Accommodation in phakic and pseudophakic eyes measured with subjective and objective methods

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PURPOSE: To measure accommodation subjectively and objectively and assess anterior segment changes during accommodation in phakic eyes and pseudophakic eyes.

SETTING: Department of Ophthalmology, Medical Health and Science Centre, University of Debrecen, Debrecen, Hungary.

DESIGN: Case series.

METHODS: Subjective and objective accommodation measurements and pupillometry were performed in phakic and pseudophakic patients. Refraction and pupil diameter were recorded with different accommodation stimuli. Corneal higher-order aberrations (HOAs) and anterior chamber depths (ACDs) were detected with a rotating Scheimpflug camera.

RESULTS: The mean age of the 44 patients in the phakic group was 36.34 years $\pm$ 16.6 (SD) and of the 27 patients in the pseudophakic group, 69.3 $\pm$ 9.98 years. The mean subjective accommodation was 4.49 $\pm$ 3.48 diopters (D) in phakic eyes and showed significant correlation with age, spherical aberration, changes in pupil diameter, and ACD. The mean subjective accommodation was 0.50 $\pm$ 0.28 D in pseudophakic eyes. In phakic eyes, the mean objective accommodation was 0.46 $\pm$ 1.02 D, 1.06 $\pm$ 1.33 D, and 2.2 $\pm$ 1.9 D with 2.0 D, 3.0 D, and 5.0 D, respectively, of stimulus. In pseudophakic eyes, measurable objective accommodation was recorded. In phakic eyes, the correlations were significant between these values and age, changes in ACD, pupil size, and corneal spherical aberration. In pseudophakic eyes, the only correlation was with the spherical equivalent value.

CONCLUSIONS: The magnitude of accommodation was greater with subjective measures than objective measures. In pseudophakic eyes, senile miosis and HOAs can be regarded as underlying factors in subjective accommodation; however, objective accommodation is not clinically significant.

Financial Disclosure: No author has a financial or proprietary interest in any material or method mentioned.

J Cataract Refract Surg 2013; ■:■–■ © *2013 ASCRS and ESCRS*

The accommodation of a human eye involves an increase in the dioptric power when focusing on a near object. Several controversial theories on the accommodative process have been proposed.[1–3] At present, one of the greatest challenges in ophthalmology is to restore the significantly declining and finally ceasing accommodation in presbyopic eyes by surgical means. It is of great importance to measure accommodation and to distinguish between subjective accommodation and objective accommodation. This allows assessment of the surgical effects on presbyopia[4,5] and of the effects of different intraocular lens (IOL) types. To gain a full understanding of the accommodative process in the long run, an accurate, repetitive, and reliable measurement is indispensable. Accommodation measurements can be performed using subjective[6,7] and objective[8–10] methods. Our goal was to evaluate and compare the amplitude of accommodation and changes in pupil size measured subjectively and objectively with a binocular open-field autorefractor/keratometer in phakic eyes and pseudophakic eyes and to observe anterior segment changes during accommodation using Scheimpflug imaging.

PATIENTS AND METHODS

In this study, all procedures adhered to the tenets of the Declaration of Helsinki and were approved by a local ethics committee. All participants provided informed consent. The

0886-3350/$ - see front matter
http://dx.doi.org/10.1016/j.jcrs.2013.04.030

inclusion criteria were a spherical refractive error less than 3.0 diopters (D) and a cylindrical refractive error less than 2.0 D in both eyes, no previous intraocular surgery except cataract surgery, and contact lens use.

Before the accommodation measurements in each eye, the subjective refractive error was tested. Then, the keratometry, axial length (AL), and anterior chamber depth (ACD) were assessed using 3 repeated measurements with partial coherence interferometry (PCI) (IOLMaster, software version 5.4, Carl Zeiss Meditec AG). When the keratometric data were evaluated, the degree of corneal astigmatism was defined as against the rule (ATR) when the steeper corneal curvature measured between 0 degree and 30 degrees and between 150 degrees and 180 degrees, oblique when the steeper corneal curvature measured between 30 degrees and 60 degrees and between 120 degrees and 150 degrees, and with the rule (WTR) when the steeper corneal curvature measured between 60 degrees and 120 degrees. Three tests were performed in the order shown below.

Method 1: Subjective Accommodation Test

Under standard room illumination (Eurolite Luxmeter LM-50) and mesopic conditions (ranging from 5 to 15 lux), the patient was seated with a full-distance refractive correction while viewing the smallest letter representing a 100% correct response on the visual acuity chart. Next, gradually increasing minus-power lenses in 0.25 D steps were added (minus-lenses-to-blur method), thus stimulating and measuring accommodation, until the patient was unable to recognize the letter representing 100% visual acuity. This added diopter was defined as the amplitude of accommodation.

Method 2: Objective Accommodation Test and Pupillometry

Measurements were performed with a WAM-5500 binocular autorefractor/keratometer (Grand Seiko Co., Ltd.). The device is an open-field autorefractor with an infrared pupillometry function. The patient was seated with his or her head supported and looked at a real target through a view window with both eyes. The fixation point is not a built-in light source as in most ophthalmology equipment. The distant refractive state was obtained and the pupil size measured by asking the patient to fixate on a target (a black star on a white sheet) placed 5 m from the window. For measurements at a near viewing distance, the patient looked at the target of a black star on a white sheet hanging from the ruler attached to the upper part of the window at 50 cm, 33 cm, and 20 cm.

During examination, the patient viewed stimuli binocularly; however, only 1 eye was examined at a time and the patient was unaware of which eye was being examined. During the examination, the operator kept the pupil in focus on the screen with the help of the joystick. Measurements were obtained automatically in the case of centrally adjusted pupils. In each case, 3 repeated measurements were taken with the adjustments; that is, there was a sensitivity of 0.01 D and a 0.0 mm vertex distance for measured refractions. Refractive results (spherical and cylindrical with axis) and pupil sizes were also recorded for further calculations. The lighting in the examination room ranged between 5 lux and 15 lux at the eye level and was measured with the lux meter.

Method 3: Measurement of Anterior Segment Parameters and Changes

Three images were obtained for each eye with the high-resolution Pentacam HR device (Oculus Optikgeräte GmbH). The device is based on the rotating Scheimpflug imaging technique with a distant 0.0 D adjustment in 25 images/sec mode. The red, flashing circle target of the device was modified by the built-in diopter scale, as described previously.[11] This adjusted power is required for the ocular focusing of the target with the accommodation. The patient was instructed to focus on the target continuously while the camera was rotating and capturing the images. Three images were also obtained with 2.0 D, 3.0 D, and 5.0 D of stimuli. The following data were recorded for further calculations: the ACD, corneal total root mean square (RMS), corneal higher-order aberrations (HOAs) RMS, and spherical aberration of the cornea.

In the pseudophakic group, measurements were taken after aspheric monofocal IOL (Ar40e, Abbott Medical Optics, Inc.) implantation at least half a year after surgery and after the refraction was considered stable. The same experienced ophthalmologist performed each measurement.

Statistical Analysis

Statistical analysis was performed with Medcalc software (version 10.0, Medcalc Software). Descriptive statistical results were described as the mean, standard deviation (SD), and 95% confidence interval (CI) of the mean. The normality of the data was assessed using the Kolmogorov-Smirnov test. If the normality was rejected ($P<.05$), a nonparametric test was used. The Mann-Whitney U test was used for comparisons between groups or variables and the Spearman rank test for the correlation. A P value less than .05 was considered statistically significant. Bland-Altman plots were created to estimate the agreement between measurement techniques, and the 95% limits of agreement (LoA) were calculated as the mean $\pm$1.95 SD of the difference. On the Bland-Altman graphs, the central line represents the mean of the intraindividual differences and the broken lines represent the 95% LoA.

RESULTS

Forty-four phakic patients and 27 pseudophakic patients were examined in the study. The mean age was 36.34 years $\pm$16.6 (SD) (95% CI, 32.8 to 39.8; range 19 to 75 years) in the phakic group and 69.3 $\pm$ 9.98 years (95% CI, 66.54 to 72.05; range 20 to 84 years) in the pseudophakic group ($P<.01$). The mean AL measured by PCI was 23.41 $\pm$ 1.02 mm (95% CI,

Submitted: January 25, 2013.
Final revision submitted: April 9, 2013.
Accepted: April 9, 2013.

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23.192 to 23.63; range 21.34 to 26.37 mm) in the phakic group and 23.16 ± 1.14 mm (95% CI, 22.84 to 23.47; range 21.16 to 26.3) in the pseudophakic group (P=.63). The mean ACD measured by PCI was 3.43 ± 0.41 mm (95% CI, 3.34 to 3.52; range 2.17 to 4.33 mm) in the phakic group. In the phakic group, WTR astigmatism was identified in 73 cases (82.9%), ATR in 4 cases (4.6%), and oblique in 11 cases (12.5%). In the pseudophakic group, WTR was found in 27 cases (50.0%), ATR in 17 cases (31.5%), and oblique in 10 cases (18.5%). No correlation was found between the amplitude of subjective accommodation and the direction of astigmatism (P=.28, analysis of variance [ANOVA]).

Method 1: Subjective Accommodation Test

The mean subjective accommodation in phakic eyes was 4.49 ± 3.48 D (95% CI, 3.74-5.24; range 0.0 to 12.0 D). It was significantly correlated with age ($r = -0.8$, $P<.001$), corneal spherical aberration ($r = -0.25$, P=.02), resting pupil diameter ($r = 0.46$, $P<.001$), and ACD ($r = 0.41$, $P<.001$) as well as with the changes in pupil diameter ($r = -0.25$, P=.01) and ACD ($r = -0.39$, $P<.001$) during accommodation.

The mean subjective accommodation in pseudophakic eyes was 0.50 ± 0.28 D (95% CI, 0.42-0.58; range 0.0 to 1.0 D). There were no significant correlations with any parameter mentioned above.

Method 2: Objective Accommodation Measurement and Pupillometry

In phakic eyes, the mean objective accommodation was 0.46 ± 1.02 D with 2.0 D of stimulus, 1.06 ± 1.33 D with 3.0 D of stimulus, and 2.2 ± 1.9 D with 5.0 D of stimulus ($P<.001$, ANOVA) (Figure 1). There was a correlation between these values and age ($r > 0.7$, $P<.001$); the magnitude of astigmatism ($r > 0.4$, $P<.001$); resting ACD ($r < -0.5$, $P<.001$); total RMS cornea ($r > 0.25$, $P<.01$); changes in ACD ($r > 0.3$, $P<.01$), pupil size ($r > 0.25$, $P<.01$), and corneal spherical aberration ($r > 0.35$, $P<.001$); and spherical aberration changes detected during accommodation ($r < -0.3$, $P<.01$).

In pseudophakic eyes, the mean objective accommodation was 0.23 ± 0.4 D with 2.0 D of stimulus, 0.13 ± 0.5 D with 3.0 D of stimulus, and 0.12 ± 0.5 D with 5.0 D of stimulus (P=.55, ANOVA) (Figure 2). The rate of objective accommodation with induced stimuli exceeded 0.50 D in 8 pseudophakic cases (29.6%); these eyes also showed higher subjective accommodation (mean 0.69 ± 0.53 D). Regarding objective accommodation, no significant correlation was found with the parameters mentioned above. However, a correlation with spherical aberration values was seen ($r > 0.3$, $P<.001$).

The mean resting pupil diameter was 5.54 ± 1.03 mm (95% CI, 5.31 to 5.78; range 2.9 to 7.6 mm) in phakic eyes and 3.94 ± 0.86 mm (95% CI, 3.69 to 4.19; range 2.5 to 5.8 mm) in pseudophakic eyes ($P<.001$). With a full 5.0 D of stimulus, the mean changes in pupil diameter were −0.69 ± 0.74 mm (95% CI, −0.85 to −0.52; range −3.2 to 0.8 mm) in phakic eyes and −0.9 ± 1.46 mm (95% CI, −1.33 to −0.47; range −5.60 mm to 0.93 mm) in pseudophakic eyes (P=.26).

The subjective method significantly overestimated the amplitude of accommodation measured objectively in phakic eyes and in pseudophakic eyes. Moreover, the results of both methods correlated well

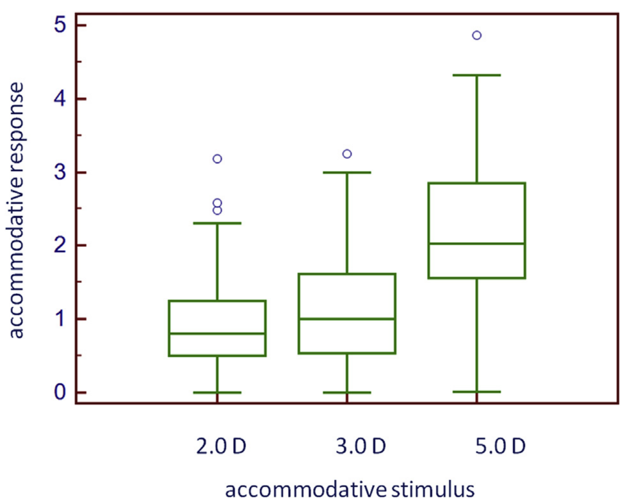

Figure 1. Objective accommodation values with 2.0 D, 3.0 D, and 5.0 D of stimuli measured with the autorefractor/keratometer in phakic eyes (P=.01, ANOVA).

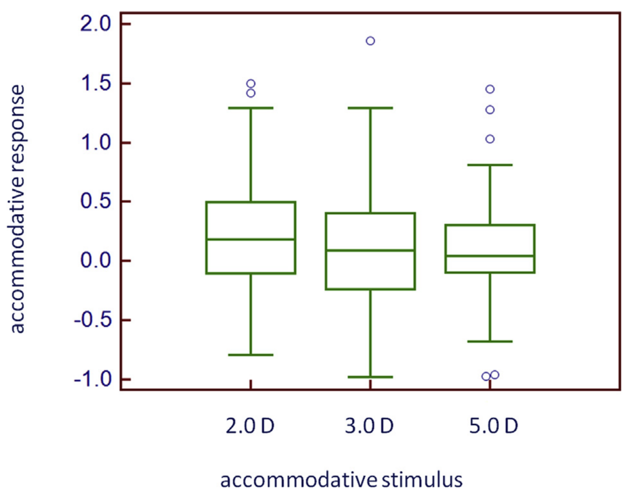

Figure 2. Objective accommodation values with 2.0 D, 3.0 D, and 5.0 D of stimuli measured with the autorefractor/keratometer in pseudophakic eyes (P=.55, ANOVA).

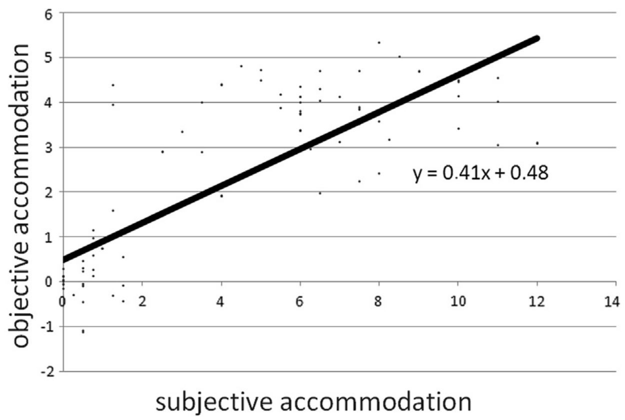

Figure 3. Correlation between subjective and objective accommodation based on Spearman correlation in phakic eyes ($r = 0.76$, $P<.001$).

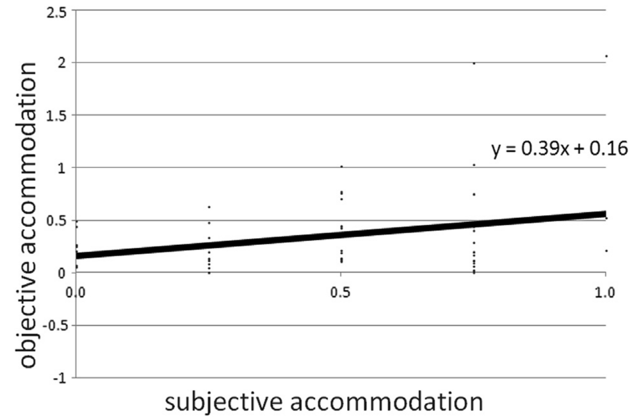

Figure 4. Correlation between subjective and objective accommodation based on Spearman correlation in pseudophakic eyes ($r = 0.05$, $P=.73$).

in phakic eyes ($r = 0.76$, $P<.001$) (Figure 3) and showed no statistically significant correlation in pseudophakic eyes ($r = 0.05$, $P=.73$) (Figure 4). Nonetheless, a comparison of the 2 methods showed good agreement (Figures 5 and 6).

The mean accommodative lag was 2.68 ± 2.28 D (95% CI, 2.19 to 3.17; range 0.0 to 9.2 D) in the phakic group and 4.93 ± 0.68 D (95% CI, 4.74 to 5.12; range 3.20 to 7.02 D) in the pseudophakic group ($P<.001$). Its value correlated well with age in the phakic group ($r = 0.85$, $P<.001$) and was borderline significant in the pseudophakic group ($r = 0.26$, $P=.05$).

Method 3: Measurement of Anterior Segment Parameters and Changes

The mean change in ACD measured with the rotating Scheimpflug camera during the entire accommodation process was −0.02 ± 0.05 mm (95% CI, −0.03 to −0.01; range 0.05 to −0.25 mm) in the phakic group and −0.04 ± 0.19 mm (95% CI, 0.19 to −0.5; range −0.50 to 0.43 mm) in the pseudophakic group ($P=.28$). In 15 pseudophakic cases (27.7%), an effective IOL shift of more than 0.3 mm was observed.

In phakic eyes, the mean corneal total RMS was 1.82 ± 1.05 μm (95% CI, 1.6 to 2.05; range 0.78 to 6.80 μm) at distance vision and 1.74 ± 0.64 μm (95% CI, 1.6 to 1.88; range 0.72 to 5.46 μm) at near vision with a 5.0 D stimulus ($P=.45$). The RMS value was statistically significantly higher in pseudophakic eyes than in phakic eyes ($P<.001$). At distance vision, the mean total corneal RMS was 3.15 ± 2.18 μm (95% CI, 2.55 to 3.75; range 1.01 to 11.88 μm) and at near vision with 5.0 D of stimulus, 2.97 ± 1.82 μm (95% CI, 2.44 to 3.49; range 0.91 to 7.50 μm) ($P=.51$).

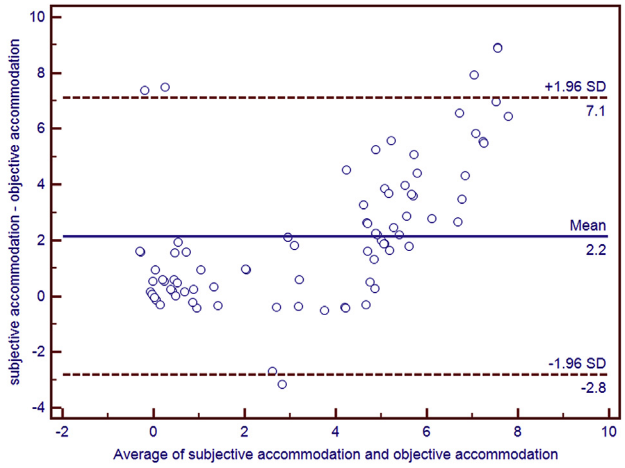

Figure 5. Difference in accommodation response measurements between subjective (minus-lenses-to-blur) and objective (autorefractor/keratometer) techniques against their mean in the phakic group (Bland-Altman plot).

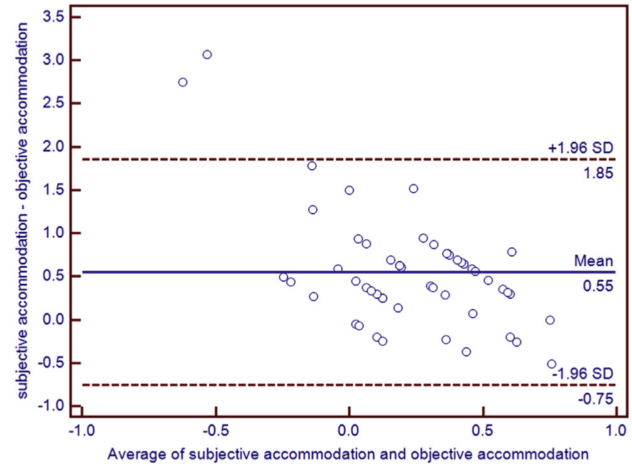

Figure 6. Difference in accommodation response measurements between subjective (minus-lenses-to-blur) and objective (autorefractor/keratometer) techniques against their mean in the pseudophakic group (Bland-Altman plot).

The corneal HOA RMS values were statistically significantly higher in pseudophakic eyes than in phakic eyes ($P<.001$). The mean total corneal HOA RMS in phakic eyes was 0.38 ± 0.19 μm (95% CI, 0.34 to 0.42; range 0.17 to 1.85 μm) at distance vision and 0.39 ± 0.27 μm (95% CI, 0.33 to 0.46; range 0.16 to 2.10 μm) at near vision with 5.0 D of stimulus ($P=.45$). In pseudophakic eyes, the mean total corneal HOA RMS was 0.94 ± 0.83 μm (95% CI, 0.71 to 1.17; range 0.24 to 4.50 μm) at distance vision and 0.87 ± 0.68 μm (95% CI, 0.68 to 1.06; range 0.24 to 3.24 μm) at near vision with 5.0 D of stimulus ($P=.65$).

The mean spherical aberration in phakic eyes was 0.78 ± 0.35 μm (95% CI, 0.71 to 0.86; range 0.16 to 2.61 μm) at distance vision and 0.75 ± 0.31 μm with 5.0 D of stimulus at near vision (95% CI, 0.68 to 0.81; range 0.01 to 1.73 μm) ($P=.57$). The mean spherical aberration in pseudophakic eyes was 0.83 ± 0.33 μm (95% CI, 0.74 to 0.92; range 0.23 to 1.74 μm) at distance vision and 0.86 ± 0.38 μm (95% CI, 0.75 to 0.97; range 0.05 to 2.10 μm) at near vision with 5.0 D of stimulus ($P=.62$). No deviation was found in spherical aberration values in the phakic or pseudophakic group ($P=.86$).

DISCUSSION

Human accommodation is a process whereby the dioptric power gradually increases when viewing a nearby target. In this process, the changes in crystalline lens power are of crucial importance.[12] The active function of the ciliary muscle[13] is considered to be one of the conditions necessary for the accommodative process. According to classic theory, the physiological adjustment ability of the lens is regarded as the principal underlying factor; however, the shifting of the lens may also play an important role.[1–3,14,15] With aging, a change in the shape, size, and position of the lens occurs.[16,17] The age-related decline and the total ceasing of the accommodation amplitude are called presbyopia.[18] The restoration of accommodation is one of the greatest challenges in ophthalmology at present. The measurement of accommodation is important when analyzing the effects of various surgical techniques. When performing subjective measurements apart from real accommodation, several other factors play important roles in near vision; these include pupil size, corneal multifocality, and the resulting increased depth of focus. On the other hand, objective measurements of accommodation are always device dependent.

In the present study, we measured refraction alterations and changes in pupil size during accommodation with an open-field autorefractor/keratometer (WAM-5500) in phakic eyes and pseudophakic eyes and compared the data with the results of the subjective test. We also used Scheimpflug analysis to monitor anterior segment changes during the accommodative process.

Studies have found data indicating that there are changes in astigmatism during the accommodative process[19,20] and that certain wavefront aberration alterations (spherical aberration, coma) can occur.[21–25] Subjective accommodation measurements in pseudophakic eyes showed a correlation with the proportion of corneal coma-like aberrations.[26] In our objective measurements, no changes in corneal aberration were observed during accommodation; however, we detected a significantly higher total corneal RMS and total HOA RMS in pseudophakic eyes than in phakic eyes. This deviation is mainly explained by age differences and may also help increase the depth of focus. Miosis, being a member of the accommodative triad, may also significantly influence the effect of HOAs, thus also increasing the depth of focus. In addition, it is well known that the entire eye and corneal HOAs, especially spherical aberration, increase with age,[27] leading to an increase in the depth of focus.[21] In our study, HOA RMS and spherical aberration increased with age. Previous studies[11,28] have evaluated the possible role of corneal pseudoaccommodation. With respect to ocular cyclotorsion, examinations did not confirm changes in the topography of the cornea during accommodation,[11,29] nor did our study verify such corneal deviations during accommodation.

The most widely used subjective methods for measuring accommodation are the pushup test and the minus-lenses-to-blur test.[6,7] In the former technique, the patient is tested wearing distance correction; as the target is moved closer to the patient, he or she is instructed to report when the text is no longer in sharp focus. In the latter technique, while the patient is focusing on a distant target, the value of the minus lens at which the target becomes blurry is determined. These methods stimulate and measure accommodation at the same time. Subjective tests seem to overestimate the results obtained with objective tests[6,8,9,30–33] and are instead used to estimate reading ability. In subjective tests, the increasing effect of the depth of focus of a narrow pupil and of ocular aberrations is added to the active real accommodative power, as is the tolerance against blur perception. This may explain the overall 0.5 D amplitude of subjective accommodation after monofocal IOL implantation in pseudophakic eyes. Our data verified the presence of senile miosis; a significantly narrower pupil was found in pseudophakic eyes, which may support the process of accommodation. We also confirmed the intensified presence of corneal aberrations at an elderly age. It is well known that mild ATR myopic astigmatism can be beneficial to uncorrected near acuity in pseudophakic eyes,[34] although in our smaller cohort of patients, no correlation was found between the subjective accommodation amplitude and the direction of astigmatism.

The real changes in the optical power of the eye are measured by objective tests. Objective accommodation measurements can be performed using Hartinger coincidence refractometry,[10] wavefront aberrometry,[27] dynamic retinoscopy, or open-field-of-view autorefractors.[35–37] Open-field refractometers that apply infrared lights are capable of measuring real binocular physiological accommodation and pupil size changes in real circumstances. During accommodation measurement, if 1 of the eyes is occluded, inaccurate data can be obtained. A study[32] found that off-axis viewing tests in phakic patients showed very small mean differences due to off-axis viewing. In our study, we used the open-field refractometer to measure 1 eye without occluding the other eye during binocular accommodation. Previous studies found no disparity in the results of different objective measurement techniques[9] and considered Grand Seiko autorefractors[8,9,38,39] and certain aberrometers[9] to be adequately reliable for objectively measuring accommodation. These devices are also capable of measuring dynamic accommodation, which may give further useful information about the characteristics of the accommodative process[40] and may play an important role when assessing near work–induced discomfort symptoms.[41]

The accommodative response to a stimulus is always smaller than the stimulus itself. The lag of accommodation is denoted as the dioptric value by which, for example, the accommodation during reading is lower than the actual stimulus. Between the ages of 18 years and 22 years, in 69% of cases with low myopia, the accommodative lag for a 33 cm target is 1.00 D or more by autorefraction.[42] The normal value may vary between 0.50 D and 0.75 D in a nonpresbyopic patient[43] when tested at 40 cm. In addition, in presbyopia, the lag also increases in the case of uncorrected hyperopia or accommodative insufficiency[44] and the lack of the accommodative lag may suggest latent hyperopia. The response to an accommodative stimulus is affected by the refractive error,[45–47] refractive error stability,[48,49] nature of the target,[50–52] and method of stimulus presentation.[45,49] We found that the accommodative lag is age dependent in phakic eyes. An age dependency was also observed in pseudophakic eyes; however, it was considered to be weak.

Accommodation can also be measured subjectively and objectively in pseudophakic eyes.[53–55] In pseudophakic eyes, indirect measurements using ultrasonic A-scan measurements[56] and PCI[53,57] before and after ciliary muscle contraction using pilocarpine or phenylephrine found changes in the ACD, suggesting shifting of the IOL. The rate of the shift is highly dependent on the measuring technique and, with these indirect measurements, it is rather the maximum accommodation potential that is being measured. Significant objective accommodation has been neither expected nor observed after standard monofocal IOL implantation.[32] After implantation of various IOL models, a WR-5100 K autorefractor (Grand Seiko) recorded valid and repeatable refraction values.[58] We also found that the difference between autorefractor data and the results of the subjective method were nearly constant.

In the pushdown test by Win-Hall and Glasser,[32] the defocus curves had a range of 2.0 D for a distance-corrected visual acuity of 20/40 or better. With the application of monofocal IOLs, the subjective amplitude of accommodation can vary from 0.42 to 1.08 D[53,59]; however, an accommodation of 1.33 to 2.36 D has also been measured.[53,59,60] For such a range of subjective amplitudes, the depth of focus and eye aberrations may give an explanation.[53,59] According to the literature, when an objective measurement is obtained using an autorefractor, the accommodation amplitude is approximately 0.1 D in pseudophakic eyes.[32] Our results suggest similar, average, and true accommodation. Changes in the ACD during accommodation were minimal in our study, although ACD changes of at least 0.3 mm were detected in 28% of our patients. During Pentacam HR examinations, motivation seems to play a more important role in the sense of how much the patient “wants” to get the target in focus and keep it there.

Subjective accommodation and objective accommodation were better in eyes with accommodating IOLs; however, near visual acuity and the subjective and objective amplitudes of accommodation decreased 2 years after IOL implantation.[54] We performed our measurements after monofocal IOL implantation and during minimal, clinically insignificant objective accommodation of 0.5 D; an average subjective accommodation was recorded. No significant correlation was found between subjective accommodation and objective accommodation and the parameters evaluated in pseudophakic eyes with the exception of the spherical equivalent and amount of objective accommodation. As a result of senile miosis in pseudophakic eyes, measurements showed a much narrower pupil and of the parameters evaluated, only the narrower pupil and the higher corneal HOAs may pay a role in the increase in the depth of focus in pseudophakic eyes.

In summary, our data verify that subjective accommodation is significantly higher than objective accommodation in phakic eyes. The 0.5 D subjective accommodation in pseudophakic eyes can be explained by the combined effect of the pupil miosis–induced increase in the depth of focus and the age-related, significantly higher, corneal aberrations. In pseudophakic eyes, we observed objectively measurable, minimal, and clinically insignificant accommodation with a WAM-5500 autorefractor/keratometer. The value of this objectively measured accommodation correlated well with the results of the subjective test.

WHAT WAS KNOWN

- Subjective accommodation is significantly higher than objective accommodation.
- In pseudophakic eyes, no objective accommodation can be observed.

WHAT THIS PAPER ADDS

- In pseudophakic eyes, 0.5 D of subjective accommodation was measured. This can be explained by the combined effect of the pupil miosis–induced increase in the depth focus and the age-related significantly higher corneal aberrations.
- In pseudophakic eyes, objectively measurable, minimal and clinically insignificant accommodation was observed with an autorefractor/keratometer.

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