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Corneal Wavefront Measurement in Amblyopic Patients

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Objective: To assess the corneal wavefront findings in amblyopic eye and compare it with normal eye of the same individual.

Method: A comparative cross-sectional study with sample of 30 subjects with one eye as amblyopic was taken. Age ranges from 5 to14 years. Females were 13 (43%) and males were 17 (57%). Corneal topography was done on each eye. The topography findings of normal eye was taken as standard for comparison with that of amblyopic eye in the same individual. Ziemer GALLIEI G2 was use for corneal topography. Low order aberration (defocus and astigmatism) and high order aberrations (trefoil, spherical and coma) were studied.

Results: There was a significant difference in third order vertical trefoil, third order vertical coma and 7th order aberration. In all the other aberration such as 2nd order aberration, 2nd order oblique astigmatism, 2nd order Defocus, 2nd Order Regular Astigmatism, 3rd order aberration, 3rd order horizontal coma, 3rd order horizontal trefoil, 4th order aberration, 4th order oblique quatrefoil, 4th order regular astigmatism, 4th order defocus, 4th order vertical astigmatism, 4th order regular quatrefoil, 5th order aberration, 6th order aberration and 8th order aberration there was no significant difference

Conclusion: There was significant difference in corneal aberrations between normal and amblyopic eyes.

Introduction:

Amblyopia is a disorder including whole visual system occurs during development in extra-striate cortex of visual pathway. It reveals as a decrease of visual acuity in eye which is amblyopic. Some other abnormalities of entire visual system e.g. contrast sensitivity and streopsis may also decrease. Amblyopia occurs during development of brain. Amblyopia may be caused by organic pathology and functional abnormalities in visual pathway. It may occur mainly due to anisometropia or strabismus. Confirmation of diagnosis of amblyopia depends on refraction by inducing cycloplegic, measurement of visual acuity and assessment of orthoptic problem. Screening and risk factor are also important in diagnosis. In the younger age, treatment is more effective. Treatment is done by occlusion or patching of good eye.

In order to determine, prevalence of amblyopia in Asian and Hispanic children with age group (6-72) months. A comprehensive study was done and clinical examination was conducted in which visual status and visual acuity was recorded. It was concluded that prevalence of amblyopia in both Asian and Hispanic was same but it seemed to be stable in Asian by age.

Amblyopia may be unilateral or bilateral causing decrease of vision. This problem is caused by underdevelopment of optic nerve causing the brain to favor one eye on the other. It is a leading cause of vision deprivation in children. The amblyopia is caused by following factors.

1. Anisometropia
2. Strabismus
3. Strabismic Amblyopia
4. Visual deprivation
5. Organic amblyopia[3].

Amblyopia can be classified as

1. **Strabismic** amblyopia which is due to suppression of one eye, which is deviated, a result of disturbed interaction of both eyes.
2. **Anisometropic** amblyopia which is due to difference in refractive status of both eyes.
3. Amblyopia due to stimulus deprivation in which vision of one eye is deprived. It may be due to media opacities in one eye.
4. **Ametropic** amblyopia due to refractive error which is symmetrical.
5. **Meridional** amblyopia occurs due to astigmatism[4].

Due to abnormal visual status in early life, visual cortex disorder which results in amblyopia. Amblyopia causes vision loss in infants and children of young age. During the disturbance of normal visual development visual impairment occurs in amblyopia.

Amblyopia is an ideal model to understand how plasticity of brain may be harnessed. Due to ordinary viewing condition under amblyopia, results in impaired depth perception. Impairment of streopsis has effect on visuomotor depending tasks. In Strabismic amblyopia, streopsis affects more as compared to anisometropic amblyopia. The efficacy of treatment in Strabismic amblyopia is more than anisometropic amblyopia. The improvement of treatment in Strabismic amblyopia is more with dichoptic anisometropic training than monocular training[5].

There is some capacity of binocular vision in amblyopic patients. It is important to quantify suppression that has been present. There is some type of suppressive interaction at visual cortex, if we improve this the both monocular and binocular defects improves. It is necessary to investigated the measurement of binocular single vision in patients of Strabismic, anisometropic and amblyopia of mixed type[6].

It is very important in treatment of amblyopia to regain binocular single vision. In amblyopia treatment it is important to measure the extent to which amblyopic eye suppresses the normal eye. Suppression is a binocular system binocularly but functionally monocular. Improvement in Strabismic amblyopia occur with reduction of suppression[7]. In early childhood due to binocular disruption, amblyopia result. In amblyopia there is disorder extend from primary visual cortex to extra-striate visual cortex which are involved in visual integration[8].

On the basis of geometrical optics, visual acuity at both distance and near would be same. However in amblyopic patients visual acuity at distance and near varies. In amblyopic eyes near vision is reduced than distance with reduced accommodation[9].

The most important risk factors for unilateral amblyopia are strabismus and high refractive error. For the development of bilateral amblyopia important risk factors are bilateral astigmatism and hypermetropia of bilateral type[10].

With increasing severity of amblyopia, the function of vision in amblyopic eye decreases, and the ability to resolve high frequency also decrease and decrease of contrast sensitivity of amblyopic eye decreases. There may be low processing of Parvocellular and Magnocellular pathway[11].

There is some degree of damage at both these areas[12].

Amblyopia is reduction of visual acuity unilateral and bilateral. There is no abnormality of eye structures and in posterior visual pathways. Amblyopia treatment responds well in early life[13].

Amblyopia may occur as a result of abnormal visual interaction. The most common causes of amblyopia are strabismus, anisometropia and visual deprivation which may

be as a result of congenital cataract and ptosis. Amblyopia occurs as a difference of two lines of visual acuity between two eyes[14].

Occlusion therapy is best method to treat amblyopia. It gives good overall success rate. But in this method there are chances of reoccurrence of amblyopia in severe cases. It is necessary to put compliances to parents[15].

Accommodative performance of amblyopic eye should always be measured. Modified Nott Retinoscopy was used to measure the accommodative effort. When seen monocular accommodative effort is more as compared to both eyes results in retinal image to defocus[16].

Full time patching gives best result on treatment of amblyopia of severe type. In these patients advised to patch good eye for six hours a week for three months. It gives best result in improvement of amblyopia. Patching in amblyopia improves visual acuity without any complication[17].

Radii of Curvature of cornea are the curvature of both anterior surface and posterior surface. Curvature is measured in millimeter and also in diopter. Shape of cornea expressed in micrometers. Both of these identify corneal astigmatism. Surface should be optically smooth. Any irregularity results in degradation of image. Optical property of cornea is power. It is dependent on shape of cornea and refractive index. Thickness of cornea measured in micrometer. Corneal topography machine based on principle of Placido reflective analysis of image[18].

A procedure used to measure the changes in shape of cornea of an eye. Corneal topographer emits a series of concentric rings of illuminated light on cornea of patient which are then reflected back on the instruments. This data analyzed in to machine and gives topographical map of that cornea. This is helpful in measuring the aberration of cornea[19].

Corneal topography measures corneal aberrations. Optical aberration measures the wavefront error of entire eye. Analysis of wavefront is done by abberoscope. This technique measures all type of aberration that is second order, third order, fourth order and high order aberrations. Three principles used in corneal topography instruments. These are Placido disc reflection, scanning and scheimpflug photography[20].

There are following two types of aberration in eye. Low order aberration makes 85% of total aberration in eye. They consist of defocus and astigmatism. High order aberration makes 15 % 0f total aberration. They consist of spherical aberration, coma and trefoil. Order means complexity of wavefront shape. Order of aberration depends on complexity of shape[21].

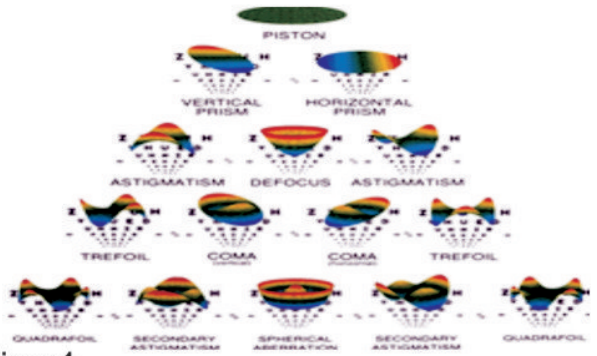

Figure 1:

This fig reveals the aberration shapes when light from wavefront machine reflects on eye of impaired vision. (Image: Alcon Inc.)[21]

If it is considered that the ray of light which is travel in a bundle, and we draw perpendicular line to the bundle of rays called as wavefront map. Wavefront of perfect is regular and of imperfect eye is irregular. These are pattern of different distortion of wavefront.

Aberometry is a way of measuring light wavefront coming from refractive media of eye. Distortion occurs as a result of aberometry called aberration, which give us information about refractive status. It measures both aberrations of Higher-order which are complex, lower-order aberrations which are common.

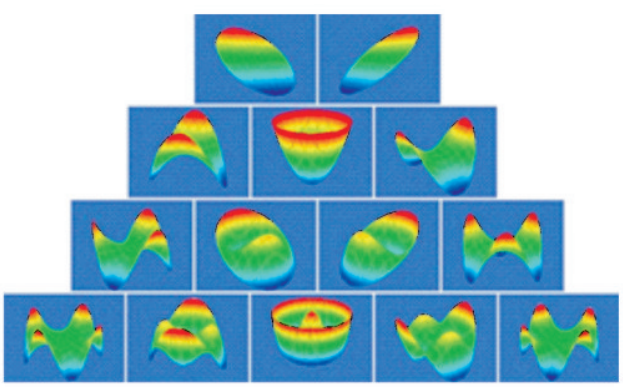

Figure 2:

Coma, trefoil and spherical aberration are high order aberration. Aberometry now correctly measure these aberrations. Wavefront measurements of an eye are done by aberrometers. It objectively measures all vision problems in detail. Ask the patient to place chin on the chin refocuses light, after a few second wavefront maps is produced. Map is produced by comparing with wavefront pattern which is saved in machine. Map may be flat or two dimensional.

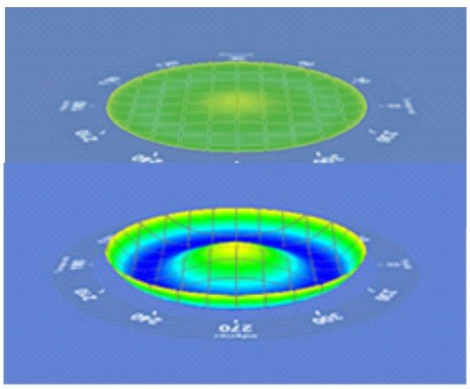

Figure 3:

Three-dimensional map of an eye can be produced by comparing with flat one. Zernike polynomials which is mathematical expression is used.

Aims and Objectives:

Aim and objective are as follows:

1. To find the relationship of amblyopia and wavefront changes.
2. To assess the predictability of wavefront aberrations in development of amblyopia or vice a versa.

Study Design, Materials & Methodology

Inclusion criteria:

- Individuals of age group 4-15 years[29].
- Male and female both included.
- Patients having Amblyopia.

Exclusion Criteria:

- Any other ocular pathology.

Population and Sampling Method/Sample Size

1. Population: Patients coming at Mayo Hospital OPD.
2. Sampling method: Non probability Convenient Method.
3. Sample size: 30 people having Amblyopia.
4. Sample design: Descriptive type/cross sectional study.
5. Data collection method: wavefront measurement of 30 patients having Amblyopia using Abberometer.

Tools: Pro Forma Containing:

- Patient profile
- Machine print out used as Performa

Instruments /Equipment to be used:

- Corneal topography (Galilei)

Data analysis Method:

- SPSS soft ware is used to analyzed data which shows the result in the form of tables and graph

Results:

Table No 1: Comparison of paired sample means of amblyopic and normal group

Pair .1	2nd order aberrations eye	1.8530	30	.68505	.12507
	2nd order aberrations of normal eye	1.7590	30	.84181	.15369
Pair .2	2nd order Oblique astigmatism of amblyopic eye	.0003	30	.57885	.10568
	2nd order Oblique astigmatism of normal eye	.0192	30	.56722	.10356
Pair .3	2nd order defocus of amblyopic eye	.6000	30	.28410	.05187
	2nd order defocus of normal eye	.6263	30	.46751	.08536
Pair .4	2nd order regular astigmatism of amblyopic eye	1.4080	30	1.02330	.18683
	2nd order regular astigmatism of normal eye	1.3163	30	1.03858	.18962

This table shows the means and standard deviation of compared pairs of 2nd order abberation of amblyopic and normal eye, 2nd order oblique astigmatism of amblyopic and normal eye, 2nd order defocus of amblyopic and normal eye and 2nd order regular astigmatism of amblyopic and normal eye. There was significant difference of means between these pairs.

Table No 2: Correlation between paired sample of amblyopic and normal eye

		N	Correlation	Sig.
Pair .1	2nd order aberrations of eye & 2nd order aberrations of normal eye	30	.571	.001
Pair .2	2nd order Oblique astigmatism of amblyopic eye & 2nd order Oblique astigmatism of normal eye	30	-.530	.003
Pair .3	2nd order defocus of amblyopic eye & 2nd order defocus of normal eye	30	.509	.004
Pair .4	2nd order regular astigmatism of amblyopic eye & 2nd order regular astigmatism of normal eye	30	.573	.001

This table shows that there is strong corelation(rho=0.571) between 2nd order aberration of amblyopic and normal eye but the difference is not significant, strong corelation(rho=-0.530)between 2nd order oblique astigmatism of amblyopic eye and 2nd order oblique astigmatism of normal eye, strong corelation(rho=0.509) between 2nd order defocus of amblyopic eye & 2nd order defocus of normal eye and strong corelation(rho=0.573) between 2nd order regular astigmatism of amblyopic eye & 2nd order regular astigmatism of normal eye but difference is not significant.

Table No 3: Paired sample t- test

		Paired Differences					t	Df	Sig. (2 - tailed)
		Mean	SD	SEM	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	2nd order aberrations of amblyopic eye - 2nd order aberrations of normal eye	.094	.72	.132	-.175	.363	.714	29	.481
Pair 2	2nd order oblique astigmatism of amblyopic eye - 2nd order oblique astigmatism of normal eye	.019	1.00	.183	-.355	.394	.107	29	.916
Pair 3	2nd order defocus of amblyopic eye - 2nd order defocus of normal eye	.026	.40	.074	-.1256	.178	.356	29	.724
Pair 4	2nd order regular astigmatism of amblyopic eye - 2nd order regular astigmatism of normal eye	-.092	.95	.174	-.447	.264	-.527	29	.602

This table shows that difference between the groups 2nd order aberrations of amblyopic eye - 2nd order aberrations of normal eye ($p \leqslant 0.05$), between 2nd order oblique astigmatism of amblyopic eye - 2nd order oblique astigmatism of normal eye ($p \leqslant 0.05$), between 2nd order defocus of amblyopic eye - 2nd order defocus of normal eye ($p \leqslant 0.05$) and 2nd order regular astigmatism of amblyopic eye - 2nd order regular astigmatism of normal eye ($p \leqslant 0.05$) is not significant.

Table No 4: Comparison of paired sample means of amblyopic and normal group

		Mean	N	SD	SEM
Pair .1	Third order aberration of amblyopic eye	.4795	30	.47920	.08749
	Third order aberration of normal eye	.5450	30	.23853	.04355
Pair .2	Third order vertical trefoil of amblyopic eye	-.1058	30	.21224	.03875
	Third order vertical trefoil of normal eye	.0387	30	.23687	.04325
Pair .3	Third order aberration of amblyopic eye	-.0083	30	.32029	.05848
	Third order aberration of normal eye	-.1200	30	.26172	.04778
Pair .4	Third order horizontal coma of amblyopic eye	-.1733	30	.36026	.06577
	Third order horizontal coma of normal eye	-.750	30	.46229	.08440
Pair .5	Third order horizontal trefoil of amblyopic eye	-.1240	30	.30607	.05588
	Third order horizontal trefoil of normal eye	-.0597	30	.27278	.04980

This table shows the means and standard deviation between groups third order aberration of amblyopic eye and third order aberration of normal eye, third order vertical trefoil of amblyopic eye and third order vertical trefoil of normal eye, third order horizontal coma of amblyopic eye and third order horizontal coma of normal eye and third order horizontal trefoil of amblyopic eye and third order horizontal trefoil of normal eye. There was no significant difference between means of these pairs

Table No 5: Correlation between paired sample of amblyopic and normal eye

		N	Correlation	Sig.
Pair 1	third order aberration of amblyopic eye & third order aberration of normal eye	30	-.031	.871
Pair 2	third order vertical trefoil of amblyopic eye & third order vertical trefoil of normal eye	30	.064	.737
Pair 3	third order vertical coma of amblyopic eye & third order vertical coma of normal eye	30	.656	.000
Pair 4	third order horizontal coma of amblyopic eye & third order horizontal coma of normal eye	30	- .053	.780
Pair 5	third order horizontal trefoil of amblyopic eye & third order horizontal trefoil of normal eye	30	.291	.119

There is strong correlation (rho=.656, p≤ 0.05) between third order vertical coma of amblyopic eye and third order vertical coma of normal eye and the difference between groups is also significant.

Table No 6: Paired sample t- test

		Paired Differences					t	‹	Sig. (2-tailed)
		Mean	SD	SEM	95% C I of Difference				
					Lower	Upper			
Pair 1	third order aberration of amblyopic eye - third order aberration of normal eye	-.065	.542	.099	-.268	.137	-.662	29	.513
Pair 2	third order vertical trefoil of amblyopic eye - third order vertical trefoil of normal eye	-.144	.308	.056	-.259	-.029	-2.57	29	.016
Pair 3	third order vertical coma of amblyopic eye - third order vertical coma of normal eye	.112	.247	.045	.019	.204	2.475	29	.019
Pair 4	third order horizontal coma of amblyopic eye - third order horizontal coma of normal eye	-.098	.601	.110	-.323	.126	-.896	29	.378
Pair 5	third order horizontal trefoil of amblyopic eye - third order horizontal trefoil of normal eye	-.064	.346	.063	-.193	.065	-1.02	29	.316

This table shows that there is significant difference between third order vertical trefoils of amblyopic eye - third order vertical trefoil of normal eye ($p \leq 0.05$) and between third order vertical coma of amblyopic eye - third order vertical coma of normal eye ($p \leq 0.05$).

Table No.7: Comparison of paired sample means of amblyopic and normal group

		Mean	N	S	SEM
Pair 1	fourth order aberration of amblyopic eye	.2193	30	.13266	.02422
	fourth order aberration of normal eye	.2760	30	.22053	.04026
Pair 2	fourth order oblique quatrefoil of amblyopic eye	-.0187	30	.03830	.00699
	fourth order oblique quatrefoil of normal eye	-.0167	30	.01348	.00246
Pair 3	fourth order oblique astigmatism of amblyopic eye	.0137	30	.02988	.00546
	fourth order oblique astigmatism of norma eye	.0260	30	.13622	.02487
Pair 4	fourth order defocus o amblyopic eye	.0950	30	.09637	.01760
	fourth order defocus o normal eye	.1030	30	.08918	.01628
Pair 5	fourth order vertical astigmatism of amblyopic eye	.0203	30	.05275	.00963
	fourth order vertical astigmatism of norma eye	.0067	30	.04080	.00745
Pair 6	fourth order regular quatrefoil of amblyopic eye	-.0580	30	.04046	.00739
	fourth order regular quatrefoil of normal eye	-.0407	30	.17354	.03168

This table shows the mean and standard deviation between groups as follows, fourth order aberration of amblyopic eye and normal eye, fourth order oblique quatrefoil of normal eye and of amblyopic eye, fourth order defocus of amblyopic eye and of normal eye, fourth order vertical astigmatism of amblyopic eye and of normal eye, fourth order regular quatrefoil of amblyopic eye of normal eye.

Table No. 8: Correlation between paired sample of amblyopic and normal eye

		N	Correlatic	Sig.
Pair 1	fourth order aberration of amblyopic eye & fourth order aberration of normal eye	30	.564	.001
Pair 2	fourth order oblique quatrefoil of amblyopic eye & fourth order oblique qu atrefoil of normal eye	30	.318	.086
Pair 3	fourth order oblique astigmatism of amblyopic eye & fourth order oblique astigmatism of normal eye	30	.476	.008
Pair 4	fourth order defocus of amblyopic eye & fourth order defocus of normal eye	30	.713	.000
Pair 5	fourth order vertical astigmatism of amblyopic eye & fourth order vertical astigmatism of normal eye	30	.074	.697
Pair 6	fourth order regular quatrefoil of amblyopic eye & fourth order regular quatrefoil of normal eye	30	.537	.002

This table shows that there is strong correlation between fourth order aberration of amblyopic eye & fourth order aberration of normal eye (rho=.001), fourth order oblique astigmatism of amblyopic eye & fourth order oblique astigmatism of normal eye (rho=0.008), fourth order defocus of amblyopic eye & fourth order defocus of normal eye (rho=0.000), fourth order regular quatrefoil of amblyopic eye & fourth order regular quatrefoil of normal eye (rho=.002) but there is no significant difference between these groups.

Table No 9: Paired sample t- test

		Paired Differences					t	df	Sig.(- 2 tailed)
		Mean	SD	SEM	95% CI of the Difference				
					Lower	Upper			
Pair 1	fourth order aberration of amblyopic eye - fourth order aberration of normal eye	-.057	.182	.033	-.125	.011	-1.70	29	.099
Pair 2	fourth order oblique quatrefoil of amblyopic eye - fourth order oblique quatrefoil of normal eye	-.002	.036	.007	-.016	.012	-.302	29	.765
Pair 3	fourth order oblique astigmatism of amblyopic eye - fourth order oblique astigmatism of normal eye	-.012	.125	.023	-.059	.034	-.541	29	.592
Pair 4	fourth order defocus of amblyopic eye - fourth order defocus of normal eye	-.008	.071	.013	-.034	.018	-.620	29	.540
Pair 5	fourth order vertical astigmatism of amblyopic eye - fourth order vertical astigmatism of normal eye	.014	.064	.012	-.010	.038	1.16	29	.253
Pair 6	fourth order regular quatrefoil of amblyopic eye - fourth order regular quatrefoil of normal eye	-.017	.156	.028	-.075	.041	-.610	29	.547

This table shows that there is no significant difference between all of these groups. P value is ($p \geqslant 0.05$) in all groups.

Table No 10: Comparison of paired sample means of amblyopic and normal group

		Mean	N		SEM
Pair 1	fifth order aberration of amblyopic eye	.0860	30		.012
	fifth order aberration of normal eye	.0820	30		.011
Pair 2	sixth order aberration of amblyopic eye	.0720	30		.008
	sixth order aberration of normal eye	.0587	30		.004
Pair 3	seventh order aberration of amblyopic eye	.0237	30		.001
	seventh order aberration of normal eye	.0288	30		.003
Pair 4	eight order aberration of amblyopic eye	.0190	30		.001
	eight order aberration of normal eye	.0220	30		.002

This table shows the mean and stranded deviation between the groups, fifth order aberration of amblyopic eye and fifth order aberration of normal eye, sixth order aberration of amblyopic eye and sixth order aberration of normal eye, and seventh order aberration of amblyopic eye and seventh order aberration of normal eye.

Table No 11: Correlation between paired sample of amblyopic and normal eye

		N	Correlat	Sig.
Pair 1	fifth order aberration of amblyopic eye & fifth order aberration of normal eye	30	.622	.000
Pair 2	sixth order aberration of amblyopic eye & sixth order aberration of normal eye	30	.495	.005
Pair 3	seventh order aberration of amblyopic eye & seventh order aberration of normal eye	30	.475	.008
Pair 4	eight order aberration of amblyopic eye & eight order aberration of normal eye	30	.122	.520

This table shows that strong correlation between fifth order aberration of amblyopic eye & fifth order aberration of normal eye (rho= 0.662, p=0.000), sixth order aberration of amblyopic eye & sixth order aberration of normal eye (rho=0.495, p=0.005), and seventh order aberration of amblyopic eye & seventh order aberration of normal eye (rho=0.008, p⩽ 0.05) But difference is not significant in eighth order aberrations between amblyopic and normal eye.

Table No 12: Paired sample t- test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	SD	SEM	95% CI of the Difference				
					Lower	Upper			
Pair 1	fifth order aberration of amblyopic eye - fifth order aberration of normal eye	.004	.055	.010	-.016	.024	.399	29	.693
Pair 2	sixth order aberration of amblyopic eye - sixth order aberration of normal eye	.013	.036	.007	-.000	.027	2.03	29	.052
Pair 3	seventh order aberration of amblyopic eye - seventh order aberration of normal eye	-.005	.013	.002	-.010	-.000	-2.14	29	.041
Pair 4	eight order aberration of amblyopic eye - eight order aberration of normal eye	-.003	.012	.002	-.007	.001	-1.39	29	.174

This table shows that there is significant difference between seventh order aberrations of amblyopic eye - seventh order aberration of normal eye ($p < 0.05$).

Table No 13: Comparison of paired sample means of amblyopic and normal group

		Mean	N	SD	SEM
Pair 1	defocus of amblyopic eye	.478	30	.229	.042
	defocus of normal eye	.507	30	.302	.055
Pair 2	astigmatism second order of amblyopic eye	1.28	30	.534	.097
	astigmatism second order of normal eye	1.12	30	.666	.122
Pair 3	coma third order of amblyopic eye	.375	30	.257	.047
	coma third order of normal eye	.344	30	.168	.031
Pair 4	trefoil third order of amblyopic eye	.171	30	.067	.012
	trefoil third order of normal eye	.156	30	.055	.010
Pair 5	spherical of amblyopic eye	-.049	30	.074	.014
	spherical of normal eye	-.045	30	.064	.012

This table shows the mean and stranded deviation between the groups, astigmatism second order of amblyopic eye and astigmatism second order of amblyopic eye, astigmatism second order of amblyopic eye and astigmatism second order of normal eye, coma third order of amblyopic eye and coma third order of normal eye, trefoil third order of amblyopic eye and trefoil third order of normal eye, and spherical of amblyopic eye and spherical of normal eye.

Table No 14: Correlation between paired sample of amblyopic and normal eye

		N	Correlation	Sig.
Pair 1	defocus of amblyopic eye & defocus of normal eye	30	.761	.000
Pair 2	astigmatism second order of amblyopic eye & astigmatism second order of normal eye	30	.454	.012
Pair 3	coma third order of amblyopic eye & coma third order of normal eye	30	.143	.449
Pair 4	trefoil third order of amblyopic eye & trefoil third order of normal eye	30	.271	.148
Pair 5	spherical of amblyopic eye & spherical of normal eye	30	.681	.000

This table shows that strong correlation between defocus of amblyopic eye & defocus of normal eye (rho=.000), astigmatism second order of amblyopic eye & astigmatism second order of normal eye (rho=.012), and spherical of amblyopic eye & spherical of normal eye (rho=.000), but difference is not significant.

Table No 15: Paired sample t- test

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	SD	SEM	95% CI of the Difference				
					Lower	Upper			
Pair 1	defocus of amblyopic eye - defocus of normal eye	-.029	.196	.036	-.102	.044	-.810	29	.425
Pair 2	astigmatism second order of amblyopic eye - astigmatism second order of normal eye	.915	.637	.116	-.079	.397	1.36	29	.183
Pair 3	coma third order of amblyopic eye - coma third order of normal eye	.031	.286	.052	-.076	.138	.586	29	.562
Pair 4	trefoil third order of amblyopic eye - trefoil third order of normal eye	.015	.074	.014	-.012	.043	1.125	29	.270
Pair 5	spherical of amblyopic eye - spherical of normal eye	-.00400	.056	.010	-.025	.017	-.390	29	.699

This table shows that there is no significant difference between all of these groups ($p \leq 0.05$)

Discussion:

Amblyopia is an idiopathic disease in which there is reduction of visual acuity when no fundal pathology seen on examination. Amblyopia results due to strabismus, visual deprivation and due to unequal refractive status during early development of life. In young children and adults of middle age the common cause of visual impairment is amblyopia and it is increasing the risk of vision loss (1.2%).

High refractive errors when occur in both eyes leads to isometropic amblyopia. Strabismus is also secondary cause of amblyopia. If there is large difference in refractive status of two eyes leads to anisometropic amblyopia. As they play a potential role in image quality so High order aberration seems to be a causative factor in development of amblyopia.

The treatment outcome and management is difficult to treat in younger children, due to issue of compliance. Amblyopia can easily be treated in individuals above 10 years. Even after treatment completed successfully amblyopic patients when check give eye behaves as anThere are following two types of aberration in eye. Low order aberration makes 85% of total aberration in eye. They consist of defocus and astigmatism. High order aberration makes 15 % 0f total aberration. They consist of spherical aberration, coma and trefoil. Order means complexity of wavefront shape. Order of aberration depends on complexity of shape.

High order astigmatism makes small contribution in eye's total wavefront, studies shoes that high order aberration has deleterious effect on image quality. This study compared ocular aberrations in amblyopic eye and normal eye of same individual, the results showed that in amblyopic eyes third order vertical trefoil ($p = 0.016$),($p \leq 0.05$), third order vertical coma ($p = 0.019$),($p \leq 0.05$) and 7th order aberration ($p = 0.041$),($p \leq 0.05$). The differences were statistically significant.

In conclusion, high order aberrations are the main cause in the development of amblyopia. Further studies with larger sample sizes are required to further study the effect of HOAs in children with amblyopia.

The Wave Scan Wavefront which is known as aberometry was used to investigation of four groups of children which were kept under dark accommodation and paralysis of cilliary muscle. In this study cases of emetropic group were 45, in the amblyopic group 87, in the corrected-amblyopic group 92 and in the refractory amblyopic group 38. (ANOVA) t-test was used to analyze all the data. Third order coma Z(3)(-1)-Z(3)(1)), trefoil (Z(3)(-3)-Z(3)(3)) and 4th order aberration (Z(4)(0)); and 3rd order coma have the highest percentage from all three main aberrations. Within 3rd order

coma, vertical coma (Z(3)(-1)) have greater percentage than horizontal coma (Z(3)(1)). Vertical coma in the amblyopic group (0.17 +/- 0.15) was significantly higher than in the emetropic group (0.11 +/- 0.13, P < 0.05). In the refractory amblyopic the vertical coma (0.19 +/- 0.15) was higher as compared to the emetropic group (P < 0.05), the 5th order aberration (0.11 +/- 0.08) was also significantly higher than in the emetropic group (0.07 +/- 0.04, P < 0.05).Lower order aberrations are major factors that determining the retinal image quality, higher order aberrations have significant effect in amblyopic eyes[22].

A study was conducted to evaluate the high order aberration and wavefront pattern in amblyopic children. A cross sectional study was done and patients having previously diagnosis of Amblyopia were analyzed using zyptix platform. It was found that loss of symmetry of wavefront pattern between two eyes[23].

A population of 78 patients with age group (18-67) having Amblyopia were analyzed, on all eyes corneal topography and aberometry was done It was concluded from study that low order aberrations are main factors affecting Amblyopia[24].

To assess visual function, ocular aberrations and the wavefront aberration patterns was used amblyopic eyes in 7 healthy individuals having amblyopic eyes. Visual acuity for different types of contrast sensitivity of high (100%), medium (50%), and low (10%) contrast and contrast sensitivity were at 10, 20, and 25 cycles per degree (cpd) measured. The modulation transfer function was based on the aberration data. The point spread function also based on aberration data. In all measures 3 and 5.5 mm pupil sizes were taken. No significant differences in visual acuity and contrast sensitivity were found. The higher-order aberrations seen to have no effect on decreased visual function in idiopathic amblyopic eyes[24].

Higher order aberrations (HOAs) were analyzed in 54 anisometropic amblyopic children using the ZY-WAVE II aberometry. A comparative study was done between normal fellow and amblyopic eyes. Difference was not significant in mean root square of total HOAs, total coma (TC), total spherical aberration (TSA), and the 5th root mean square (RMS5). There was seen correlation between the degree of anisometropia and TC. As the degree of anisometropic amblyopia increases there is increase in HOAs. Lower order aberrations are the main factors leading to amblyopia, and HOAs causes' anisometropic amblyopia. The study mechanism was helpful to understand the mechanism of amblyopia[26].

Aberrometers provide measurement of wavefront which give us clinical information. High order aberrations in overall wavefront measurement can be determined easily. In the recent past year's wavefront measurement which were done on the basis of Zernike polynomials did not give information about quality of retinal image. Thus several approaches have been implemented to enhance optical performance. Studies have been done to enhance quality of retinal image i-e (pupil-plane matrices') and (image-plane matrices). These are derived from wavefront measurement analysis. This paper gives the most recent information about wavefront measurement and also discussed the quality of image and optical quality that are now-a-days used in wavefront calculated to describe optical and image quality[27].

Unilateral amblyopia is caused by high order aberrations. Strabismus, microtropia, stimulus deprivation and organic are the causes which are rule out. Both eyes are observed by wavefront machine and difference is noted. Defocus was dominant in left eye and trefoil in right eye. From this result probable causes of amblyopia are noted. No exact result was found and further studies are required[28].

A study was conducted to check the aberrations of amblyopic eye and its relationship to the treatment. Aberrometers was used on sample size of 75 patients, with age group (5 -14). There was a significant difference between second order aberration of amblyopic and normal eye. It was concluded that low order aberrations are main factor in development of amblyopia[29].

In another study however high order aberrations are noted in amblyopic patient. Sample size was 78. Comparison between amblyopic and normal eye was noted. It was concluded that high order aberrations are the causes in development of amblyopia[30].

Recommendation:

The aim of amblyopia treatment is to correct refractive error to clarify the retinal image. Lower order aberrations are corrected by the use of lenses, but these options cannot be used to correct high aberrations. Defocus and astigmatism improves image quality to some extent but due to residual astigmatism retinal blur occur after correction.

Difference in ocular aberrations can affect binocular summation, and visual performance. This makes the treatment of amblyopia more difficult. This study will help in new treatment modalities for amblyopia.

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