.3%) were children. No significant differences were determined between the adult and pediatric populations for both eyes ($p = 0.069$ and $p = 0.303$, respectively).

Many other variables were comparable with the final postoperative RNFL value.

Table-1 Age and sex distribution

Age categories	Sex		Total
	Female	Male	
0-10	7	4	11
11-20	7	13	20
21-30	7	10	17
31-40	3	1	4
41-50	1	1	2
Total	25	29	54

Table-2 Mean values of central macular thickness and retinal nerve fibre thickness pre and post treatment for both eyes

Category	Mean	Std deviation	Median
Pre-operative central macular thickness od	226.49	39.59	226
Preoperative central macular thickness os	236.60	33.24	237.5
Pre-operative retinal nerve fibre thickness od	76.52	22.67	82
Pre-operative retinal nerve fibre thickness os	83.60	11.81	83.5
Final post-operative central macular thickness od	225.50	41.08	223.50
Final post-operative central macular thickness os	234.34	31.74	240
Final post-operative retinal nerve fibre thickness od	76.59	21.87	82
Final post-operative retinal nerve fibre thickness od	83.51	13.60	87

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Table-3 comparative study of central macular thickness and retinal nerve fibre thickness pre and post treatment for both eyes

Variable-1	Variable-2	P value	Significance
Pre-operative central macular thickness od	Final post-operative central macular thickness od	0.341	No
Pre-operative central macular thickness os	Final post-operative central macular thickness os	0.167	No
Pre-operative retinal nerve fibre thickness od	Final post-operative retinal nerve fibre thickness od	0.006	Yes
Pre-operative retinal nerve fibre thickness os	Final post-operative retinal nerve fibre thickness os	0.014	Yes
Pre-operative stereopsis	Final post-operative stereopsis	0.049	Yes
Prep bcva od	Final post-operative bcva od	0.000	Yes
Pre op bcva os	Final post-operative bcva os	0.000	Yes

Table-4 comparative study of other variables and retinal nerve fibre thickness pre and post treatment for both eyes

Variable-1	Variable-2	P value
Hirschberg test	RNFL OD,OS	0.363,0.313
Worth for dot test	RNFL OD,OS	0.472,0.108
Amblyopia	RNFL OD,OS	0.202,0.647
Nystagmus	RNFL OD,OS	0.153,0.151
Alternate deviation	RNFL OD,OS	0.000,0.003
Near point of Accommodation	RNFL OD,OS	0.000,0.000
Near point of Convergence	RNFL OD,OS	0.000,0.000
AC/A ratio	RNFL OD,OS	0.000,0.000
Presenting Stereopsis	RNFL OD,OS	0.927,0.645
Final stereopsis	RNFL OD,OS	0.705,0.058

Discussion

The results revealed improvements in stereopsis and vision following strabismus treatment. Moreover, mean RNFL but not CMT exhibited significant improvement after treatment. Stereopsis indicates the vision quality [1, 2, 3, 6, and 7]. Many conditions affect stereopsis in children [2, 6, and 7]. Many methods are available to examine stereopsis [14-17]. A study indicated interpersonal differences in stereopsis measurements [18]. Another previous study compared measurements obtained using different methods (18). Stereopsis affects performance in learning, catching, and literacy [19-23]. A study revealed that stereopsis can affect movements in older patients (24, 25). Moreover, stereopsis causes a reading deficiency [26, 27].

Improvement in stereoacuity following squint management was reported [28-31]. All strabismus types exhibited improvement including esotropia, accommodative esotropia, and exotropia; this result is similar to ours [28-31].

Here, we observed increases in RNFL following improved stereoacuity and vision. No study has demonstrated this improvement. This finding suggests neuroanabolism, which refers to functional improvements in affected retinal tissue structures. Studies have examined stereoacuity and retinal cellular structures [38, 39]. Many studies examined MCT in amblyopia [39-43]. A study revealed thickness changes in anisometropic amblyopia [44]. Araki et al observed the reversal of macular changes after amblyopia management but could not find any difference [45]. Okamoto et al found improved stereoacuity and retinal microstructure after macular hole surgery [46]. A study limitation is the inclusion of a small sample with a short follow-up.

Multicenter studies including individuals of different races and ethnicities should be conducted to establish this finding. Early improvement in strabismus can improve stereoacuity, thus resulting in structural improvement.

Conclusion

Functional improvement may be associated with structural improvement following stereoacuity correction and strabismus surgery.

Conflict of interest:

The authors report no conflict of interest.

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