EXTENDED REPORT

Investigation of the stability of one-piece acrylic intraocular lenses in cataract surgery and in combined vitrectomy surgery

T Iwase, K Sugiyama

Br J Ophthalmol 2006;90:1519–1523. doi: 10.1136/bjo.2006.097766

See end of article for
authors' affiliations

Correspondence to:
T Iwase, Department of
Ophthalmology, Toyama
Prefectural Central
Hospital, 2-2-78
Nishinagae, Toyama City,
Toyama 930-8550,
Japan; Tsuyoshilwase@
aol.com

Accepted 6 August 2006
Published Online First
16 August 2006

Background: To compare the degrees of intraocular lens (IOL) movement between eyes that received a one-piece acrylic IOL and those that received a three-piece acrylic IOL after cataract surgery, and also among eyes that received a one-piece acrylic IOL after a combined vitrectomy surgery for cataract.

Methods: In the first study, we report on 50 patients who were implanted with a one-piece acrylic IOL in one eye and a three-piece acrylic IOL in the contralateral eye for senile cataract. In the second study, we report on 50 patients who were implanted with a one-piece acrylic IOL in combined vitrectomy surgery for cataract and retinal diseases. The degree of IOL decentration and tilt, and anterior chamber depth (ACD) were measured using Scheimpflug video photography at 1 week, 1 month, 3 months and 6 months after surgery in both the studies. The postoperative refractive status was also examined.

Results: The mean decentration and tilt showed no marked changes during the follow-up in eyes with either IOL implanted, and no marked differences were noted in either study throughout the follow-up. The ACD did not change after surgery with one-piece IOL implantation, for either the cataract surgery group or the combined surgery group, except for 1 week after surgery in eyes requiring gas tamponade. In contrast, marked shallowing in ACD was observed in the three-piece group after cataract surgery. The spherical equivalent did not change markedly in either study.

Conclusions: The one-piece acrylic IOL was stable in the capsular bag, both horizontally and vertically, after cataract surgery, and also after combined surgery.

One-piece acrylic intraocular lenses (IOLs; SA30AL and SA60AT, Alcon Laboratories, Texas, USA) have extremely flexible open-loop haptics composed of soft acrylic polymer.¹⁻⁴ The haptic compression force of the one-piece acrylic IOLs has been reported to be about one-seventh that of the three-piece acrylic IOLs.¹⁻² Although low compression forces are desirable, they do pose a concern regarding IOL stability in the capsular bag. However, previous studies have reported that the longitudinal movement of one-piece acrylic IOLs is markedly less than that of three-piece IOLs.³⁻⁵

Cataract surgery and posterior chamber IOL implantation appear to be well tolerated in eyes after pars plana vitrectomy,⁶ eliminating the need for additional procedures and providing rapid visual rehabilitation.⁷ With the recent progress in vitrectomy and cataract surgery, these two procedures have been combined and the combination is performed with favourable results in patients with vitreous disease, although the refractive errors in eyes undergoing the combined surgery had more myopia when compared with those eyes undergoing cataract surgery alone.⁸

The movement of an IOL after combined surgery may differ from that of an IOL after cataract surgery alone because vitreous is not present after vitrectomy and in some cases, gas occupies the vitreous cavity. The two main objectives of this prospective study were: (1) to verify previously reported results that measure the degree of IOL movement between eyes that received a one-piece acrylic IOL and those that received a three-piece acrylic IOL after cataract surgery alone; and (2) to assess the degree of IOL movement among eyes that received a one-piece acrylic IOL during a combined cataract surgery and vitrectomy procedure.

PATIENTS AND METHODS

This single-centre prospective study was conducted at the Department of Ophthalmology, Toyama Prefectural Central Hospital (Toyama, Japan). Surgery was carried out after approval of the institutional review board using the ethical standard established by the Declaration of Helsinki, and informed consent was obtained from all patients. The first study reports the findings for cataract surgery with 100 eyes of 50 patients who underwent phacoemulsification and aspiration (PEA) and IOL implantation for senile cataract between September 2004 and January 2005 by a single surgeon (TI). The second study reports on 50 eyes of 50 patients undergoing combined surgery of PEA, IOL implantation for senile cataract and a vitrectomy for retinal diseases between September 2004 and January 2005 by a single surgeon (TI).

The power of the IOL was calculated by the SRK-T formula, using the preoperative radius of corneal curvature, axial length and the A constant of the IOL.⁹ The A constant was set at 118.8 for the MA60BM and at 118.4 for the SA60AT. IOL power was determined to obtain the predicted postoperative refraction at around -1.0 D.

All patients were followed up for at least 6 months after the surgery. Exclusion criteria were history of intraocular surgery, uveitis, retinitis pigmentosa, pseudoexfoliation syndrome glaucoma and axial length >25 mm or <21 mm. The continuous curvilinear capsulorhexis (CCC) was sized to ensure complete overlap of the IOL optic during surgery. Patients with intraoperative complications (eg, incomplete

Abbreviations: ACD, anterior chamber depth; CCC, continuous curvilinear capsulorhexis; IOL, intraocular lens; PEA, phacoemulsification and aspiration

CCC, posterior capsular rupture) or with postoperative complications (eg, iris synechia) were excluded from this study. Incomplete CCC included anterior capsular crack formation and incomplete overlap of the IOL optic.

Assignment of IOLs

In the first study, one eye of each patient was randomly assigned to receive a hydrophobic acrylic one-piece IOL (AcrySof SA60AT, Alcon Laboratories) in one eye and a three-piece lens with the same optic material (AcrySof MA60BM, Alcon Laboratories,) in the contralateral eye. The SA60AT IOL has an anterior asymmetric biconvex optic with a diameter of 6 mm, an overall length of 13 mm, supporting haptics of the same soft acrylic material as the optic, and no haptic angulation (0°). The MA60BM IOL has a similar biconvex optic design with a diameter of 6 mm and an overall length of 13 mm. The modified J-loop haptics are polymethyl methacrylate and are angulated at 10° . For the combined surgery (second study), all patients received a SA60AT IOL.

Surgical technique

In the study of cataract surgery alone, after giving subtenon anaesthesia, a 3-mm-wide self-sealing temporal sclerocorneal tunnel was created. The anterior chamber was filled with a viscoelastic material, and a 5–5.25-mm CCC, slightly smaller than the IOL optic diameter, was made to attain circumferential 360° -capsulorhexis–IOL overlap. Thorough hydrodissection, phacoemulsification of the nucleus and aspiration of the residual cortex were carried out. The wound was not enlarged and the SA60AT was inserted in the capsular bag using the Monarch II injector.

In the combined surgery study, after giving retrobulbar anaesthesia, a half-round fornix-based conjunctival incision was created. After cataract surgery as described above, a standard three-port vitrectomy was carried out. The vitreous body was removed as much as possible towards the periphery. Fluid–air exchange or endophotocoagulation were performed when needed before closing the three-port system. Finally, the scleral and conjunctival wounds were sutured.

Measurement of IOL decentration, IOL tilt, anterior chamber depth and refraction

The degree of IOL decentration and tilt, as well as anterior chamber depth (ACD) were measured using Scheimpflug video photography (EAS-1000, Nidek, Japan) at 1 week, 1 month, 3 months and 6 months after surgery in both studies. At each visit, the visual acuity and spherical equivalent were recorded. The spherical and cylindrical

powers were measured in dioptres using an autorefractometer (ARK-2000, Nidek). The SE value was determined as the sum of spherical power and half the cylindrical power in diopters.

Statistical analysis

Normality of data distribution was assessed using the Kolmogorov–Smirnov test. Differences in the degree 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. A repeated-measures analysis of variance was used to compare differences at the various examinations. Differences with $p < 0.05$ were considered significant.

RESULTS

First study: comparison of MA60BM and SA60AT movement and performance after cataract surgery alone

Of the 73 patients undergoing cataract surgery alone, 23 patients were excluded on the basis of the exclusion criteria during and after surgery. The reasons for the exclusions were incomplete CCC (ie, anterior capsular crack formation or incomplete overlap of the IOL optic; $n = 22$) and posterior capsular rupture ($n = 1$). Accordingly, 50 patients were included in this study.

The mean (standard deviation (SD)) age of the patients was 69.4 (7.9) years (range 52–89 years). There was no significant difference between the MA60BM group and SA60AT group in the ACD or axial length before surgery.

Figure 1 shows the mean degree of decentration and tilt in MA60BM and SA60AT groups. There was no significant change during follow-up in decentration or tilt in either group. In addition, no significant differences were noted between the groups for IOL decentration or tilt throughout the follow-up.

Figure 2 shows mean ACD and mean spherical equivalent after cataract surgery alone. The ACD did not change significantly in the SA60AT group over time, whereas the mean ACD in the MA60BM group was significantly shallower 6 months after surgery than at 1 week after surgery ($p < 0.01$). The mean ACD was shallower in the SA60AT group than in the MA60BM group throughout the follow-up; however, the difference was significant only at 1 week ($p < 0.05$). The mean spherical equivalent did not change in either group over time, nor were any significant differences noted between the groups throughout the follow-up.

Figure 1 Mean degree of intraocular lens decentration (A) and tilt (B) in the MA60BM and the SA60AT groups after cataract surgery alone. (A,B) There was no significant change during follow-up in the MA60BM group or SA60AT group, and no significant differences were noted between the groups throughout the follow-up.

Figure 2 Change in mean anterior chamber depth (ACD) (A) and spherical equivalent (SE) (B) in the MA60BM and the SA60AT groups after cataract surgery alone. (A) The ACD did not change significantly in the SA60AT group, whereas the ACD 6 months after surgery showed significant shallowing compared with 1 week after surgery in the MA60BM group ($p<0.01$). The difference in ACD between the groups was significant only at 1 week ($p<0.05$). (B) The SE did not change in the MA60BM group or SA60AT group, and no significant differences were noted between the groups throughout the follow-up.

Second study: comparison of SA60AT movement and performance after cataract surgery alone or after combined cataract surgery and vitrectomy

Of the 69 patients undergoing combined surgery, 19 patients were excluded on the basis of the exclusion criteria during and after surgery. The reasons for the exclusions included incomplete CCC (ie, anterior capsular crack formation or incomplete overlap of the IOL optic; $n=15$), posterior capsular rupture ($n=3$) and iris synechiae ($n=1$). Transient increased intraocular pressure was noted in five eyes that did not require glaucoma surgery, and these eyes were included in this study. No recurrent retinal detachment or vitreous haemorrhage was observed. Accordingly, 50 eyes of 50 patients were included in this study.

For the combined surgery group, vitrectomy was carried out for diabetic retinopathy in 20 eyes and for an epiretinal membrane in 13 eyes (without the gas tamponade group), and rhegmatogenous retinal detachment in 17 eyes (with the gas tamponade group).

Figure 3 shows the mean degree of decentration and tilt in cataract surgery alone (PEA and IOL) and combined surgery (PEA, IOL and vitrectomy) with and without gas tamponade. There was no significant change over time in decentration or tilt after combined surgery, regardless of the presence or absence of gas tamponade. Furthermore, no significant

differences in decentration and tilt were observed among the three groups throughout the follow-up.

Figure 4 shows the change in mean ACD and mean spherical equivalent over time after cataract surgery alone (PEA and IOL) and combined surgery (PEA, IOL and vitrectomy) with and without gas tamponade. The ACD did not change significantly over time in the group without gas tamponade, but in the group with gas tamponade, it did show a significant increase from 1 week after surgery throughout the follow-up period ($p<0.05$). The mean spherical equivalent did not change over time in any of these groups. However, both combined surgery groups showed significantly more myopia compared with the mean spherical equivalent in the cataract surgery group at all time points ($p<0.05$).

DISCUSSION

As expected from previous reports,³⁻⁵ IOL decentration and tilt in eyes with either the SA60AT or MA60BM implanted did not change after surgery and were similar between both IOLs. Furthermore, even in the combined surgery groups, despite performing gas tamponade, IOL decentration and tilt did not change over time after surgery, and no significant differences were noted between the group undergoing cataract surgery with SA60AT implantation and the

Figure 3 Mean degree of intraocular lens (IOL) decentration (A) and tilt (B) in phacoemulsification and aspiration (PEA) and IOL (SA60AT) and combined surgery (PEA, IOL and vitrectomy) with and without gas tamponade. (A,B) There was no significant change during follow-up in combined surgery with or without gas tamponade, and no significant differences were observed among the three groups throughout the follow-up.

Figure 4 Change in mean anterior chamber depth (ACD) (A) and spherical equivalent (SE) (B) in phacoemulsification and aspiration (PEA) and intraocular lens (IOL; SA60AT) and combined surgery (PEA, IOL, and vitrectomy) with and without gas tamponade. (A) The ACD did not change significantly in the group without gas tamponade, whereas the ACD at 1 month postoperatively was significantly greater at 1 week after surgery in the gas tamponade group ($p < 0.05$). (B) The mean SE did not change in the combined surgery groups with and without gas tamponade. The SE in the combined surgery groups with and without gas tamponade showed a significant shift towards myopia throughout the follow-up relative to the cataract surgery group ($p < 0.05$).

combined surgery groups. These results indicate that the SA60AT remains well centred in the capsular bag even after combined surgery.

In confirmation of previous studies,³⁻⁵ the ACD of eyes receiving the one-piece IOL was constant over time, whereas a slight shallowing of the ACD in the early postoperative period was noted in eyes receiving the three-piece IOL. Wirtitsch *et al*⁴ noted that haptic angulation has a negative influence on the stability of IOL in the capsular bag, and proposed that the shallowing of ACD in eyes with angulated IOLs (as with the MA60BM) may be due to the forward shift of the IOL, as haptic memory is lost during fusion and shrinkage of the anterior and posterior leaves of the capsular bag. In a separate study, Hayashi *et al*³ further suggested that one-piece acrylic IOLs may have less axial movement because of the low compression force of the soft loops of the haptics.

As a consequence of ACD shallowing after implantation of the three-piece IOL, the mean SE in the MA60BM group also changed over time, showing a tendency for an early postoperative myopic shift. Not surprisingly, the one-piece IOLs, which had stable ACDs, exhibited stable refraction over time. Both IOLs, however, produced more myopia than predicted, which was probably due largely to inadequate customisation of the A constant. Therefore, although the one-piece IOL showed greater stability of refraction than the three-piece IOL, haptic design did not appear to affect predictability of refraction.

Figure 4 shows comparisons made among patients receiving the SA60AT IOL under different circumstances: during cataract surgery alone, during combined surgery with gas tamponade or during combined surgery without gas tamponade. Consideration was given to include patients receiving the three-piece MA60BM; however, it was decided to restrict our statistical analysis to only the one-piece IOL data, thereby removing the additional variable of haptic design from the interpretation of the data.

In the combined surgery group, the ACD was stable in eyes without gas tamponade, similar to the stability of eyes implanted with SA60AT after cataract surgery alone. However, the ACD in eyes with gas tamponade deepened over time. This may be explained by the gas tamponade in the vitreous cavity forcing the IOL anteriorly after surgery. With time, the ACD became deeper, coinciding with the dissipation

of gas from the vitreous cavity. No published reports were found that described ACD after combined vitrectomy surgery for cataract; therefore, we cannot compare our results with those of other IOLs in a similar situation. More studies are necessary to compare the performance of the AcrySof IOL with other lens types to determine its performance in combination with other retinal procedures.

It is interesting to note that despite patients in the combined surgery group having deeper ACDs (although not significantly) than those in the cataract surgery group, these patients were actually more myopic postoperatively than those who underwent cataract surgery alone (fig 4). This phenomenon may be explained primarily by noting the differences among predicted spherical equivalent values in each group. The mean predicted spherical equivalent values for the combined surgery groups were approximately 0.5 D more myopic than the mean predicted SE values for the cataract surgery group. Taking this disparity of predicted values into account, there is only a modest difference between the success of the combined surgery groups and the cataract surgery group in achieving target SE, with all three groups substantially more myopic than predicted. One of the causes for this greater than expected postoperative myopia may be that the A constant was not appropriately customised. In addition, the inaccurate measurement of axial length (such as by using the A mode) may cause error between predicted and actual refraction.¹⁰ The somewhat larger error in the combined surgery group may result from the difficulty in accurately measuring axial length in eyes requiring vitreous surgery for retinal detachment and macular oedema, which may have resulted in myopic refractions because of macular protrusion. In a similar study, Suzuki *et al* reported that actual refractive errors in patients undergoing combined surgery shifted towards myopia compared with those undergoing cataract surgery alone.⁸ We should therefore consider the error between predicted and actual refraction when calculating the IOL power in the eye requiring combined surgery.

In conclusion, eyes implanted with the SA60AT were stable in the capsular bag, both horizontally and vertically, even in combination surgeries. Therefore, the SA60AT is considered an effective IOL in terms of the movement in the capsular bag postoperatively not only in cataract surgery, but also in

combination surgeries. Further experience and study is necessary to examine and potentially minimise the difference between the predicted and actual refractions after cataract surgery combined with other retinal surgeries.

Authors' affiliations

T Iwase, Toyama Prefectural Central Hospital, Toyama, Japan
K Sugiyama, Kanazawa University Graduate School of Medical Science, Kanazawa, Japan

Competing interests: None.

REFERENCES

- 1 **Caporossi A**, Casprini F, Tosi GM, *et al*. Preliminary results of cataract extraction with implantation of a single-piece AcrySof intraocular lens. *J Cataract Refract Surg* 2002;**28**:652–5.
- 2 **Lane SS**, Burgi P, Milius GS, *et al*. Comparison of the biomechanical behavior of foldable intraocular lenses. *J Cataract Refract Surg* 2004;**30**:2397–402.
- 3 **Hayashi K**, Hayashi H. Comparison of the stability of 1-piece and 3-piece acrylic intraocular lenses in the lens capsule. *J Cataract Refract Surg* 2005;**31**:337–42.
- 4 **Wirtitsch MG**, Findl O, Menapace R, *et al*. Effect of haptic design on change in axial lens position after cataract surgery. *J Cataract Refract Surg* 2004;**30**:45–51.
- 5 **Nejima R**, Miyai T, Kataoka Y, *et al*. Prospective inpatient comparison of 6.0-millimeter optic single-piece and 3-piece hydrophobic acrylic foldable intraocular lenses. *Ophthalmology* 2006;**113**:585–90.
- 6 **Smiddy WE**, Stark WJ, Michels RG, *et al*. Cataract extraction after vitrectomy. *Ophthalmology* 1987;**94**:483–7.
- 7 **Koenig SB**, Mieler WF, Han DP, *et al*. Combined phacoemulsification, pars plana vitrectomy, and posterior chamber intraocular lens insertion. *Arch Ophthalmol* 1992;**110**:1101–4.
- 8 **Suzuki Y**, Sakuraba T, Mizutani H, *et al*. Postoperative refractive error after simultaneous vitrectomy and cataract surgery. *Ophthalmic Surg Lasers* 2000;**31**:271–5.
- 9 **Retzlaff JA**, Sanders DR, Kraff MC. Development of the SRK/T intraocular lens implant power calculation formula. *J Cataract Refract Surg* 1990;**16**:333–40.
- 10 **Olsen T**. Sources of error in intraocular lens power calculation. *J Cataract Refract Surg* 1992;**18**:125–9.