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Original Research Article

A Study to Compare Accommodative Convergence Over Accommodation (AC/A) Ratio When Myopic Patient Changes from Spectacles to Contact Lenses

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Abstract

Aim: The aim of the present study was to compare accommodative convergence over accommodation (AC/A) ratio when Myopic patient changes from Spectacles to Contact lenses.

Methods: A Prospective, cross-sectional study included 50 myopic subjects in the Department of Ophthalmology, Nalanda Medical College and Hospital, Patna, Bihar, India from July 2017 to June 2018. 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.

Results: 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. Stimulation horizontal dissociated phoria (with+3DS and - 3DS) showed less exophoric values in near and more esophoria 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.

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.

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

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Introduction

The ratio of accommodative convergence that occurs per dioptre (D) of accommodative response is referred to as the response AC/A ratio. Imbalances in this important cross-coupling gain relationship between these two key elements of clear and single binocular vision may produce clinically significant phoria or tropia. [1] The AC/A ratio matures early in life and is stable across a broad span of ages. Values in infants 13 to 16 weeks of age were similar to those of pre-presbyopic adults, with adult-like ratios recorded in a subset of the most cooperative infants as early as 0 to 8 weeks of age. [2] Cross-sectional studies report stable values in school-age children between 6 and 14 years [3] and from infancy into adulthood for subjects as old as 46 years. [4]

Although the AC/A ratio matures early and changes little into adulthood, several factors may affect it: orthoptic training, presbyopia, cycloplegia, and refractive error. Of these, the neurologic or oculomotor changes that follow orthoptic training seem to have the least effect. Two weeks of orthoptic training increased vergence ranges and the degree of vergence adaptation to base-out prism, but the response AC/A ratio was virtually unchanged compared to baseline. [5,6] Periods of orthoptic training longer than 2 weeks had no greater effect, producing either no significant change [7] or small but temporary increases in the response AC/A ratio that dissipated within a year. [8] However, the AC/A ratio has shown changes in animal and human studies during periods of vergence adaptation following short-term application of prisms and optical changes to the interpupillary distance. [9–11]

Older age has a much greater effect; the response AC/A ratio increases by roughly a factor of two as presbyopia approaches. [12–14] This effect is presumably due to the increased effort needed to produce accommodative changes after age 30 years when accommodative amplitude begins its most rapid decline. [15] Recent magnetic resonance imaging data show that adults in the age range of 30 to 50 years undergo the same ciliary muscle contraction per dioptre of measurable accommodative response. [16] The increase in the AC/A ratio suggests that more effort is needed to produce the same ciliary muscle contraction per dioptre of accommodative response by the aging accommodative plant. Rather than poor muscle contractility, aging effects that might increase the effort needed per dioptre of accommodation include increased tension on the ciliary muscle from choroidal sclerosis, documented in the rhesus monkey. [17] The effort, or force of contraction of the ciliary muscle, needed per dioptre of accommodation has been referred to as the "Myo dioptre" by Fisher. [18] This increase in the AC/A ratio with increased effort needed to accommodate is analogous to the two to three times increase in AC/A seen when cycloplegia impairs accommodation to 1 to 2 D of residual amplitude.[19]

The aim of the present study was to compare accommodative convergence over accommodation (AC/A) ratio when Myopic patient changes from Spectacles to Contact lenses.

Materials and Methods

A Prospective, cross-sectional study included 50 myopic subjects in the Department of Ophthalmology, Nalanda Medical College and Hospital, Patna, Bihar, India. 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. Objective refraction and central corneal curvature were measured with Auto Kerato-Refractometer (AKR) (TOPOCON, KR8900, POWER75 VA, and JAPAN). 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 than 4.00 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 centimetres Δn= Deviation at 33 cm or 3 dioptres Δd =Deviation at 6 meters distance in prism dioptres d = the fixation distance at near in dioptres.

Results

Table 1: Comparison near point of convergence, accommodation, fusion and AC/A ratio parameters between spectacle and soft contact lenses (mean± SD)

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

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.

Discussion

Myopia has become a significant global public health and socioeconomic problem with significant geographic variation in prevalence. [20] 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. [21] 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. [22] 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.

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. Uncorrected myopia decreases the accommodative demand and has been shown to reduce accommodative lag using this study's protocol[23] but all children in the analysis accommodated at least 1 D and were within the range of linearity between accommodation and accommodative convergence.30 The AC/A ratio would be expected to be independent of lag within this range. Longer-term adaptation to wearing glasses, however, may affect cover test and AC/A ratio results. The AC/A ratio has been reported to be higher by approximately 0.75 Δ/D with a new full correction in previously under corrected subjects compared to results 1 week later. [24] The decrease over the week was attributed to the dissipation of habitually greater positive relative convergence while under corrected rather than to changes in lag; there was no substantial difference in accommodative response between visits.[24] Corrected subjects in the current study wore their spectacles or contact lenses to testing and were therefore likely to be adapted wearers. Subjects without spectacles or contact lenses had approximately −1.4 D of uncorrected myopia on average. The 1.0 to 1.5 Δ/D higher AC/A ratios in uncorrected children may well represent habitual use of greater positive relative convergence while uncorrected. Likewise, the decreasing proportion of children with near esophoria after myopia onset might represent less of this excess positive relative convergence in the larger number of children wearing and adapting to myopic corrections.

Stimulation horizontal dissociated phoria (with+3DS and - 3DS) showed less exophoric values in near and more esophoria 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. Young myopes have several characteristics suspected of promoting faster rates of myopia progression: increased amount of near work, greater accommodative lag, having near esophoria, and having a higher AC/A ratio. However, results in the literature have not provided consistent evidence in favour of a substantial role for these factors. For example, near work was related to the rate of myopia progression in one study of Norwegian engineering students [25] but showed inconsistently significant results with minimal clinical relevance to progression in CLEERE [26] and showed no association with progression in several studies from Asia. [27]

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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