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Analysis of the AC/A ratio in myopia patients in relation to spectacles and soft contact lenses

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Abstract
Purpose: To compare accommodative convergence over accommodation (AC/A) ratio when Myopic patient changes from Spectacles to Contact lenses.
Methods: A prospective, cross-sectional study group of 50 subjects and Myopic error from -0.75DS to - 6.00DS. The AC/A ratio was measured by two methods; the heterophoria method and the gradient method. Gradient method was measured by plus and minus Lenses technique. Heterophoria in near and distance was measured to calculate heterophoria method. Wilcoxon Signed Ranks Test was used to compare between two methods p value < 0.05.
Results: The mean AC/A ratio in Gradient method when using Soft Contact Lenses in comparison to Spectacles was: with+3(2.21, 2.24), and with-3(1.51,150) respectively. Although the AC/A ratio was less in amount with +3D lens in near and more in distance with -3D lens as compared to Spectacles, there were no significant differences found between the two (P:0.285 and P:0.317 respectively). The means of AC/A ratio as calculated by Heterophoria method was increased with soft contact lenses (5.97) as compared to spectacles (5.96) with no significant difference p: 0.317
Conclusion: No significant difference has been found for myope when changing from spectacles to contact lenses.

Keywords: Myopia, contact lenses, spectacles, AC/A, accommodation, convergence, gradient method, heterophoria method

Introduction

Myopia has become a significant global public health and socioeconomic problem with significant geographic variation in prevalence [1]. The number of people affected by myopia is projected to increase from 1.4 billion to 5 billion by 2050, affected about half the world's population [2]. Myopia treatment has come a long way from spectacles or contact lenses to advanced minimally invasive refractive procedures. About 75% of the adult population worldwide uses vision correction products, and 64% of them wear glasses and 11% uses contact lenses. Over 4 billion people in the world wear glasses. Contact Lenses are used by over 150 million people worldwide [3]. As of 2010, the average age of contact lenses wearers globally was 31 years old, and two-thirds of wearers were female. Because contact lenses provide cosmetic and optical advantages over spectacles, some spectacle wearers shift to contact lenses.

In optical calculation there are many changes when a patient shifts from spectacles to contact lenses. These changes include convergence demand, accommodation demand and accommodative convergence. Resulting from these changes, the AC/A ratio may be disturbed [5]. The AC/A ratio is the amount of convergence that occurs reflex in response to a change of accommodation of 1D [6]. The use of term 'convergence' includes true convergence (positive convergence) and divergence (negative convergence). AC/A finding is important in diagnosing and treating binocular vision anomalies [7]. The normal AC/A ratio is about 3 to 5 prism diopters for one diopter of accommodation. Actually in clinical use that is not single normal value of AC/A ratio, it must view in relation to method use to measure it. The normal AC/A ratio in gradient methods by use of both plus and minus lenses is 2:12 [8]. The normal AC/A ratios founded for near gradient, distance gradient, gradient using synoptophore and heterophoria methods were 2.0,1.0,1.0 5.0, respectively [9]. The majority of myopes have a high AC/A ratio as compared with emmetropes, there is no correlation between the degree of myopia and magnitude of AC/A ratio.The pupillary distance must also be considered in determination of AC/A ratio [10].

Clinically, there are three methods used to determine the AC/A ratio: the gradient, fixation disparity and calculated heterophoria. Previous studies have established the gradient method to be most accurate [11]. The difference between the gradient and heterophoria methods has been found [12]. Clinically, advises using both plus and minus lenses while measuring AC/A ratio with the gradient method rather than a single lens type [13].

Dr. Parul M. Danayak, *et al*. and Dr. Raimundo Jimenez. Loreto, *et al*. studied the AC/A ratio as a part of binocular vision status when they compare between spectacles and contact lenses. Dr Parul measured AC/A ratio only by heterophoria method and Dr Raimundo measured it by heterophoria method and gradient method with +/-1DS. Each of these previous studies showed that there was no significant difference in AC/A ratio when wearing spectacles or contact lenses [14, 15]

Material and Methods

Prospective, cross-sectional study included 50 myopic subjects. Written informed consent was obtained from all the subjects who were included in the study. Subjects who had spherical myopia from at least –0.75 DS to -6 of both eyes, an astigmatic ametropia ≤1.00 D and anisometropia ≤2.00 DS were included in this study. All subjects with eye movement disorder and ocular pathology were excluded. Relevant demographic data and type of correction were obtained. All subjects underwent a thorough optometry examination. The Snellen E chart was used to measure distance vision Three readings were taken for each eye.

The results were refined subjectively using Snellen's E chart and trial set of lenses. The exact refraction compensated for vertex distance was used for refractive error greater than4.00 D; table for correction of vertex distance was used to determine contact lenses power. Horizontal visible iris diameter (HVID) was measured by the ruler to select suitable diameter of the contact lenses. Contact lenses were spherical disposable soft contact lenses (Equivue, 55% water content). When myopia and astigmatism were combined, lenses with appropriate spherical equivalent were selected. The visual acuity was measured by Spectacles and Contact Lenses. Jaeger near chart was used to measure near visual acuity and accommodation, both monocular and binocular amplitude of accommodation were measured by two different methods: Donder's push-up method and minus lens method. Near point of convergence (NPC) was evaluated by push-up technique using unaccommodating target. Fusional vergence was assessed using a 1 to 40 pd horizontal prism bar for near fixation (33 cm). A single Snellen letter (6/12 level) was used as near fixation. Both positive (convergence) and negative (divergence) fusion were measures with base-out (BO) prism and base in (BI) prism, respectively.For Gradient method, near horizontal heterophoria was measured with Maddox wing at distance of 33 cm. The instrument uses septum so that one eye sees the scale and the other eye sees an arrow. The subject reads the position of each arrow on the appropriate scale, the number on the scale to which an arrow point indicated the horizontal deviation. Using Maddox wing kept the interpupillary distance (IPD) and vertex distance. Following the measurement of near horizontal phoria with best distance correction +3.00 lenses were placed in front of Maddox wing and the new phoria value was noted. -3.00D lenses were added when measuring the distance horizontal phoria by prism bar and cover test and new phoria was reported. These values were used for calculation of AC/A ratio.

For Heterophoria method, near phoria was measured by Maddox wing, distance horizontal phoria was measured by prism bar and cover test. IPD was measured by ruler. These values were used for calculation of AC/A ratio according to Heterophoria method equivalent.

All these tests were performed with subjects wearing spectacles and then same test procedures were repeated with contact lenses after adaptation period of fifteen minutes, the soft contact lens fitting evaluated.

Gradient method equivalent to calculate

AC/A ratio: $AC/A = (\Delta L - \Delta O)/D$,

Where

ΔL = Deviation with additional lenses. ΔO = Original deviation without additional lenses. D = Dioptric power of the additional lenses.

Heterophoria method equivalent to calculate

AC/A ratio: $AC/A = IPD + (\Delta n - \Delta d)/d$,

Where

IPD= interpupillary distance in centimeters Δn= Deviation at 33 cm or 3 diopters Δd =Deviation at 6 meters distance in prism diopters d = the fixation distance at near in diopters

Results

A total of 50 subjects: 9 (18%) males and 41(82%) females, their ages ranged between (17-28) years with mean 21.54 ± 2.99. The values for the parameters in the two groups were compared. Wilcoxon signed ranks test was applied at a confidence level of 95% to compare between two corrections and methods. Subjective break test for near point of convergence showed a significant difference exists between spectacle and soft contact lenses $p< 0.001$. It appears closer with contact lens compared to spectacle. There was no statistically significant difference in amplitude of accommodation by either method (push-up and minus lenses) P: 0.102, P: 0.059 respectively. But the means of accommodative amplitude by all methods increased with contact lenses as compared to the spectacle lenses. Fusional vergence (positive and negative) showed no significant difference when wearing spectacles compared to soft contact lenses P: 0.317 in both. The positive Fusional vergence mean increased with contact lenses as compared to the spectacles and the negative fusional vergence mean decreased with contact lenses as compared to the spectacle. Near and distance horizontal dissociated phoria showed less exophoria with contact lenses compared to spectacles with no significant differences p:0.157 and P:0.317 respectively. Stimulation horizontal dissociated phoria (with+3DS and -3DS) showed less exophoric values in near and more esophoric values in distance with contact lenses as compared to spectacles with no significant difference P:0.180 and P:0.317 respectively. There were no significant differences in both AC/A ratio while using gradient and heterophoria methods when subjects changed from spectacles to contact lenses P:(0.285, 0.317) with +/-3DS in gradient method respectively and P:0.317 in heterophoria method. The gradient AC/A ratio showed less amount with +3D lens in near and more with -3Dlens in distance with contact lenses as compared to spectacles. The mean of AC/A ratio as calculated by the heterophoria method was greater with contact lenses than spectacles.

Table 1: comparison near point of convergence, accommodation, fusion and AC/A ratio parameters between spectacle and soft contact lenses (mean± SD). Statistically significant differences with wilcoxon signed rank test (p<0.05). (Negative values indicate exophoria and positive indicate esophoria)

Parameter method	Mean ± SD spectacles	Mean ± SD contact lenses	p value
N.C.P objective break	6.08±0.93	5.84±0.91	0.00
Accommodation push up	11.348±1.156	11.351±1.153	.102
Minus lens	9.964±1.174	9.999±1.173	.059
Fusion			
+ve break	36.32±3.98	36.36±3.95	.317
-ve break	10.88±2.685	10.84±2.682	.317
H. heterophoria			
Near MWT	-1.48±1.38	-1.40±1.41	.157
Near with+3D	-8.24±1.49	-8.12±1.63	.180
Distance PCT	-0.36±.77	-0.32±.74	.317
Distance with-3D	4.16±.88	4.24±1.04	.317
Parameter method	Mean ± SD	Mean ± SD	
	spectacles	contact lenses	p value
Gradient			
AC/A +3.00D	2.24±.29	2.21±.32	.285
-3.00D	1.50±.32	1.51±.35	.317
Heterophoria	5.96±.58	5.97±.59	.317

Discussion

Fannin and Grosvenor indicated most contact lens wearers have refractive errors ranging from$\pm 1.00Dto \pm 5.00D$, refractive error of this study population ranging from$-0.75Dto -6.00D$. This study found no significance difference in accommodation amplitude by either method (push up P: 0.102 or minus lens P: 0.059) when subjects changed from spectacle to contact lenses. Although the mean of accommodative amplitude grater was when the subject wore contact lenses. Also, Dr. Parul *et al*. 2014 and Raimundo Jimenez *et al.* 2010 found no significant difference in accommodative amplitude. Dr. Parul *et al.* measured it by push up technique P:0.20 and Raimundo Jimenez *et al*. measured it by push up technique P:0.76 and minus lens P:0.15. Objective NPC was found to be closer with soft contact lenses than spectacle lenses with significant differences p<0.001 which agree with the study done by Dr. Parul *et al.* P: 0.02. Dr. Parul *et al.* and Raimundo Jimenez *et al*. found no significant difference in NPC subjectively P:0.52 and p:0.46 respectively. The mean of positive fusional vergence was increased, and negative fusion vergence was decreased when subjects wore contact lenses compared to spectacles with no significant difference P:0.317 for both. The studies done by parul *et al.* showed the same result with positive fusion P:0.60 and negative fusion P:0.70. Raimundo. J *et al.* showed no significant difference in positive fusion P:0.99 and significant difference in negative fusion p:<0.01 with mean of positive fusion decreased, and negative fusion was increased when subjects wore contact lenses. Distance and near heterophoria showed reduced exophoria when subjects wore contact lenses compared to spectacle with no significant difference P:0.317,P:0.157 respectively. Dr. Parul *et al*. agreed with this result for distance P:0.27 and near heterophoria P:0.34. Raimundo. J *et al*. have agreed with distance heterophoria P:0.07 and disagree with near heterophoria p<0.05.

This study showed that no significant difference was present in AC/A ratio when measuring by the two different methods while subjects wore soft contact lenses or spectacles P:0.285,0.317 and0.317 for Gradient with +3, Gradient with -3 and heterophoria methods respectively. Heterophoria and Gradient methods done by Dr. Parul *et al*. were agreed with this result P: 0.44, P: 0.49 respectively. Heterophoria method was done by Raimundo J *et al*. agreed with this result P:0.44. In the gradient method the mean of AC/A ratio showed less amount with +3.00D lenses and more with - 3.00D lenses when subject worn soft contact lenses compared to spectacles lenses. This agrees with the study done Raimundo Jimeneze *et al*. The heterophoria method the mean of AC/A ratio showed increased in amount while using contact lenses compared to spectacles lenses, which agree with Parul *et al*. results and disagreed with Raimundo Jimeneze *et al.*

Conclusion

No significant change in the AC/A ratio has been found when myope shifts from spectacles to contact lenses. Although there was increase in accommodation amount, increase in convergence and reduction of horizontal exophoria at near when use contact lenses, which should be considered when myopic patients become symptomatic when shift from spectacles to contact lenses.

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