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Original Article

The Effects of Miotics on Accommodative Convergence/Accommodation (AC/A) Ratio of Nigerian Youths

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ABSTRACT

Miotics are autonomic effectors which are routinely used as diagnostic and therapeutic agents in ophthalmic practice, exerting actions on autonomic nervous control of the eye. This in turn controls changes in the pupil size, accommodation, convergence and aqueous humor dynamics. Gradient AC/A ratios were assessed in Nigerian youths of both sexes with ages ranging between 18 and 30 years (mean 20.5± 2.6 yrs). Initial values of the AC/A ratio were assessed on each volunteer and thereafter pilocarpine ophthalmic solution 4% and physostigmine ophthalmic solution 0.5% were applied topically, and the AC/A ratio re-assessed. Results showed that AC/A ratios were reduced after the application of the miotics relative to normal gradient AC/A ratios. The decrease in AC/A ratio following the use of the miotics was highly significant ($p<0.01$) and was associated with the normal gradient AC/A ratio. In conclusion, the miotic–induced spasm of accommodation significantly decreased the AC/A ratio of Nigerian youths.

Keywords*:* Miotics, Accommodation, Convergence, AC/A ratio.

INTRODUCTION

Many factors affect the AC/A ratio of individuals such as age, refractive error, reaction time, illumination, elevation, pupil size and pathology. Among the most important drugs employed in ophthalmic practice are those that exert their actions on the autonomic nervous control of the eye, that is, the mechanism that govern the changes in the pupil size, accommodation and convergence. The miotics are a class of drugs affecting the cholinergic branch of the autonomic nervous system and there are two types, the direct-acting ones such as pilocarpine and the indirect acting ones, for instance, physostigmine. The direct acting ones mimic the action of acetylcholine on the iris and the ciliary musculature while the indirect acting miotics exhibit inhibitory effects on cholinesterase enzyme rendering them incapable of hydrolyzing acetylcholine. Since miotics cause pupillary constriction (miosis) and ciliary spasm which influence accommodation and convergence, it follows from physiological point of view that these drugs might have effect on AC/A ratio [1]. Accommodation is defined as the function whereby the converging power of the optical system of an eye is increased so that light diverging from a near source may be brought to a focus upon the retina. It involves increase in the curvature of the lens and its thickness and a decrease in diameter with a resultant flattening at the periphery. The phenomena of convergence and pupillary constriction are associated with accommodation. Convergence is accomplished by the medial recti while the pupillary constriction is governed by the sphincter pupillae and the ciliary muscle governs accommodation [2,3]. Convergence can be described as the inward turning of the visual axis towards each other and is influenced by innervational supplies which can be divided into tonic, accommodative, fissional and proximal convergence [4].

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Accommodation acts like a reflex, but can be constantly controlled. Mammals, birds and reptiles vary the optical power by changing the formation of elastic lens, using the ciliary body in humans up to 15 diopters. Fish and amphibians vary the optical power by changing the distance between a rigid lens and the retina with muscles [5-7]. This study deals with the effects of miotics on AC/A ratio of Nigerian Youths. The use of drugs in the assessment of visual functions necessitates the fact that eye care providers should have adequate knowledge of the multiple factors which can influence drug responses in man.

MATERIALS AND METHODS

Forty, healthy Nigerian youths of both sexes whose ages ranged between 18 and 30, mean (20.5±2.6) years, body weight 60-65kg were screened and selected from those attending the Optometry Clinic at Abia State University, Uturu, Nigeria. The protocol for the study was explained to each participant and those not willing to comply were excluded. Volunteers on any form of medication, oral, topical or systemic including smokers were excluded from the study. Each volunteer was interviewed separately and information on socio-demographic data and medical history obtained. Each volunteer was further subjected to screening, ocular and visual examination, by the optometrist to rule out refractive errors or ocular pathologies which might introduce errors in the study. Additionally, each volunteer had a normal near point of convergence (NPC) of (8–10 cm) and pupil-diameter (3.0–4.0 mm) before the study.

Subjects had initial measurements of the pupil size (PD), visual acuity (VA), at far and near, near point of convergence (NPC), habitual phoria, at far and near; the amplitude of accommodation (AA) and tonometry using the Schiotz tonometer before commencement of protocol so as to establish their initial values. The visual function under study (AC/A ratio) of all the subjects was then determined by gradient method to establish their initial values. The gradient AC/A ratio for each participant was measured by taking the horizontal phoria at 40cm using the reduced Snellen chart as target. A plus one diopter (+1.00D) lens was kept in place before both eyes and the phoria at 40cm was repeated. This represents the normal plus one gradient AC/A ratio. Similarly, the normal minus 1 (-1) gradient ratio was measured. This involved measuring the horizontal phoria at 40cm, and after that a minus one (-1.00D) diopter lens was kept in front of the two eyes and the phoria was repeated at 40cm. This gave the normal minus one gradient AC/A ratio, and then the mean value of the plus one (+1) gradient AC/A ratio and minus one (-1) gradient AC/A ratio was considered as the normal gradient AC/A ratio. The subjects were divided into two random groups, A and B, after the initial measurements above. Group A (n=20) received 2 drops of 4% pilocarpine ophthalmic solution, while Group B (n=20) received 2 drops of 0.5% physostigmine ophthalmic solution. The maximum effects of the drugs were determined by measuring the pupil size using the pupiliometer until the maximum constriction was attained.

Preliminary experiments indicate that maximum constriction occurs within 40 minutes for pilocarpine and 50 minutes for physostigmine. Differences between the initial values of AC/A ratio and values obtained after drug administration were regarded as the effects of the drug on the AC/A ratio of the individual. Each reading was taken four times and the mean determined.

Reagents and Equipment: Physostigmine ophthalmic solution (0.5%) and Pilocarpine ophthalmic solution (4.0%) were obtained from (Ranbaxy Laboratories, India). Pupiliometer, Tonometer–Schiotz, Phoropter and its accessories, Reduced Snellen chart were employed.

Statistical Analysis: Data were presented in tabular form. Each subject served as his/her own control. Differences between the initial value of AC/A ratio prior to drug administration and the value obtained after administering the drugs was regarded as the change in AC/A ratio. ANOVA was used to assess the level of significance and to determine the correlation co-efficient.

RESULTS

All the subjects had a normal NPC of 8–10cm and each subject served as his or her own control. The pupil size (diameter) of all the participants ranged between 3.0-4.0mm (mean 3.46±0.35mm), age range 18–30yrs (mean 20.5±2.6yrs). In Table 1, the effects of 4% pilocarpine ophthalmic solution on AC/A ratio are shown. The initial mean value of AC/A ratio prior to drug administration was (3.84±0.5) while the mean value after drug administration was (2.3±0.21) or 34.8% reduction. Table 2, shows the effects of 0.5% physostigmine ophthalmic solution on AC/A ratio. The mean initial value of AC/A ratio was 4.20±0.81 which decreased to (2.45±0.42) or 41.20% reduction after drug administration.

Table 1: Changes in AC/A Ratio following Topical Administration of 4.0% Pilocarpine Ophthalmic Solution.

AC/A Ratio before Pilocarpine	AC/A Ratio after Pilocarpine 4%	Change in AC/A	% Change in AC/A Ratio
5.0	4.0	1.0	20
4.5	1.0	3.5	77.78
2.5	1.0	1.5	60
4.5	3.0	1.5	33.33
4.0	2.5	1.5	37.5
3.5	2.0	1.5	42.86
3.0	2.0	1.0	33.33
5.0	2.5	2.5	50
4.0	2.5	1.5	37.5
3.0	2.5	0.5	16.67
3.5	2.0	1.5	42.86
3.0	2.5	0.5	16.67
3.3	2.0	1.3	39.39
4.0	3.0	1.0	25
4.0	3.0	1.0	25
3.0	2.0	1.0	33.33
4.5	3.0	1.5	33.33
4.0	2.5	1.5	37.5
5.0	4.0	1.0	20
Mean: 3.84	**2.3**	**1.34**	**34.82**

Table 2: Changes in AC/A Ratio following Topical Administration of 0.5% Physostigmine Ophthalmic Solution

AC/A Ratio before Physostigmine 0.5%	AC/A Ratio after Physostigmine. 0.5%	Change in AC/A Ratio	% Change in AC/A Ratio
6.5	2.0	4.5	69.23
3.0	2.0	1.0	33.33
4.5	3.5	1.0	22.22
3.0	2.5	0.5	16.67
5.0	3.0	2.0	40
3.0	2.0	1.0	33.33
5.0	3.5	1.5	30
4.0	2.5	1.5	37.5
4.0	2.0	2.0	50
5.0	3.0	2.0	40
4.0	2.5	1.5	37.5
3.0	2.0	1.0	33.33
4.0	2.0	1.5	37.5
3.5	2.0	1.5	42.86
4.5	2.5	2.0	44.44
4.5	3.0	1.5	33.33
4.0	2.5	1.5	37.5
3.0	1.5	1.5	50
4.0	3.0	1.0	25
6.5	2.0	4.5	69.33
Mean: 4.20	**2.45**	**1.73**	**39.12**

DISCUSSION

Parasympathetic miotics produce marked constriction or reduction in the size of the pupil or miosis, and would also cause a reduction in AC/A ratio as shown in the present study. Piolocarpine ophthalmic solution (4.0%) caused a mean percentage decrease in AC/A ratio of 34.8% while physostigmine ophthalmic solution (0.5%) caused a reduction in AC/A ratio of 41.2%. These changes are statistically significant at $p<0.01$. The cholinergic miotics decrease the AC/A ratio

because they facilitate neuromuscular transmission due to increased acetylcholine concentration so that a lower level of innervation is necessary to attain a given amount of accommodation which would activate less reflex convergence, hence reduction in AC/A ratio [8]. Pilocarpine is a direct acting cholinomimetic which binds directly on the ciliary body, facilitating transmission at the myoneural junction, activating muscarinic receptors in the eye causing miosis. On the other hand, physostgimine inhibits cholinesterase enzyme increasing endogenous acetylcholine and acts as amplifiers of acetylcholine which would activate muscarinic receptors in the eye causing miosis and a reduction in AC/A ratio. They reduce the central demand for accommodative innervations and therefore reduce the amount of convergence induced by accommodation. The concentration of acetylcholine in pilocarpine treated subjects was still being hydrolyzed by the cholinesterase, because of the presence of anticholinesterase, while such did not exist in subjects treated with physostigmine; and therefore the greater the concentration of acetylcholine the higher the percentage reduction in AC/A ratio[9,10]. By inhibiting acetylcholinesterase, physostigmine would increase the endogenous acetylcholine concentration in the synaptic clefts and neuroeffector junction and the excess acetylcholine in turn stimulates cholinoceptors in the ciliary body to evoke increased responses and in this case miosis and a reduction of AC/A ratio since physostigmine acts where acetylcholine is physiologically released and would amplify endogenous acetylcholine[11]. Accommodation and convergence are inter-related and they develop together so that a single clear image is appreciated. The ratio accommodative–convergence (AC) over accommodation (A) indicates the relationship between the amount of convergence produced by a stimulus (miotics) to accommodate and the amount of accommodation which produces that convergence [12]. The AC/A ratio is believed to be inborn and remains constant throughout life, independent of age and sex but varies greatly from individual to individual[13]. When humans accommodate to a near object they also converge their eyes and as a result constrict their pupils. However, the constriction of the pupils is not part of the process called lens accommodation. The combination of these three movements, accommodation, convergence and miosis is under the control of Edinger–Wesphal nucleus and is referred to as near triad or accommodation reflex[14] and can be modified by drugs or pharmacologically active agents. On statistical analysis of the results, the ratio was found to be the same for the same subjects for the different miotics. It was further observed that a unit change in the stimulus to accommodation resulted in a corresponding specific amount of change in the accommodative–convergence, that is, the relationship between AC and A was linear or positive co-relationship exists ($r = 0.37$).

CONCLUSION

The findings from this study have demonstrated that miotics, employed in routine optometric practice affect some principal functions of the visual mechanism, namely, accommodation, convergence and their ratio (AC/A) through the miotic-induced spasms. The miotic-induced spasm might affect other visual functions and adnexa in patients on whom these drugs are used for diagnostic or therapeutic purposes, hence eyecare providers should be on the watch-out for such miotic-induced (drug-induced) spasms during assessment or test of visual functions.

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