

Original Research Article

**A Comparison of Accommodation Amplitudes
of Three Different Acrylic Intraocular Lenses**

ABSTRACT

Aim: To assess the accommodative amplitudes of three different foldable acrylic intraocular lenses (IOLs) by measuring with photorefractor Plusoptix CR03 (Plusoptix GmbH, Nuernberg, Germany).

Methods: Fifty five pseudophakic eyes of 46 patients (mean age 65.25 ± 10.63 years) were analyzed at one month after uneventfull phacoemulsification and IOL implantation surgery. Rayner Centerflex (C-Flex) (n= 17), AcyrSof MA60BM (n= 17), Sensor AR40e (n= 21) IOLs were implanted. An objective, dynamic measurement technique with R mode of Plusoptix CR03 device was used to measure accommodation. Accommodation was measured at near distance (0.33 m) and far distance (5 m).

Results: Accommodation amplitudes (mean $\pm$ SD) measured with photorefractor at near distance in Rayner, AcyrSof and Sensor groups were 1.45 ± 0.76 diopter (D), 2.82 ± 1.88 D, 2.44 ± 1.02 D, respectively. Accommodative response of AcyrSof and Sensor IOLs was greater than Rayner IOL significantly ($p= 0.027$ and $p= 0.004$, respectively). At far distance, measured accommodation amplitudes in Rayner, AcyrSof and Sensor groups were 1.34 ± 0.54 D, 1.87 ± 0.74 D and 1.74 ± 1.70 D, respectively. There were no significant difference between the groups ($p= 0.109$).

Conclusion: The 3-piece hydrophobic acrylic IOLs, AcrySof MA60BM and Sensor AR40e) had a significantly higher accommodative response than the 1-piece plate-haptic hydrophilic acrylic Rayner C-Flex IOL.

Keywords: Accommodation, intraocular lens, photorefractor, pseudophakic accommodation

1. INTRODUCTION

Accommodation is the ability of the eye to focus on a distant target, projecting this visual image of the target onto the retina. Refractive power of the eye is regulated by two mechanisms: either by adjusting focal point of the imaging system or by removing the projection plane further from the focal plane. Therefore, during accommodation either distance between retina and lens may change or focal point is adjusted with changes in the radii of the curvature or in the refractive indices of the refractive elements of the eye (1).

Some patients with monofocal intraocular lenses (IOLs) have good near visual acuity without correction due to pseudophakic accommodation. Pseudophakic accommodation is the results of the dynamic refractive state change due to accommodative effort of ciliary (1). Pseudophakic pseudoaccommodation refers to static optical features of the pseudophakic eye independent of the ciliary muscle such as corneal multifocality, minus cylinder, and small pupil size resulting in increased depth of field (1-4).

In our study, we measured and determined the accommodative amplitudes of three different monofocal IOLs with the infrared photorefractor Plusoptix CR03 (Plusoptix GmbH, Nuernberg, Germany) using the principle of eccentric photorefraction.

2. MATERIAL AND METHODS

Forty six patients' 55 pseudophakic eyes were analyzed at one month after uneventful phacoemulsification and IOL insertion. Patients with significant IOL decentration, corneal astigmatism > 1.0 D, posterior or anterior synechia formation due to postoperative inflammation or significant eye pathology decreasing visual acuity were excluded. Standard phacoemulsifications with clear corneal incision were performed. From three different types of monofocal IOLs, one was implanted in-the-bag in randomized fashion. Three different monofocal IOLs were either AcyrSof MA60BM (n= 17) or Sensor AR40e (n= 21) or Rayner Centerflex (C-Flex) (n= 17).

The AcrySof MA60BM (Alcon Inc, Fort Worth, TX, USA) is configured as a 3-piece hydrophobic acrylic IOL with its haptic as flexible polymethyl methacrylate (PMMA) C-loop with 10-degree angulation. Its optic diameter is 6.0 mm and overall diameter is 13.0 mm. The Sensor AR40e (Abbott Medical Optics, Santa Ana, CA, USA) is configured as a 3-piece hydrophobic acrylic IOL with its haptics as flexible PMMA C-loop with 5-degree angulation. Its optic diameter is 6.0 mm and overall diameter is 13.0 mm. The Rayner C-Flex (Rayner Intraocular Lenses Limited, East Sussex, UK) is configured as a 1-piece hydrophilic acrylic IOL. Its haptics have a plate-haptic configuration without angulation. Its optic diameter is 5.75 mm and overall diameter is 12.0 mm.

To measure accommodation, an objective, dynamic measurement technique with R mode of Plusoptix CR03 (Plusoptix GmbH, Nuernberg, Germany) device was employed. All measurements were performed in one session by two

experienced ophthalmologists in the same lightning conditions. With the Plusoptix CR03, the patient was alternately fixated on a 5 m far target and a near 0.33 m target. Off-axis measurement errors due to eye movements were prevented as the near and far targets were located in a fixation line to the patient with a minimal tilt to the detection path of the infrared camera (5).

SPSS 13.0 software is used for statistical analysis; the data were given as mean $\pm$ SD. Differences between measured parameters of three groups were evaluated with Kruskal-Wallis test. Mann-Whitney U test was performed for dual comparisons between groups and a P value of 0.05 was set as the level of significance.

3. RESULTS AND DISCUSSION

3.1 Results

Fifty five eyes (37 unilateral and 9 bilateral) of 46 patients (22 men and 24 women) who underwent uneventful phacoemulsification and had received any of these three lenses; AcyrSof MA60BM (n=17), Sensar AR40e (n=21) or Rayner Centerflex (n=17) were included in the study. Mean patient age was 65.25 ± 10.63 years (range 40 to 83 years). Accommodation amplitudes (mean $\pm$ SD) measured with photorefractor at near distance in AcyrSof, Sensar and Rayner groups were 2.82 ± 1.88 diopters (D), 2.44 ± 1.02 D, 1.45 ± 0.76 D respectively (Table). Accommodative response of AcyrSof and Sensar IOLs was greater than Rayner IOL significantly ($p= 0.027$ and $p= 0.004$, respectively). At far distance, measured accommodation amplitudes in AcyrSof, Sensar and Rayner groups were 1.87 ± 0.74 D, 1.74 ± 1.70 D and 1.34 ± 0.54 D, respectively (Table). No statistically significant difference were detected between the groups ($p= 0.109$).

Table. Accommodation amplitudes measured with photorefractor.

IOL Type	Accommodation amplitude (D)	
	Near	Far
AcrySof MA60BM	2.82 ± 1.88	1.87 ± 0.74
Sensar AR40e	2.44 ± 1.02	1.74 ± 1.70
Rayner C-Flex	1.45 ± 0.76 *	1.34 ± 0.54

Values are given as mean $\pm$ SD. (IOL: intraocular lens, D: diopters, *: $p<0.05$)

3.1 Dscussion

There are several different assessment techniques and devices to measure accommodation (1, 6, 7). Subjective techniques are based on the patients capability of reading optotypes on a far or near target whereas objective techniques measure the refraction of the eye (1, 8-10). In the present study, we performed objective measurement with a new photorefraction device.

Automated infrared photorefraction works with the of eccentric photorefraction principle and does not interfere with the actual visual condition. It is potentially useful because it works from a remote distance and video image of the eyes is used for determination of the refractive state (11-14). The camera could be incorporated into experimental and field settings for the reason that the standard measurement distance from the eyes to the video camera is 1 m (13, 15). The Plusoptix CR03 provides the dynamic scan mode allows measurement of accommodation.

Pseudophakic eyes of some patients have good vision for both near and distance with distance correction only (16-18). This has been ascribed to diverse optical properties of the eye and IOL like the IOL movement along the anteroposterior axis, corneal multifocality and enhanced depth of focus associated with myopic astigmatism (1, 4, 16, 19).

The amount of accommodation in eyes with monofocal IOLs have been evaluated in a number of studies. Nakazawa et al (18) stated a mean apparent accommodation of 2.01 ± 0.95 D in pseudophakic eyes after implantation of posterior chamber intraocular lenses. The mean depth of focus was 1.27 ± 0.57 D and the mean amplitude of legibility was $2.72 \pm$

1.10 D in the study by Elder et al (19). Oshika et al (16) measured the amplitude of accommodation as 2.03 ± 0.93 D in their study group. Langenbucher et al (1) measured the accommodation to be 0.35 ± 0.26 D using the photorefractor. In our study, accommodation amplitudes measured with photorefractor at near distance in Rayner, AcyrSof and Sensor groups were 1.45 ± 0.76 D, 2.82 ± 1.88 D, 2.44 ± 1.02 D, and at far distance they were 1.34 ± 0.54 D, 1.87 ± 0.74 D and 1.74 ± 1.70 D, respectively.

Nemeth et al (3) compared the amplitudes of accommodation in pseudophakic eyes with three-piece and single-piece IOLs and they did not find any difference between two types of examined IOLs. However, Vamosi et al. (20) examined the accommodative amplitude of 2 monofocal IOLs with different haptic configurations and found that 3-piece IOL with 10-degree posterior angulation exhibited a higher accommodative capacity than the single-piece plate-haptic IOL. Also, in our study, the 3-piece IOLs with angulated haptic configuration had higher accommodation amplitudes than the single-piece plate-haptic IOL that is in conjunction with previous study.

4. CONCLUSION

In conclusion, we demonstrated that the 3-piece IOLs with haptic angulation, AcrySof (MA60BM) and Sensor (AR40e) had higher accommodative response than the 1-piece plate-haptic Rayner (C-Flex) IOL.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Author RY' designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author ME' managed the analyses of the study, collected study data, made the critical revision of the article. Author UEA and BA' collected study data, managed the literature searches. Author IFH and SD' provided administrative, technical and logistic support. All authors read and approved the final manuscript.

REFERENCES

1. Langenbucher A, Seitz B, Huber S, Nguyen NX, Kuchle M. Theoretical and measured pseudophakic accommodation after implantation of a new accommodative posterior chamber intraocular lens. Arch Ophthalmol 2003; 121: 1722-7.
2. Fukuyama M, Oshika T, Amano S, Yoshitomi F. Relationship between apparent accommodation and corneal multifocality in pseudophakic eyes. Ophthalmology 1999; 106: 1178-81.
3. Nemeth G, Tsorbatzoglou A, Vamosi P, Sohajda Z, Berta A. A comparison of accommodation amplitudes in pseudophakic eyes measured with three different methods. Eye (Lond) 2008; 22: 65-9.
4. Trindade F, Oliveira A, Frasson M. Benefit of against-the-rule astigmatism to uncorrected near acuity. J Cataract Refract Surg 1997; 23: 82-5.
5. Kuchle M, Nguyen NX, Langenbucher A, Gusek-Schneider GC, Seitz B, Hanna KD. Implantation of a new accommodative posterior chamber intraocular lens. J Refract Surg 2002; 18: 208-16.
6. Rosenfield M, Cohen AS. Repeatability of clinical measurements of the amplitude of accommodation. Ophthalmic Physiol Opt 1996; 16: 247-9.

- 175 7. Wetzel PA, Geri GA, Pierce BJ. An integrated system for measuring static and dynamic accommodation with a
176 Canon Autorefractometer. *Ophthalmic Physiol Opt* 1996; 16: 520-7.
- 177 8. Kruger PB. The effect of cognitive demand on accommodation. *Am J Optom Physiol Opt* 1980; 57: 440-5.
- 178 9. Kruger PB, Nowbatsing S, Aggarwala KR, Mathews S. Small amounts of chromatic aberration influence dynamic
179 accommodation. *Optom Vis Sci* 1995; 72: 656-66.
- 180 10. Arici C, Turk A, Soner K, Ceylan OM, Mutlu FM, Altinsoy Hİ. Effect of cycloplegia on refractive errors measured
181 with three different refractometers in school-age children. *Turk J Med Sci* 2012; 42: 657-65.
- 182 11. Bobier WR, Braddick OJ. Eccentric photorefractive: optical analysis and empirical measures. *Am J Optom Physiol*
183 *Opt* 1985; 62: 614-20.
- 184 12. Howland HC. Optics of photoretinoscopy: results from ray tracing. *Am J Optom Physiol Opt* 1985; 62: 621-5.
- 185 13. Schaeffel F, Wilhelm H, Zrenner E. Inter-individual variability in the dynamics of natural accommodation in
186 humans: relation to age and refractive errors. *J Physiol* 1993; 461: 301-20.
- 187 14. Wesemann W, Norcia AM, Allen D. Theory of eccentric photorefractive (photoretinoscopy): astigmatic eyes. *J Opt*
188 *Soc Am A* 1991; 8: 2038-47.
- 189 15. Choi M, Weiss S, Schaeffel F, Seidemann A, Howland HC, Wilhelm B, Wilhelm H. Laboratory, clinical, and
190 kindergarten test of a new eccentric infrared photorefractor (PowerRefractor). *Optom Vis Sci* 2000; 77: 537-48.
- 191 16. Oshika T, Mimura T, Tanaka S, Amano S, Fukuyama M, Yoshitomi F, Maeda N, Fujikado T, Hirohara Y, Mihashi
192 T. Apparent accommodation and corneal wavefront aberration in pseudophakic eyes. *Invest Ophthalmol Vis Sci* 2002; 43:
193 2882-6.
- 194 17. Nakazawa M, Ohtsuki K. Apparent accommodation in pseudophakic eyes after implantation of posterior chamber
195 intraocular lenses. *Am J Ophthalmol* 1983; 96: 435-8.
- 196 18. Nakazawa M, Ohtsuki K. Apparent accommodation in pseudophakic eyes after implantation of posterior chamber
197 intraocular lenses: optical analysis. *Invest Ophthalmol Vis Sci* 1984; 25: 1458-60.
- 198 19. Elder MJ, Murphy C, Sanderson GF. Apparent accommodation and depth of field in pseudophakia. *J Cataract*
199 *Refract Surg* 1996; 22: 615-9.
- 200 20. Vamosi P, Nemeth G, Berta A. Pseudophakic accommodation with 2 models of foldable intraocular lenses. *J*
201 *Cataract Refract Surg* 2006; 32: 221-6.