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DETERMINING THE EXISTENCE AND EXTENT PSEUDOPHAKIC ACCOMMODATION IN PATIENTS WITH PSEUDOPHAKIC

ODREĐIVANJE POSTOJANJA I OBIMA PSEUDOFAKNE AKOMODACIJE KOD BOLESNIKA SA PSEUDOFAKIJOM

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Ključne reči
akomodacija, pseudofakija, pseudoakomodacija, intraokularno sočivo, pilokarpin.

Abstract

Aim: To indicate and evaluate pseudoaccommodation influencing intraocular lens (IOL) movement, measured as a change in anterior chamber depth caused by pilocarpine-induced ciliary muscle contraction.
Methods: Forthy eyes of 32 patiens were included in this study. Distance and near visual acuity (Snell and Jaeger at 35cm), best corrected distance and best corrected near visual acuity were measured before and 60 minutes after application of pilocarpin 2%. Anterior chamber depth and pupil diameter were measured with ultrasound biomicroscopy (UBM) before and 60 minutes after application of pilocarpin 2%.
Results: The IOL moved anteriorly in 18 (55%) eyes and posteriorly in 22 (45%) eyes after pilocarpin 2%. There was no significant difference in change of ACD whether the IOL moved forward or backward ($p > 0.05$). Movement of IOL, indicating an accommodation of 0.16 ± 0.15Dpt, was not statistically significant ($p > 0.05$).
The near visual acuity significantly increased ($p<0.01$), whether IOL moved forward and non significantly increased ($p>0.05$), whether IOL moved backward.
The positive addition for best near visual acuity was high statistically significant less ($p<0.01$) whether IOL moved forward, and it was statistically significant less ($p<0.05$) whether IOL moved backward.
Conclusions: Pilocarpine-induced ciliary muscle contraction caused movement of IOL indicating an accommodation of 0.16 ± 0.15Dpt. The near visual acuity increased and positive addition for best near visual acuity decreased, whether the IOL moved forward or backward. This points out pseudoaccommodation rather than pseudophakic accommodation.

INTRODUCTION

The process of changing the refractive power of the eye to have a clear image for objects at different distances is called accommodation. This adaptation is primarily attributed to the elasticity of the human crystalline lens, the ciliary muscle and the zonule fibers.

According to Helmholtz's theory, when the ciliary muscle contracts, zonule fibers relaxed and the human crystalline lens changes it's shape, mainly by steepening the curvature of it's anterior face [1-3]. After cataract surgery and intraocular lens implantation, there is no such movement and patients become presbyopic. Although most patients with monofocal IOL need correction for near visual acuity, some may have good near visual acuity. The simple myopic astigmatism, corneal multifocality, ability of the pupil to constrict on accommodative effort, and anterior movement of the IOL during accommodation are suggested factors for this phenomenon. This phenomenon is referred to as pseudoaccomodation or apparent accommodation, and is a result of the increased depth of field of the entire optical system of the eye. Pseudoaccomodation is also found in aphakic patients, proving that it does not rely on the presence of an IOL [4-7].

True pseudophakic accommodation could be achieved by an anterior shift of the IOL optic during ciliary muscle contraction. In an eye of usual dimensions an anterior shift of 600 micrometers of the IOL corresponds to an accommodative effect of 1 diopter (2, 3).

After the IOL implantation postoperative capsular fibrosis and contraction result in firm attachment of the capsule to the IOL haptics and optic. As a consequence, IOL can not change shape or position during ciliary muscle contraction and provide only one focal distance (8-10).

There is great interest in pseudophakic accommodation. Refractive and diffractive multifocals IOL are associated with high incidence of side effects such as halos, flare, glare and reduced visual acuity and contrast sensitivity (11-3, 14). Accommodating IOL that can focus on object at different distances by an anterior shift of the optic caused by ciliary muscle contraction have been recently proposed (15-17).

Ultrasound imaging is the most common technique for dynamic study of accommodation. It is objective method that can demonstrate biometric changes in the eye (18-20).

PATIENTS AND METODS

The study was conducted according to the principles of the Declaration of Helsinki and good clinical practice guidelines.

Forty eyes of 32 patients with pseudophakia were included in the study. Of the patients, 18 were man and 14 were women. The mean age of the patients was 68.8 ± 8.48 years (range 52 to 83 years).

A single surgeon (M.J.) performed all procedures. All patients had corneal incision, continuous curvilinear capsulorhexis, hydrodissection, phacoemulsification of the nucleus and aspiration of the residual cortex. Foldable IOL was implantation in the capsular bag. In this series, no sutures were placed in any patient. The 31 eyes had the implantation of Acrysof, Alcon, MA60BM IOL (optic diameter 6.0mm, overall size diameter 13 mm) and 9 had the Akreos AO IOL, Bauch&Lomb (optic diameter 6.0 mm, diameter 10.5 mm). Eight patients had bilateral and 24 patients had unilateral IOL implantation. The mean time interval between surgery and examination was 8.5 ± 7.8 month. The range was from 3 to 41 months, and most common range was 4 months.

The axial length was measured by ultrasound biometry which was performed after instillation of topical anesthetic with a contact biometry transducer before surgery. The mean of 10 scans was used for calculation.

Patients had extensive evaluation, including ophthalmic history and examination that included visual acuity measurements, slitlamp biomicroscopy, Goldmann tonometry and fundus examination.

Visual acuity measurements included distance visual acuity, best corrected distance visual acuity, near visual acuity and best corrected near visual acuity at 35cm, before and after application of pilocarpine 2%. Distance visual acuity was measured by Snellen and near visual acuity by Jaeger charts at 30cm.

Exclusion criteria were previous ophthalmic surgery, significant other ophthalmic disease (pseudoexfoliation, glaucoma, uveitis, corneal or retinal changes, corneal astigmatism over 1.5 Dpt, macular degeneration) and complication during cataract surgery or postoperatively.

The pupil diameter and ultrasound biomicroscopy (UBM) measurements (UD-6000, Tomey) were acquired before application of 2 drops of pilocarpine 2% five minutes apart and 60 minutes after the first drop. One examiner (I.S.) performed UBM in the study. Following topical anesthesia with Novocain 1% was applied, an eyecup filled with water was inserted between the eyelids. A high frequency transducer was used to perform the UBM examination. The best scan is defined as the scan in which the IOL and pupil is oriented centrally and structures seem symmetric at each side of the scan. The anterior chamber depth for UBM was defined as the distance between the central posterior corneal surface and the anterior IOL surface at the center of the papillary space. The movement of the IOL was defined as the difference of the anterior chamber depth before and after application of pilocarpine 2%.

Results were evaluated with statistical analysis software SPSS 10.0 (student T test, ANOVA, Mann-Whitney test, Wilcoxson test, Pearson and Spearman correlation)

RESULTS

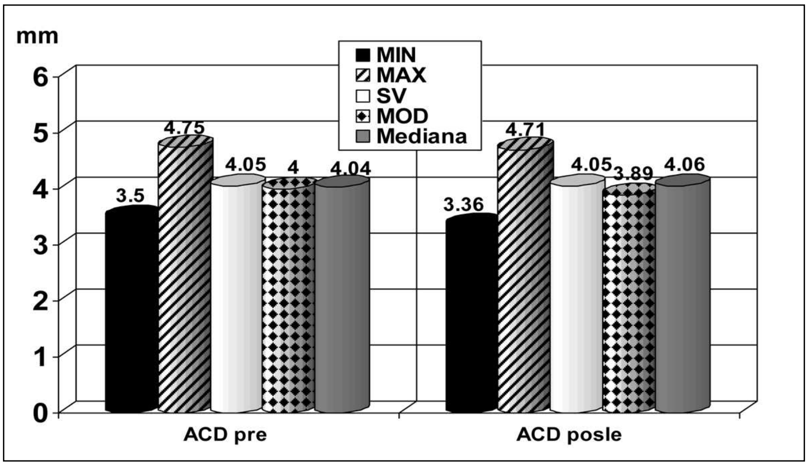

Figure 1. The anterior chamber depth before and after pilocarpine

The median anterior chamber depth (ACD) before pilocarpine 2% was 4.05 ± 0.26 mm. After installation of pilocarpine 2% median ACD was 4.05 ± 0.32 mm. The ACD range was from 3.5mm to 4.75mm before, and from 3.36mm to 4.71mm after, installation of pilocarpine 2%. There was no significant difference in change of ACD after pilocarpine 2% whether the IOL moved forward or backward (p > 0.05).

Table 1. The IOL movement before and after application of pilocarpine 2%

Measurement	IOL movement (mm)	
	Forward	Backward
Mean	-0.09	0.11
SD	0.05	0.12
MOD	-0.13	0.20
Mediana	-0.08	0.06
Min	-0.01	0.01
Max	-0.19	0.47

The median foreward IOL movement was -0.09 ± 0.05mm. The range was from -0.01mm to -0.19mm. Most common range of movement was -0.13mm. The median backward movement was 0.11 ± 0.12mm. The range was from 0.01mm to 0.47mm. Most common range of movement was 0.20mm.The IOL movement before and after application of pilocarpine 2% due to IOL movement forward or backward had high significantly difference (p<0.001).

Table 2. The value of pseudophakic accommodation

Accommodation	Dpt
Mean	0.16
SD	0.15
MOD	0.03
Mediana	0.12
Min	0.02
Max	0.78

Movement of IOL, indicating an median pseudophakic accommodation of 0.16 ± 0.15 Dpt, was no statistically significant (p>0.05). The range was from 0.2 Dpt to 0.78 Dpt. Most common range of accommmodation was 0.03Dpt.

The best corrected distant visual acuity (BCDVA) significantly increased (p<0.05), and best corrected near visual acuity (BCNVA) high significantly increased (p<0.05) whether IOL moved forward. The range of BCDVA before pilocarpine was from 0.1 to 1.0, with most common range of 0.8 ± 0.23. After pilocarpine BCDVA shaws range from 0.5 to 1.0 with median 0.9 ± 1.7. The BCNVA before pilocarpine was from 10 to 1.0, with most common range of 5 ± 2.56. After pilocarpine BCDVA shaws range from 8 to 1.0 with median 3 ± 2.24.

Table 3.The best corrected distant visual acuity and best corrected near visual acuity before and after application of pilocarpine 2%, whether IOL moved forward

Visual acuity	BCDVA		BCNVA	
	before pilocarpin	after pilocarpin	before pilocarpin	after pilocarpin
Mean	0.8	0.9	5	3
SD	0.23	1.7	2.56	2.24
MOD	1.0	1.0	5	1
Mediana	0.8	1.0	5	2.5
Min	0.1	0.5	10	8
Max	1.0	1.0	1	1

The best corrected distant visual acuity significantly increased (p<0.05), and best corrected near visual acuity is not significantly increased (p>0.05) whether IOL moved backward. The range of BCDVA before pilocarpine was from 0.1 to 1.0, with most common range of 0.7 ± 0.33. After pilocarpine median BCDVA was 0.8 ± 0.30. The BCNVA before pilocarpine was from 10 to 1.0, with most common range of 3.5 ± 2.30. After pilocarpine BCDVA shaws range from 5 to 1.0 with median 3 ± 1.18.

Table 4.The best corrected distant visual acuity and best corrected near visual acuity before and after application of pilocarpine 2%, whether IOL moved backward

Visual acuity	BCDVA		BCNVA	
	before pilocarpin	after pilocarpin	before pilocarpin	after pilocarpin
Mean	0.7	0.8	3.5	3
SD	0.33	0.30	2.30	1.18
MOD	1.0	1.0	2	2
Mediana	0.8	1.0	3.5	3
Min	0.1	0.1	10	5
Max	1.0	1.0	1	1

The mean postoperative refraction for best corrected distant visual acuity, and mean positive addition for best corrected near visual acuity is high significantly decreased (p<0.01) whether IOL moved forward. The range of refraction for BCDVA before pilocarpine was from -0.5Dpt to -1.75Dpt, with most common range of -0.71 ± 0.47Dpt. After pilocarpine median refraction was -0.57 ± 0.41Dpt. In one case refraction before

Table 5.The mean postoperative refraction and mean positive addition before and after application of pilocarpine 2%, whether IOL moved forward

Visual acuity	BCDVA		BCNVA	
	before pilocarpin	after pilocarpin	before pilocarpin	after pilocarpin
Mean	-0.71	-0.57	+1.72	+1.34
SD	0.47	0.41	0.78	0.71
MOD	-0.5	-0.5	+1.0	+0.5
Mediana	-0.5	-0.5	+1.5	+1.25
Min	-0.5	-0.5	+0.5	+0.5
Max	1.75	-1.5	+3.5	+3.0

Table 6.The mean postoperative refraction and mean positive addition before and after application of pilocarpine 2%, whether IOL moved backward

Visual acuity	BCDVA		BCNVA	
	before pilocarpin	after pilocarpin	before pilocarpin	after pilocarpin
Mean	-0.65	-0.56	1.88	1.73
SD	1.12	0.88	0.83	0.82
MOD	-0.5	-0.5	+1.5	+1.5
Mediana	-0.5	-0.5	+2.0	+1.5
Min	0.5	-0.5	+0.25	+0.25
Max	3.0	2.0	+3.5	+3.25

pilocarpine was +0,25Dpt, and after pilocarpine was 0.5Dpt. The range of refraction for BCNVA before pilocarpine was from +0.5Dpt to +3.50Dpt, with most common range of +1.75 ± 0.78Dpt. After pilocarpine median refraction of BCNVA shows median range of +1.34 ± 0.71Dpt.

The mean postoperative refraction for best corrected distant visual acuity is not significantly difference ($p>0.05$) , and mean positive addition for best corrected near visual acuity is significantly decreased ($p<0.05$) whether IOL moved backward. The range of refraction for BCDVA before pilocarpine was from -0.5Dpt to -3.00Dpt, with most common range of -0.65 ± 1.12Dpt. After pilocarpine median refraction was -0.56 ± 0.88Dpt. The range of refraction for BCNVA before pilocarpine was from +0.25Dpt to +3.50Dpt, with most common range of +1.88 ± 0.83Dpt. After pilocarpine median refraction of BCNVA shows median range of +1.73 ± 0.82Dpt.

DISCUSSION

The findings in this study confirm movement capabilities in pseudophakic eyes and these movements indicate that some eyes with a monofocal IOL have the capability to accommodate.

Forty eyes of 32 patients with pseudophakia were included in the study. Of the patients, 18 (52.5%) were man and 14 (47.5%) were women. The mean age of the patients was 68.8 ± 8.48 years (range 52 to 83 years). The mean time interval between surgery and examination was 8.5 ± 7.8 months. The range was from 3 to 41 months, and moust common range was 4 months.

There was no significant difference in change of ACD after pilocarpine 2% whether the IOL moved forward or backward. There was no correlation between the magnitude of the ACD and the patient age, sex, time interval between surgery and measurement, preoperative axial length and IOL types. Kriechbaum at al. have been reported study with 28 pseudophakic eyes with no significant difference in change of ACD. Findl O et al.[15] reported study with 110 pseudophakic eyes with accommodative and conventional IOL. There is no statistically significant change ACD at the patients with conventional IOL. Hardman Lea et al.[6] reported same results.

The IOL movement before and after application of pilocarpine 2% due to IOL movement forward or backward had high significantly difference ($p<0.001$). It points out that there is some significantly movements of IOL. Clinically IOL movement is not enough (patient still need presbyopic correction) but it can be used to show capability of pseudophakic accommodation.The median IOL movement was no correlation with patient age, sex, time interval between surgery and measurement, axial length and IOL types.The IOL moved forward in 18 (55%) eyes and backward in 22 (45%) eyes after pilocarpine 2%. There was no significant difference between those two groups. Findl O et al. reported that Acrysof MA60MB IOL had significantly backward movement (mean 0.16 ± 0.11mm). This may be becouse of rigid haptic design, which absorbs little induced radial pressure. The overall size of the IOL (13mm) is too large for the average capsular bag (10.4mm). Posterior shift of the IOL also can be induced as a result of the ten-degree posterior angulation at the optic-haptic junction. Posterior shift may be counteracted by anterior movement of the ciliary body-iris-bag complex and increased vitreous pressure doing muscle contraction. Construction of the IOL with anterior haptic angulation, decreased overall size (10.0mm) and modified optic–haptic junction can improved anterior shift of the IOL. Muftuogly et al.[8] reported mean IOL posterior shift movement of 0.06±0.07mm and mean IOL anterior shift movement of -0.15 ±0.09mm of the conventional IOL. Langenbucher et al. reported mean anterior shift movement of 0.18±0.12mm. Legeais JM et al. at group of 15 conventional IOL reported mean anterior shift of 0.28±0.38mm. Kuchle M et al. at group of 12 conventional IOL reported mean movement of 0.15±0.05mm. Also, they had a group of 12 accommodative IOL which had mean movement of 0.63±0.16mm. Between these two group was statisticaly significient difference.

Movement of IOL, indicating an median pseudophakic accommodation of 0.16 ± 0.15 Dpt, was no statistically significant ($p>0.05$). Clinically accommodation is not enough. Findl O et al. reported estimated accommodative amplitude less than 0.50 Dpt in most patients and up to about 1.00 Dpt in the best cases. Langenbucher A et al. reported median accommodation of 0.25±0.19 Dpt. Gonzales F et al. reported accommodation up to 1 Dpt in study at group of 8 conventional IOL. Kuchle M et al. at group of 12 conventional IOL reported median accommodation of 0.2±0.19 Dpt.

Backward movement of the IOL should wosen near reading ability. In our study , near visual acuity significantly increased after application of pilocarpine 2% whether IOL moved forward but not significantly increased whether IOL moved backward. But, all eyes had a better near visual acuity. Muftuogly et al. reported that near visual acuity significantly increased whether IOL moved forward or backward. Nakazawa and Ohtsuki [7] had reported correlation between pseudoaccomodation and pupil diameter – when pupil diameter decrease, effect of pseudoaccomodation increase. This result has been confirmed by others [21].

Increased depth of focus after decreased pupil diameter, decreased positive addition for BCNVA. In our study positive addition was high statistically significantly less as pupil diameter decreased, whether IOL moved forward and it was statistically significant less whether IOL moved backward. Same results reported Muftuogly et al. and Fukuyama and coauthors.

CONCLUSSION

Pilocarpine-induced ciliary muscle contraction caused movement of IOL indicating an accommodation of 0.16 ± 0.15Dpt.The near visual acuity increased and positive addition for best near visual acuity decreased, whether the IOL moved forward or backward. This points out pseudoaccommodation rather than pseudophakic accommodation.

Apstrakt

Cilj: Ispitati postojanje i obim akomodacije kod pseudofaka na osnovu pomeranja intraokularnog soèiva posle aplikacije kapi pilokarpina 2%

Metode: Ispitano je èetrdeset pseudofaknih oèiju kod 32 pacijenta: odredjen im je nativni vizus na daljinu i na blizinu, kao i najbolje korigivani vizus na daljinu i na blizinu (Snell i Jaeger na 35cm) pre i 60 minuta posle aplikacije kapi pilokarpina 2%. Ultrazvuènom biometrijom je merena dubina prednje oène komore i širina zenice, pre i posle aplikacije pilokarpina.

Rezultati: Intraokularna soèiva su se nakon aplikacije pilokarpina 2% pomerala ka napred kod 18 (55%) oèiju, a nazad kod 22 (45%) oka. Promena ACD se nije statistièki znaèajno razlikovala bez obzira u kom pravcu je došlo do pomeranja IOL-a ($p > 0.05$). Promena dioptrije nakon pomeranja IOL-a je u proseku iznosila 0.16 ± 0.15Dpt, što statistièki nije znaèajno ($p > 0.05$).

Oštrina vida na blizinu je visoko statistièki znaèajno veæa ($p<0.01$), kod pacijenata kod kojih se soèivo pomerilo napred, a nije statistièki znaèajno veæa ($p>0.05$), kod pacijenata kod kojih je došlo do pomeranja IOL ka nazad

Smanjenje korekcione dioptrije za vid na blizinu je visoko statistièki znaèajno veæe ($p<0.01$) kod pacijenata kod kojih je došlo do pomeranja IOL ka napred, a statistièki je znaèajno ($p<0.05$) veæe kod pacijenata kod kojih je došlo do pomeranja IOL ka nazad.

Zakljuèak: Pilokarpin indukovana kontrakcija cilijarnog mišiæa dovodi do pomeranja IOL-a indukujuæi promenu akomodacije u proseku za 0.16 ± 0.15Dpt. Vidna oštrina na blizu je bolja, a potrebna korekciona dioptrija manja, bez obzira da li se IOL pomera napred ili nazad. Rezultati pokazuju da je efekat pseudoakomodacije veæi od efekta pseudofakne akomodacije.

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