European Journal of Ophthalmology / Vol. 18 no. 3, 2008 / pp. 371-376

Postoperative refraction changes in phacoemulsification cataract surgery with implantation of different types of intraocular lens

T. IWASE[1,4], N. TANAKA[2,5], K. SUGIYAMA[3]

[1]Department of Ophthalmology, Toyama Red Cross Hospital, Toyama - Japan
[2]The Salk Institute, La Jolla, CA - USA
[3]Kanazawa University Graduate School of Medical Science, Kanazawa
[4]Department of Ophthalmology, Toyama Prefectural Central Hospital, Toyama
[5]Department of Ophthalmology, Kyorin University School of Medicine, Tokyo - Japan

PURPOSE. *To examine postoperative refraction changes following phacoemulsification cataract surgery and to assess their influential factors, including intraocular lens (IOL) materials and anterior chamber depth (ACD) of the implanted IOL.*
METHODS. *In this prospective study, 339 eyes were randomly assigned to receive a rigid polymethylmethacrylate (PMMA) IOL (811C or 824C), an acrylic IOL (MA60BM), or a silicone IOL (AQ110NV). All patients were followed for 48 weeks after surgery. Postoperative spherical equivalent refraction and ACD were measured by a refractometer and by an anterior eye segment image analyzer, respectively.*
RESULTS. *In the silicone IOL group, statistically significant myopic shift was observed at 8 weeks after the surgery and continued throughout the follow-up period. Mean myopic shift at the end (48 weeks) was –0.53 D. Concomitantly shortened ACD was also confirmed at 12 weeks after the surgery. In the other groups, postoperative refraction and IOL position did not change after surgery.*
CONCLUSIONS. *The eyes with silicone IOL caused postoperative myopic shift due to the anterior IOL movement. It is important to be aware of the characteristics of each IOL and to take myopic shift into consideration when silicone IOL is implanted. Preferably the A-constant for silicone IOL should be reconsidered to obtain rather accurate postoperative refraction. (Eur J Ophthalmol 2008; 18: 371-6)*

KEY WORDS. *Refraction changes, Intraocular lens, Anterior chamber depth, Silicone, Acrylic, Polymethylmethacrylate*

Accepted: November 3, 2007

INTRODUCTION

Modern phacoemulsification, with the development of intraocular lenses (IOL), facilitates high-quality postoperative vision for patients with cataract. In addition, the increased reliability of predicted refraction offers further benefit, especially in patients who need good visual acuity without wearing glasses. However, we have still experienced patients with decreased postoperative uncorrected visual acuity (UCVA) month by month mainly due to refraction changes.

Findl et al reported that the longitudinal IOL position changes during the first 3 postoperative months (1). An axial IOL shift toward the cornea and the retina causes myopic and hyperopic shift, respectively. Because the axial IOL position is one of the major parameters influencing postoperative refractive change (2), surgeons need to know the postoperative movement of IOL associated with the difference of IOL material.

To improve our knowledge of postoperative refraction

 1120-6721/371-06$25.00/0

change, here we followed trend of refraction change after surgery, in which different types of IOL, rigid polymethylmethacrylate (PMMA), acrylic, or silicone IOL, were implanted. Furthermore, we analyzed the actual anterior chamber depth (ACD) of implanted IOL and discovered that silicone IOL used in this study caused a postoperative myopic shift due to the anterior IOL movement.

PATIENTS AND METHODS

This single-center prospective study was conducted at the Department of Ophthalmology, Toyama Red Cross Hospital, based on the approval of the Toyama Red Cross Hospital Ethics Committee. After an explanation of the purpose of the study, informed consent was obtained from all patients. The study comprised 339 eyes of 241 patients who underwent phacoemulsification and in-the-bag IOL implantation for senile cataract between April 1995 and March 2000 by a single surgeon (T.I.). The patients were randomly assigned to receive 811C (PMMA IOL with modified C loop, Pharmacia), 824C (PMMA IOL with gull-wing loop, Pharmacia), MA60BM (acrylic IOL, Alcon), or AQ110NV (silicone IOL, Canon Starr) (Fig. 1) (Tab. I). IOL power was determined to obtain postoperative refraction at around –0.75 diopter (D) using SRK-T formula. All patients were followed for 48 weeks after surgery. Exclusion criteria were history of uveitis, retinitis pigmentosa, pseudoexfoliation syndrome and/or glaucoma, and axial length longer than 25 mm or shorter than 21 mm. The cases with intraoperative complications, including incomplete capsulorhexis (i.e., anterior capsular crack formation and/or incomplete capsulorhexis–IOL overlap) and posterior capsular rupture, and with postoperative complications, such as ocular hypertension (>20 mm Hg), were also excluded from this study.

Surgical technique

After the administration of subconjunctival anesthesia, temporal self-sealing sclerocorneal tunnel (6.0 mm in width for 811C and 824C, 3.8 mm in width for MA60BM) or corneal tunnel (3.0 mm in width for AQ110NV) was created. The anterior chamber was filled with viscoelastic material and capsulorhexis, slightly smaller than the IOL optic diameter, was made to attain a circumferential 360-degree capsulorhexis–IOL overlap. (Because of the difference in the IOL optic diameter [Fig. 1], the diameter of capsulorhexis was approximately 5.0 mm in the groups of 811C, 824C, and MA60BM, while it was approximately 4.5 mm in the AQ110NV group.) The nucleus was removed using the phaco-chop method and the residual cortex was aspirated using an irrigation/aspiration (I/A) tip. The capsular bag was reformed with viscoelastic material before IOL was implanted into the capsular bag. Then the anterior chamber was cleared and filled with balanced salt solution. No fluid leakage from the wound was confirmed.

Assessment of postoperative changes in refraction and anterior chamber depth

Spherical equivalent refraction (SER) was measured with a refractometer (ARK-2000, NIDEK) at 1, 2, 4, 8, 12, 24, 36, and 48 weeks after surgery. Anterior chamber depth (ACD) was also analyzed for some cases (44 eyes in 824C group and 60 eyes in AQ110NV group) with an anterior eye segment image analyzer (EAS-1000, NIDEK) at the postoperative periods of 2 days and 1, 2, 4, 8, and 12 weeks. ACD (mm) was defined as the distance between posterior corneal surface and anterior IOL surface (Fig. 3A). Since ACD might vary among individual cases, ACD

TABLE I - SUMMARY OF PATIENT INFORMATION

IOL type	No. of eyes	Age, yr, mean ± SD	Axial length, mm, mean ± SD	Refraction, D, mean ± SD	
				Predicted	1 week
811C	80	78.7±6.7	22.94±0.88	–0.87±0.31	–1.16±0.86
824C	83	77.8±6.4	22.85±0.85	–0.70±0.29	–0.97±0.85
MA60BM	89	76.1±8.5	22.73±0.87	–0.88±0.31	–0.50±0.82
AQ110NV	87	76.3±7.1	22.82±0.83	–0.64±0.38	–0.67±0.96

IOL = Intraocular lens

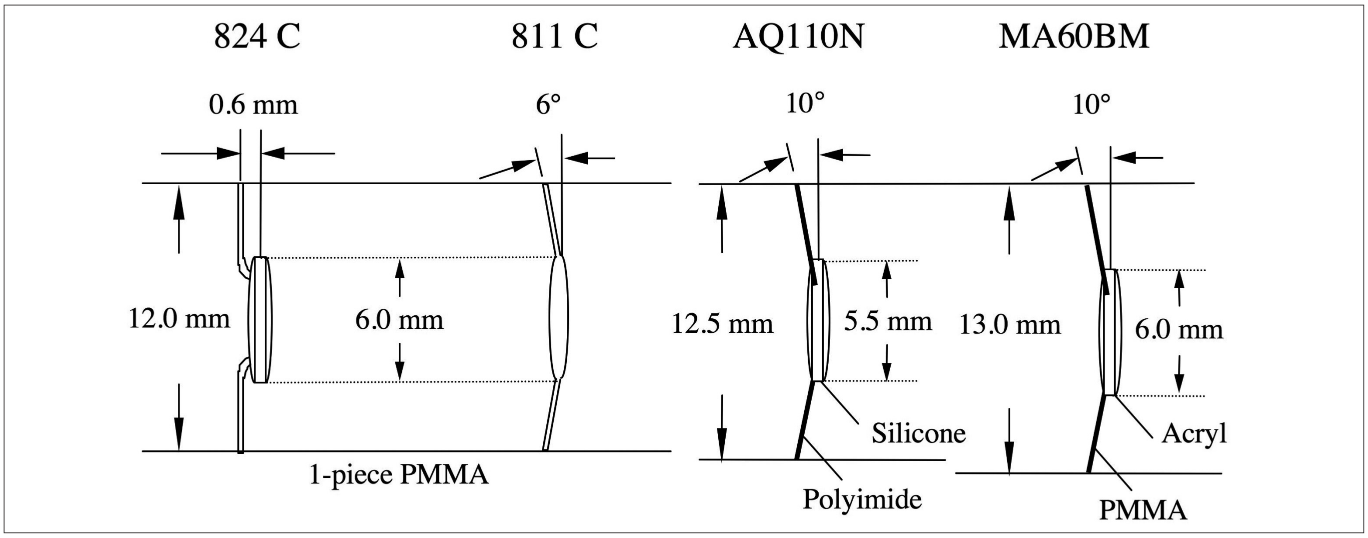


Fig. 1 - *Schematic diagram of each intraocular lens design.*

Fig. 2 - *Postoperative refraction changes in each group.* **(A)** *The graph depicts the results in 811C (open circles) and 824C (closed circles) groups.* **(B)** *The graph depicts the results in silicone intraocular lens (AQ110NV) (open circles) and acrylic intraocular lens (MA60BM) (closed circles) groups. The data at each time point were compared to those at 1 week after the surgery. *p< 0.01.*

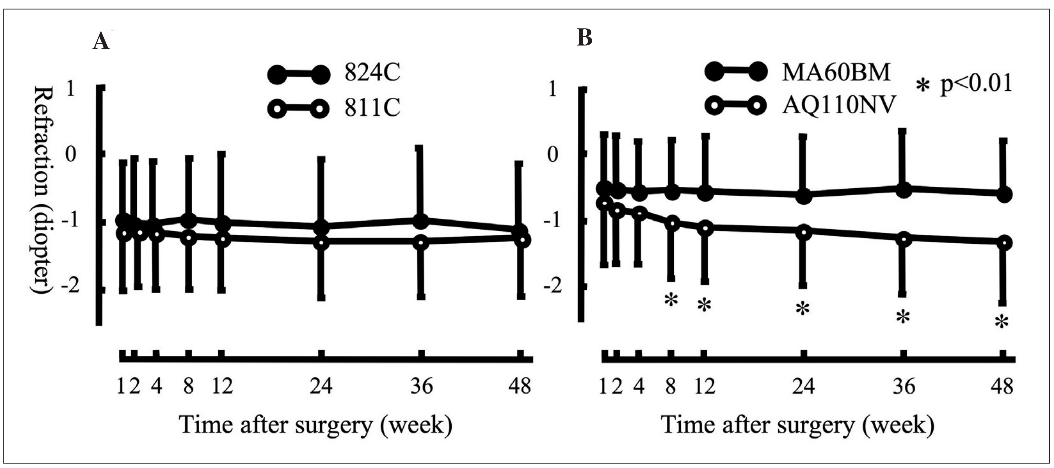
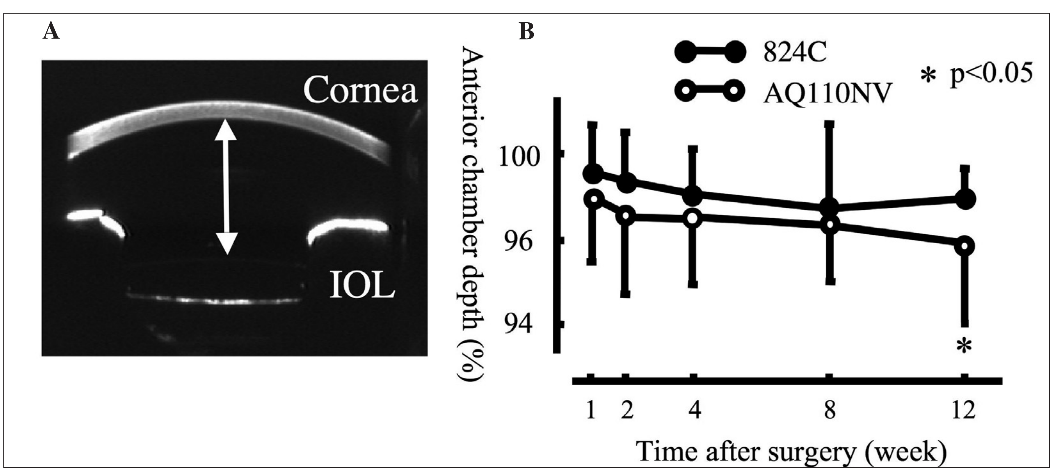


Fig. 3 - *Anterior chamber depth is the distance between posterior corneal surface and anterior intraocular lens surface as shown in* **(A)**. **(B)** *The graph depicts postoperative anterior chamber depth changes in silicone intraocular lens (AQ110NV) (open circles) and 824C (closed circles) groups. The data at each time point were compared to those at 1 week after the surgery. *p<0.05.*



(mm) data (1, 2, 4, 8, and 12 weeks) were related to that of 2 days after surgery. Percent ACD was determined by the following equation: ACD (%) = [actual depth (mm) at the indicated time period]/[Actual depth (mm) at 2 days after the surgery] x 100. All patients underwent the examinations required at all follow-up time points.

Statistical analysis

Normality of data distribution was assessed using the Kolmogorov-Smirnov test. Differences in the degrees of IOL movement that showed normal distribution were compared using the unpaired *t* test. Continuous variables without a normal distribution were compared using the Mann-Whitney *U* test. Discrete variables were compared using the Fisher exact probability test. Differences with a p value less than 0.05 were considered statistically significant.

RESULTS

Postoperative refraction changes

Predicted refraction and refraction at 1 week after surgery in each group are summarized in Table I. There was no significant difference among four groups in age and axial length before surgery ($p>0.05$) (Tab. I). The data at each time point in each group were compared to those at 1 week after the operation. Statistically significant myopic shift was observed only in the silicone IOL (AQ110NV) group at 8 weeks and continued throughout the follow-up period ($p<0.01$) (Fig. 2). At 12 weeks, the absolute changes in refraction (SER) were 0.06±0.63 D, 0.05±0.59 D, 0.07±0.62 D, and 0.33±0.59 D in 811C, 824C, MA60BM, and AQ110NV group, respectively. At 48 weeks, those were 0.09±0.66 D, 0.08±0.55 D, 0.09±0.56 D, and 0.53±0.64 D in 811C, 824C, MA60BM, and AQ110NV.

Postoperative ACD changes

To assess one of the factors influencing postoperative refraction change, the ACD of implanted IOL was measured in 824C (44 eyes) and AQ110NV (60 eyes) groups. ACD was significantly shortened in the silicone IOL group ($p<0.05$) (Fig. 3B). (Implanted IOL moved toward cornea.) At 12 weeks, ACD changes were 98.2±0.9% and 96.1±2.3% in 824C and AQ110NV groups. The forward shift of silicone (AQ110N) and PMMA (824C) IOL was also determined in the absolute value at 1 and 12 weeks after the surgery. Means and standard deviations were 140±130 mm and 80±100 mm, respectively. In addition, we could not observe any detectable haptic angulation by an anterior eye segment image analyzer (EAS-1000).

DISCUSSION

Recent advances in preoperative assessments on axial length and keratometry, along with that of IOL implant power calculation formulas (3, 4), allow us to achieve satisfactory and accurate postoperative refraction outcome. Since postoperative refraction is predictable, we are now able to provide good far or near vision without glasses depending on a patient's request. However, we have still experienced patients in whom the refraction immediately after surgery was close to the predicted value, with decreased postoperative UCVA month by month, mainly due to the refraction changes. Knowing the trend of postoperative refraction changes, including time course and extent, may help patients remain gratified with their quality of vision as long as possible, when the surgeries are performed based on those data. In this study, we have examined postoperative refraction change after surgery. At the same time, influential factors on the refraction changes, IOL materials, and ACD of implanted IOL were analyzed.

As mentioned above, only in a silicone IOL group could we detect a statistically significant myopic shift at later than 8 weeks after surgery (Fig. 2B). The determinant of these postoperative refraction changes could be the changes in corneal astigmatism produced by corneal incision and/or actual ACD of implanted IOL. The former factor, corneal astigmatism, seems to be unlikely or less effective because the width of temporal incision was smallest in a silicone IOL group (3.0 mm) than the other groups (6.0 mm wide for 811C and 824C and 3.8 mm wide for MA60BM). In addition, it was reported that no statistically significant difference in postoperative refraction change was noted between 3 mm corneal incision and

3 mm sclerocorneal incision (5). The latter factor, ACD of implanted IOL, could be a more important factor. In fact, we observed shortened ACD of implanted IOL in a silicone IOL group (Fig. 3B). IOL position was significantly translocated anteriorly toward the cornea at 12 weeks. Haigis and Trier described that a change of ACD of about 720 mm results in a 1.0 D change in refraction (6). Based on this calculation, the mean myopic shift of 0.33 D at 12-week time point in the silicone IOL group could show mean forward IOL shift of about 240 mm (720 mm: 1 D = 240 mm: 0.33 D). The mean forward shift of silicone IOL observed here was 140±130 mm in the absolute value. Therefore, about 60 percent (140 mm/240 mm x 100 = 58.3%) of myopic shift could be explained by forward IOL movement, although other contributing factors remain obscure in our study.

Although the refractive target was around –0.75 D, postoperative refraction at 1 week varied among groups (–0.5 to –1.16 D). So far, we are using A-constant provided by the manufacturer. To determine personalized A-constant for each IOL type, especially silicone IOL, based on experiences would be ideal to reduce the gap between predicted and postoperative (1 week) refraction. However, this variance could be less important, since we used postoperative refraction at 1 week as starting point and followed the refraction change afterwards. Furthermore, we should be reminded that reconsideration of the A-constant for silicone IOL would not simply give the answer to obtain more accurate postoperative refraction because of SRK-T formula in which not only the A-constant but also axial length and corneal radius will affect the predicted IOL power. The capsule shrinkage (7, 8) could alter the IOL position in the eye, while it is controversial whether it leads to a myopic or hyperopic (9) shift. Here we reported that a silicone IOL implantation causes postoperative myopic shift due to anterior IOL movement. It is known that capsule shrinkage was seen in the eyes with a silicone IOL more frequently than the eyes with other IOL such as PMMA and acrylic IOL (10, 11), presumably due to less adhesiveness of hydrophobic silicone IOL to the lens capsule, although there are arguments on this hypothesis. Recently Findl et al reported great optical stability of silicone IOL having a rectangular, sharp optic edge, the same as silicone IOL used in the present study (Fig. 1), no increased anterior capsular reaction, and preliminarily no increased capsular contraction (12). It is also known that too large capsulorhexis can result in anterior IOL movement when unrestrained. Because the size of capsulorhexis is rather small in the AQ110NV group compared to the others as described above, the size of capsulorhexis itself would not be a critical factor for postoperative anterior IOL movement. In addition, we could not assess the other important factors such as the haptic configuration, stiffness, and tension decay curves (13, 14). Therefore, it is difficult to draw a firm conclusion from our results regarding the mechanisms of myopic shift and capsular contraction.

In summary, postoperative refraction changes are minimized in the eyes with PMMA and acrylic IOLs, although obvious myopic shift (mean, 0.53±0.64 D) was observed in the eyes with silicone IOL employed here. This myopic shift resulted from anterior IOL movement and would be resolved by choosing a lower (~0.5 D in our case) IOL power for IOL implantation or by reconsidering its A-constant. We should be aware of the characteristics of each IOL, and should take myopic shift into consideration when performing silicone IOL implantation.

Neither author has a financial or proprietary interest in any product mentioned.

Reprint requests to:
Takeshi Iwase, MD
Department of Ophthalmology
Toyama Prefectural Central Hospital
Toyama, 930-8550, Japan
TsuyoshiIwase@aol.com

REFERENCES

1. Findl O, Drexler W, Menapace R, et al. Accurate determination of effective lens position and lens-capsule distance with 4 intraocular lenses. J Cataract Refract Surg 1998; 24: 1094-8.
2. Erickson P. Effects of intraocular lens position errors on postoperative refractive error. J Cataract Refract Surg 1990; 16: 305-11.
3. Hoffer KJ. Clinical results using the Holladay 2 intraocular lens power formula. J Cataract Refract Surg 2000; 26: 1233-7.
4. Narváez J, Zimmerman G, Stulting RD, Chang DH. Accuracy of intraocular lens power prediction using the Hoffer Q, Holladay 1, Holladay 2, and SRK/T formulas. J Cataract Refract Surg 2006; 32: 2050-3.
5. Oshima Y, Tsujikawa K, Harino S. Comparative study of intraocular lens implantation through 3.0 mm temporal clear corneal and superior scleral tunnel self-sealing incisions. J Cataract Refract Surg 1997; 23: 347-53.
6. Haigis W, Trier HG. Linsenberechnungsformeln. In: Trier HG. Ophthalmologische Ultraschalldiagnostik. Springer-Verlag, 1989; 75-80.
7. Hansen SO, Crandall AS, Olson RJ. Progressive constriction of the anterior capsular opening following intact capsulorhexis. J Cataract Refract Surg 1993; 19: 77-82.
8. Kimura W, Yamanishi S, Kimura T, Sawada T, Ohte A. Measuring the anterior capsule opening after cataract surgery to assess capsule shrinkage. J Cataract Refract Surg 1998; 24: 1235-8.
9. Nishigaki S, Inaba I, Minami H, Inoue T, Ichioka H. The postoperative change of depth of anterior chamber, refraction and anterior capsulorhexis size after intraocular lens implantation. Nippon Ganka Gakkai Zasshi 1996; 100: 156-8.
10. Cochener B, Jacq PL, Colin J. Capsule contraction after continuous curvilinear capsulorhexis: poly(methyl methacrylate) versus silicone intraocular lenses. J Cataract Refract Surg 1999; 25: 1362-9.
11. Georgopoulos M, Menapace R, Findl O, Rainer G, Petternel V, Kiss B. Posterior continuous curvilinear capsulorhexis with hydrogel and silicone intraocular lens implantation: development of capsulorhexis size and capsule opacification. J Cataract Refract Surg 2001; 27: 825-32.
12. Findl O, Buehl W, Menapace R, Sacu S, Georgopoulos M, Rainer G. Effect of material on posterior capsule opacification in intraocular lenses with sharp-edge optics. Ophthalmology 2005; 112: 67-72.
13. Koeppl C, Findl O, Kriechbaum K, et al. Postoperative change in effective lens position of a 3-piece acrylic intraocular lens. J Cataract Refract Surg 2003; 29: 1974-9.
14. Petternel V, Menapace R, Findl O, et al. Effect of optic edge design and haptic angulation on postoperative intraocular lens position change. J Cataract Refract Surg 2004; 30: 52-7.

on line

This paper has been selected to appear on the EJOWEB page free of charge

www.eur-j-ophthalmol.com/freearticle/index.htm