Pattern of Change in Accommodation and its Correlation with Mydriasis in Young Emmetropes After Instillation of Tropicamide Phenylephrine Eye Drops

Padma B Prabhu, Finu Amina, Fildha Kavungal Chevoyoor Kalathil, Kuzhippally Vallon Raju
Department of Ophthalmology, Govt Medical College, Kozhikode, Kerala, India

Summary
Cycloplegics relax accommodation by blocking the action of ciliary muscles. The mydriasis obtained with these drugs is expected to be related to the degree of cyclopia. This study evaluates the change in accommodation in young emmetropes and its correlation with mydriasis post instillation of tropicamide phenylephrine eye drops. A prospective descriptive study. Young adults of age group 18-22 years with uncorrected visual acuity of 6/6, near vision N6 and no asthenopic symptoms were included in the study. Age of the subject, NPA (near point of accommodation), NPC (near point of convergence), AA (accommodation amplitude), objective refraction with Autorefractometer, pupillary size and near vision (NV) were noted. The study group included 25 cases; mean age of 20.54 years (SD 1.046years). The amount of accommodation relaxed by drug ranged from 2.75D to 4.50 D. NPA, NPC, AA were inversely proportional to accommodation relaxed (p=0.00). The rate of change of pupillary dilatation and cycloplegia differed. The cycloplegic effect had a positive correlation with the increase in the visual angle; but was independent of the mydriatic effect. The effect on mydriasis and cycloplegia is not uniform and proportionate even among emmetropes of the same age group. It is affected by NPA, NPC, AA, age and SE (spherical equivalent) of the individual.

Keywords: accommodation, cycloplegics, mydriasis, tropicamide phenylephrine eye drops

Introduction
The maximum mydriatic effect of any cycloplegic agent often does not always correlate with complete cycloplegia. This results in errors during objective refraction. In this context, present study was undertaken to evaluate change in accommodation in young emmetropes and its correlation with mydriasis post instillation of a frequently used cycloplegic mydriatic, tropicamide phenylephrine eye drops.

Materials and Methods
This was a prospective descriptive study done after the approval of institutional ethical committee. The study period was 6 months. Young adults of age group 18-22 years (mean 20 years) with uncorrected visual acuity of 6/6, near vision N6 and no asthenopic symptoms, were included in the study. All consecutive cases were selected. Subject’s age, NPA (near point of accommodation), NPC (near point of convergence), AA (accommodation amplitude), objective refraction with Autorefractometer, pupillary size and near vision (NV) were noted. NPA, NPC, AA and corresponding age were measured using RAF (Royal Air Force) ruler. Refractive power was measured by Shin Nippon Accuref k9001 autorefractometer and spherical equivalent was calculated. The readings ≤ 0.25D were ignored. Near vision was measured using Snellen’s reduced near visual acuity chart and was noted in terms of visual angle. Pupillary size was measured using optician’s ruler. After these initial measurements, a single drop of Tropicamide (1%) phenylephrine (2.5%) combination was instilled in each eye. Pupillary size and near vision were noted every 10 minutes till 40 minutes. Topical Tropicamide (1%) phenylephrine (2.5%) formulation is expected to start its action by 10-15 minutes, peak effect is seen 20-40 minutes post instillation and the effect lasts up to 6hours. The values obtained at the end of 40 minutes were taken for uniformity and to ensure complete cycloplegia. Once the cycloplegic effect had weaned off, fogging for near was done. The power of convex lenses was increased in 0.25D increments to reduce the near vision up to the same visual angle found 40 minutes post instillation of the drug. This indirectly measured the amount of accommodation relaxed by the drug. Statistical analysis was performed using SPSS version 18. P value <0.05 was taken as significant. Student t test was done to compare means.

Results
The study group included 25 cases with a mean age of 20.54 years (SD 1.046years).The mean spherical equivalent was 0.55 D (SD 0.587D).The details of measured parameters, i.e NPA, NPC, AA and the amount of accommodation relaxed by the drug are given in. (Table 1) The pupillary size of the subjects at the start of drug instillation (P0) ranged from 2.5 to 5 mm with a mean of 3.36 mm (SD 0.9074mm). The pupillary dilation after 40 minutes of drug instillation (P4) ranged from 6 to 10 mm with a mean of 7.70 mm (SD 1.080). NV in terms of visual angle was found to be 20º prior to drug instillation (NV0). Visual angle at maximum pupillary dilation (NV4) ranged from 20º to 80º with a mean of 4.50 (SD 1.790). The amount of accommodation relaxed by the drug ranged from 2.75D to 4.50D. NPA, NPC, AA were inversely proportional to accommodation relaxed by drug, as expected. The increase in pupillary diameter and increase in the visual angle at 10, 20, 30 and 40 minutes post-
instillation of the drug were compared. It was found to have a linear relation as given in (Figure 1). However the rate of change of either factor differed. The cycloplegic effect had a positive correlation with the decline in the visual angle, but was independent of the mydriatic effect.

Discussion

Topical Cycloplegics agents, in the order of decreasing potency are atropine, homatropine, cyclopentolate and tropicamide. Although atropine and homatropine are more potent drugs which ensure complete cycloplegia, but the need for multiple instillations, prolonged action of the drug incapacitating the subject and presence of local as well as systemic side effects, limit the use of these drugs in routine clinical practice.1,2 Hence, though less effective, short acting cycloplegic like Tropicamide is often chosen for retinoscopy owing to its rapid and short duration of action.

It is expected that the maximum cycloplegia due to tropicamide occurs within twenty minutes post-instillation and is sustained for forty minutes.2 We observed that the drug effect though showed an initial peak at twenty minutes but continued to act linearly till forty minutes. Both pupillary dilatation and cycloplegia increased progressively without a plateau. This observation was statistically significant.

Normal NPA for a mean age of 20 years is 9cm.3 It ranges from 8-10 cm during the age group 15-25 years. In our study the mean NPA was marginally higher than the normal depicted value. Similar changes were noted in the mean amplitude of accommodation. It suggests that even among emmetropes, NPA and AA can differ. Normative data has to be defined for each population. Factors other than age which influences the absolute value of NPA have to be evaluated. The normal value for NPC ranges from 5 to 10 cm.4 It is not clear whether NPC remains constant throughout life. In our study, NPC ranged from 9 to 13 cm. NPC may be determined by factors such as facial features, racial and ethnic characteristics and orbital structure and volume.4,6 Effect of age and emmetropic status on NPC has to be studied.

Pupillary dilation showed a positive correlation with the cycloplegic effect as evidenced by increase in visual angle. As pupillary dilation increased, cycloplegia also increased. However, this relation was not uniform and proportionate. This could be accounted by the combined effect of tropicamide and phenylephrine. Richdale et al reported that low-dose (2.5%) phenylephrine does not affect ciliary muscle dimensions, ciliary muscle contractility, or accommodative response to a D near target.7 Visual angle, though similar in the pre-instillation stage, varied at the end of forty minutes. The cycloplegic effect had a positive correlation with the spherical equivalent and negative correlation with NPA, NPC, AA and age of the individual. This indicates that eventually, multiple factors as mentioned above may have their impact on the drug effect. Ciliary muscle thickness as a predictor of accommodation has been suggested by authors like Lewis et al and Lossing et al.8,9 The role of such an observation in determining the values of NPA, NPC, AA and drug effect has to be elucidated.

Lack of comparison with other cycloplegics (cyclopentolate and homatropine), small sample size, elimination of those with > 2D SE and absence of a comparative normative study, were the major limitations. Further NPA, NPC, AA were not assessed post instillation of the drug. Nevertheless this work may be considered as a pilot study and can form the basis for broader work on formulating normative data.

Table 2. Details of NPC, NPA, AA and cycloplegic effect obtained

| Parameters                | Mean  | SD      |
|---------------------------|-------|---------|
| NPC (cms)                 | 9.16  | 1.434   |
| NPA (cms)                 | 9.88  | 1.453   |
| AA (D)                    | 10.20 | 1.633   |
| Corresponding age (years) | 22.40 | 4.359   |
| Accomodation relaxed by drug (D) | 3.75 | 0.568   |

Table 2. Relation between accommodation relaxed by the drug and age of the subject, spherical equivalent and equivalent age based on the NPA value. ** - significant p value. CI – 95% confidence interval. D - dioptre

| Accomodation relaxed by the drug | 2.50 D | 3.00D | 3.50 D | 3.75 D | 4.00 D | 4.50 D | P value | Upper | CI       |
|---------------------------------|--------|-------|--------|--------|--------|--------|---------|-------|----------|
| Mean age years                  | 21     | 20.50 | 20.42  | 19.5   | 21.5   | 20.5   | 0.000** | -17.26| -16.27   |
| Spherical equivalent (D)        | 0.5    | 0.375 | 0.732  | 1.062  | 0.437  | 0.167  | 0.000** | 2.81  | 3.57     |
| Equivalent age based on NPA value | 30     | 25    | 22.14  | 23.75  | 17.5   | 21.66  | 0.000** | -20.57| -16.72   |

Figure 1: Pupillary dilatation and increase in visual angle. X axis represents the duration in minutes and y axis represents the pupillary dilatation in millimeters as well as visual angle in degrees for near vision (NV).
Conclusion
Pupillary dilatation and cycloplegia of tropicamide phenylephrine progressively increases up to forty minutes post-instillation among young emmetropes. The effect on mydriasis and cycloplegia is not uniform and proportionate. It is affected by NPA, NPC, AA, age and spherical equivalent of the individual. Marginally higher values of NPA, NPC and AA in our study indicates the need to define normative data among Indian population.

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Corresponding author:
Padma B. Prabhu
Associate Professor, Department of Ophthalmology,
Govt Medical College, Kozhikode, Kerala
Email: padmapraveen@gmail.com