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Comparison of subjective and objective accommodation amplitude values

Şerife Gülhan Konuk[1], Raşit Kılıç[1], Emre Kuyucu[2]

[1]Department of Ophthalmology, Faculty of Medicine, Tokat Gaziosmanpaşa University Tokat, Turkey
[2]Department of Biostatistics, Faculty of Medicine, Tokat Gaziosmanpaşa University, Tokat, Turkey

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ABSTRACT

Aim: Comparison of accommodation amplitude values measured using autorefractometer, push up and minus lens technique.

Material and Method: In this randomized, prospective study, both eyes of 75 healthy individuals between the ages of 15 and 40 were included in the study. They were divided into 5 groups as 15-20 age group 1, 21-25 age group 2, 26-30 age group 3, 31-35 age group 4, 36-40 age group 5 To measure the accommodation amplitude, the minus lens and push up technique were used as subjective methods, and the autorefractometer Tonoref III was used as the objective. The correlation between the measurement methods and the reproducibility of the autorefractory measurements were evaluated. In addition, changes in accommodation measurements with age, gender and pupil diameter changes were investigated.

Results: The mean accommodation amplitude values were 4.86±1.73 D in the minus lens technique, 8.79±4.58 D in the push up technique, and 2.77±1.93 D in the autorefractometer measurement. Autorefractometer accommodation amplitude values were found to decrease significantly with age (p=0.000). It was seen that the correlation between autorefractometry and subjective methods, minus lens and push up was significant and correlated (p=0.000, r=0.47, p=0.001, r=0.28, respectively). Intraclass correlation coefficients of Tonoref III accommodation amplitude were found to be 0.935.

Conclusion: Objective accommodation amplitude measurements made using Tonoref III were found to be correlated with subjective methods, but lower values were detected compared to subjective methods.

Keywords: Minus lens technique, push up technique, amplitude of accommodation

INTRODUCTION

Accommodation is a natural optical mechanism that improves the retinal image quality of nearby objects. In accommodation, the refractive power changes due to the shape change of the crystalline lens caused by contraction of the ciliary muscles (1). The research of accommodation dates back to the 1800s with the subjective push up technique. Hofstetter (2) argued that accommodation amplitude (AA) decreases linearly with age. For clinical purposes, Hofstetter combined the data to give clinicians an estimate of what the norms should be for each age group (age range, 8 to 80 years).

Based on these classical studies, many clinicians have concluded that humans have the greatest amount of AA at birth, then steadily decline until there is none.

Objective and subjective methods are used in the measurement of AA. Among the objective methods, there are dynamic retinoscopy (DR), aberrometers and autorefractometers that can be used in the clinic (3,4). Subjective techniques include push up (PU), push down (PD) and "minus lens (ML)" methods (5,6). However, the subjective methods used are not suitable for the definitive evaluation of AA. Objective accommodation tests can distinguish true accommodation in the optical power of the eye from pseudoaccommodation or other possible confounding factors. Subjective testing may result in a different measurement than it is due to ocular aberration, small pupil diameter, and active accommodation (7).

With this study, we aimed to evaluate the reproducibility and compatibility with age and gender in the use of Tonoref III (NIDEK Co., Ltd.). The use of methods in measuring AA was evaluated. In addition, we investigated comparing Tonoref III with ML and PU methods and the relationship between changes in pupil diameter.

Corresponding Author: Şerife Gülhan Konuk, gulhan3855@hotmail.com
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MATERIAL AND METHOD

The study was carried out with the permission of Tokat Gaziosmanpaşa University Medical Faculty Clinical Researches Ethics Committee (Date: 01.10.2020, Decision No: 20-KAEK-244). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

A signed informed consent was obtained from all participants before the study. Between January 2022 and June 2022, eye examination was applied to 75 healthy volunteers. Both eyes of volunteers aged between 15 and 40 were included in the study.

Participants were divided into five groups according to their age. The 1st group was 15-20 years old, 2nd group was 21-25 years old, 3rd group was 26-30 years old, 4th group was 31-35 years old, 5 groups was 36-40 years old. AA measurements made with objective and subjective methods were recorded.

A detailed ophthalmological examination including best corrected visual acuity with Snellen chart, anterior segment and fundus examination with slit lamp biomicroscopy, and intraocular pressure determination with Goldmann applanation tonometry was performed for each patient. AA was measured and recorded with a minus lens, pull-up technique, and autorefractometer Tonoref III. All measurements were made in the same time period (between 09.00-12.00 hours) and under the same environmental condition. Two consecutive measurements were made and the average of the measurements was recorded as AA.

Patients with a visual acuity of less than 20/25, refractive error with a spherical refractive error of more than ±5.0 diopters or a cylindrical value of more than 2.0 diopters, anisometropia, amblyopia, a history of significant ocular trauma, surgery or disease were excluded from the study (8). In addition, patients using drugs that may affect accommodation such as topical cycloplegics, phenothiazines, tricyclic antidepressants and antivertigo drugs were excluded from the study.

Objective Method

The Tonoref III autorefractometer device was used to objectively measure the AA. The device measures the change in pupil diameter from 3 to 8 mm with 1 mm increments. It also measures AA between 0-10 D. Only the central area is used in accommodation. The measurement ends when there is no change in accommodation for more than 6 seconds, or when the measurement time reaches 30 seconds.

During the measurement, the participants were asked to place their chin and forehead on the device and not move their heads. In addition, they were informed about carefully looking at and following the target inside the device. The measurement key was pressed for AA measurements. AA and maximum and minimum pupil diameter were analyzed. The measurement was repeated after a 10-minute rest period.

Subjective Method

ML and PU techniques were used to evaluate the accommodation amplitude subjectively. Refractive errors of all participants were corrected. They were asked to fixate on the N8 target, which consists of the letters Snellen at a distance of 40 cm.

In the ML technique, minus lenses were added at intervals of 10 seconds in increments of 0.25 D. The value at which the clarity of the participants deteriorated was recorded. All measurements were made monocular in both eyes. Total AA was determined as the sum of +2.50 D (dioptric equivalent of working distance) plus minus lens power added to the total.

In the PU technique, the letters that were focused at 40 cm were zoomed in slowly. And at the point where the participants started to see blurred, the distance from the target to the plane of the glasses was measured with a millimeter ruler and converted to diopters.

Statistical Analysis

Statistical evaluation of the data was performed using the Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics were presented as mean±standard deviation or n (%). The conformity of the data to the normal distribution was evaluated with histogram, Q-Q plots and Shapiro-Wilk test. Since all the data were not normally distributed, Mann-Whitney U was used for paired group comparisons and Kruskal Wallis H tests were used for multiple group comparisons. Correlation coefficients of fit were calculated with 95% confidence interval. The relationship between quantitative data was evaluated with Spearman correlation analysis. Significance level was accepted as $p<0.05$.

RESULTS

This study included a total of 150 eyes of the 75 patients. Of the 75 patients, 43 (57.3%) were female and 32 (42.7%) were male. The mean age of women was 26.7±8.0 and the mean age of men was 29.0±7.1 (p=0.07) (15-40 years). Best corrected visual acuity of all participants was 20/20 or better. The mean axial length was 22.18±0.45 mm and its mean spherical equivalent was -1.06±1.3 D.

Mean AA was found to be 2.77±1.93 D (0.31- 9.56 D) in measurements performed with Tonoref III. There was a linear decrease from group 1 to 5. There was a significant difference between the groups (p=0.000) (**Table 1**) (**Figure**). As age increased, the accommodation value

decreased. In the measurements made using Tonoref III, it was seen that the AA value of men was 1.88±1.33 and the AA value of women was 3.47±2.05. There was a significant difference between the two genders (p≤0.000). The mean pupil diameter values were found to be 5.50±1.04. In addition, it was determined that the pupil diameter decreased proportionally as the AA increased. However, no significant difference was observed between the groups (p=0.063) (**Table 1**).

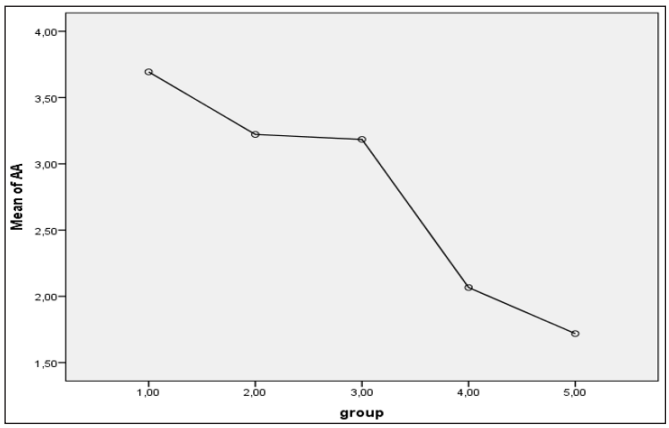

Figure. Change of mean accommodative amplitude value in groups with Tonoref III

Table 1. The mean accommodation amplitude values and pupil size in groups

	Tonoref III (D)	Pupil Size (mm)	ML	PU
Group 1	3.69±1.89	5.81±1.05	5.00±1.87	9.49±3.89
Group 2	3.22±2.35	5.65±1.29	4.81±1.40	10.25±3.61
Group 3	3.18±2.01	5.64±0.94	5.50±1.46	9.71±3.77
Group 4	2.06±1.40	5.14±0.99	4.80±1.99	7.54±5.52
Group 5	1.71±1.10	5.27±0.79	3.97±1.51	7.68±5.14
Total	2.77±1.93	5.50±1.04	4.86±1.73	8.79±4.58
P	0.00*	0.063	0.005*	0.003*

*Statistically significant, AA= accommodation amplitude, D=Diopri, ML=minus lens, PU=push up

While the mean AA value measured with the minus lens technique was 4.86±1.73 D, the AA value measured with the push up method was 8.79±4.58 Subjectively measured AA values were higher than the objectively measured autorefractometer AA values (**Table 1**). When the correlation between the ML, PU technique and the AA values measured with the autorefractometer was examined, it was seen that the difference was statistically significant, but there was a moderate correlation with ML and a weak correlation with the PU method (respectively p=0.000, r=0,43; p=0.001, r=0,28). It was found that there was a significant relationship between pupil diameter change and tonoref AA, but the correlation was moderate (p=0.00, r=3.91). In the Tonoref III AA method, the intraclass correlation coefficient (ICC) value between the two measurements was 0.935 (0.909-0.953).

DISCUSSION

The most important factor affecting AA is age (7). Decreased with age, AA presents with blurry vision and eye fatigue when looking at near objects around the age of 40. In addition, diabetes mellitus, Down syndrome, drug use such as topiramate may cause early deterioration in AA and trigger early presbyopia (9-12).

Presbyopia is a global problem and affects millions of people around the world. Near vision can be clarified with glasses or contact lenses. In recent years, surgical methods have been added to treatment options. In addition, studies using electrostimulation of the ciliary muscle to restore accommodation and studies on medical treatments are continuing (13). Accurate measurement of AA is required in order to reach the correct conclusion about the effectiveness of surgical methods and medical treatments. And it is important to determine whether accommodation and true diopter of AA decrease in early presbyopia.

For the evaluation of accommodation in clinical practice, the most frequently used methods are ML technique, PU and push down methods. Hofstetter (2) published data for the linearly decreasing estimated AA between the ages of 8 and 80 years for use by clinicians in the clinic with the PU method. Large dioptric errors can occur when measuring at close working distances in the push up method. In particular, moving the target too fast or not understanding the concept of the initial blur endpoint can cause errors (14). In the ML technique, inaccurate measurements can be obtained when there is a rapid transition between measurements or when the ambient light is not clear and high refractive errors.

There are various studies in the literature comparing objective and subjective methods. In a study comparing the AA values measured by using dynamic retinoscopy, subjective ML technique and push down method as an objective method, it was seen that the AA values measured with the objective method, as in our study, were lower than other methods. In addition, when the correlation coefficients of agreement between the objective method and both subjective methods were evaluated, it was observed that there was a significant weak agreement (4). Kurt et al. (15) used ML, focus meter, pilocarpine and Hartinger refractometer to compare objective and subjective AA methods. It has been stated that AA measured by subjective methods is higher than by objective methods. The reason for this is that subjectively measured AA measures the best near vision capacity instead of actual accommodation. But with objective measurements, changes in optical power can be measured directly. When we compared Tonoref III and subjective tests in our study, it was seen that Tonoref III had lower values.

The AA values of the genders were compared in our study. It was seen that there was significant difference. When the effect of gender adjustment on AA was considered in previous studies, it is seen that it is a controversial factor. In our study, mean AA in women was significantly higher than in men. Although there was no significant age difference between men and women, the ages of women were lower. There may be a difference due to this. In other studies, it is argued that many factors such as education and nutrition may have led to the difference between genders (16,17).

When the objective AA measurement is compared with the subjective AA measurement, one of the differences is that the pupil diameter cannot be measured in the subjective method. Pupil diameter is one of the important parameters in accommodation. Accommodation occurs together with convergence and miosis. With the reduction of the pupillary diameter, a decrease in optical aberration is observed and image clarity is provided (18). In our study, there was a significant difference between pupil diameter change and AA measurement. In addition, the pupil diameter decreases with age. In the study by Ozulken et al. (19), it was reported that the pupil diameter decreased with age, as in our study.

Intraclass correlation coefficient greater than 0.9 means excellent reproducibility (20). When comparing repeat measurements of AA values, Weng et al. (21) argued that Tonoref III is reproducible and reliable. In our study, the high intraclass correlation coefficient supports that it is a reproducible and reliable test.

Our study has some limitations. We could not compare our results with other objective methods. And our study was done on healthy patients who do not have presbyopia. Patients with presbyopia could be included in the study.

CONCLUSION

As a result, Tonoref III was found to be lower in AA measurements compared to the subjective methods. It was found to have good repeatability. Our results showed that AA was significantly associated with age, changes in pupil size during accommodation and gender.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Tokat Gaziosmanpaşa University Medical Faculty Clinical Researches Ethics Committee (Date: 01.10.2020, Decision No: 20-KAEK-244).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

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