Piggybacking Intraocular Implants to Correct Pseudophakic Refractive Error

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Objective: This study aimed to determine the safety and efficacy of implanting a second intraocular lens (IOL) to correct pseudophakic refractive error.

Design: The study design was a nonrandomized, prospective, consecutive series.

Participants: Eight eyes of eight normal pseudophakes and seven eyes of seven postpenetrating keratoplasty (PK) pseudophakes were included in the study.

Intervention: A second intraocular lens (IOL) was implanted anterior to the first in each eye in the study.

Main Outcome Measures: Efficacy was determined based on the achieved refractive correction and Snellen uncorrected visual acuity measurements. Safety was determined based on loss of best-corrected visual acuity and operative and postoperative complications.

Results: Before surgery, spherical equivalents ranged from −5.12 diopters (D) to 7.5 D, with a mean absolute deviation from emmetropia of 3.38 D (1.62). After surgery, spherical equivalents ranged from −2.75 D to 0.5 D, with a mean absolute deviation from emmetropia of 1.21 D (0.90). Before surgery, only 7% of patients had 20/40 or better uncorrected vision, whereas after surgery, 50% had that level of vision.

Conclusions: Implanting a second IOL is a viable option for correcting pseudophakic refractive error.
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In 1993, we first described the implantation of two intraocular lenses (IOLs) in the eye to provide adequate power in a case of microphthalmos.[1] Since then, the use of multiple IOLs for addressing the power needs of high hyperopes has been well documented.[2–5]

Piggybacking implants also can be used to correct pseudophakic refractive errors. Rather than submit the patient to the trauma of an IOL exchange, which increases the risk for retinal tears, cystoid macular edema, cyclodialysis, and posterior or anterior capsule rupture, a second IOL can be implanted anteriorly to the primary IOL. The power of a secondary piggybacked implant also is more predictable than an IOL exchange because of the following:

1. The surgeon can never be 100% sure of the power of the original IOL.
2. The surgeon cannot be 100% confident that an exchanged IOL would be in the same plane as the old IOL.
3. The power of the secondary implant is calculated purely by the patient's refraction.

Not only can patients with pseudophakia with residual refractive error benefit from this strategy, but patients with pseudophakia who subsequently undergo penetrating keratoplasty (PK) can have the often-disabling refractive error created by PK corrected with a secondary piggybacked implant. We have collected a series of secondary piggybacked implant cases, including seven pseudophakic PK patients, to determine the predictability and effectiveness of this strategy for treating refractive error.

Materials and Methods

Power calculation for the second IOL was based on the refraction. For moderate-to-high hyperopia, we added a second plus power IOL. For high myopia, we added a minus power IOL. For underpowered pseudophakes, we estimated the needed power by multiplying the desired change in spherical equivalent × 1.5. For overpowered pseudophakes, we used the desired spherical equivalent change. That is, a +3.0 pseudophake with a targeted spherical equivalent of −1.0 would have been given [+3 − (−1)] × 1.5 = 6 diopters (D) IOL. A −3.5 pseudophake with a target of −0.50 would have been given a −3.0 D IOL. All patients were targeted for a range of refraction between −2.00 and +0.50 D.

Surgical Technique

All patients received topical anesthesia (Proparacaine 0.5%, Voltaren, Marcaine 0.75%). The patients then were prepared and draped in the usual fashion and the lid speculum was inserted. If an acrylic lens was used, a limbal incision was made. If a polymethylmethacrylate lens was required, a corneoscleral tunnel was fashioned. The anterior chamber was entered in a self-sealing fashion, and 1% unpreserved lidocaine was injected into the eye. Viscoelastic was used to deepen the anterior chamber and to deepen the area between the implant and the posterior surface of the iris if the secondary IOL was to be placed in the sulcus. Viscoelastic was used to lift up the anterior capsulorhexis if the implant was to be AQ: 2

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Table 1.

	Secondary Double IOLs for Residual Hyperopia (n = 8)	Secondary Double IOLs Post-transplant (n = 7)	All Secondary Cases (n = 15)
Mean spherical equivalent* (D)			
Preop	3.36 (2.02)	2.95 (0.95)	3.20 (1.65)
Range	1.62 to 7.50	2.38 to 4.62	1.62 to 7.50
Postop	−1.16 (1.30)	−0.85 (0.81)	−1.03 (1.13)
Range	−2.75 to 0.50	−2.25 to 0	−2.75 to 0.50
Mean absolute deviation from emmetropia (D)			
Preop	3.36 (2.02)	3.41 (1.15)	3.38 (1.62)
Range	1.62 to 7.50	2.38 to 5.12	1.62 to 7.50
Postop	1.41 (0.97)	0.98 (0.81)	1.21 (0.90)
Range	0.25 to 2.75	0 to 2.25	0 to 2.75

IOLs = intraocular lenses.

* Mean preoperative and postoperative spherical equivalents were calculated for hyperopic cases only.

placed in the bag. Unless the original surgery was recent enough to make bag fixation feasible, the implant was placed in the sulcus. Power was not adjusted for sulcus fixation versus bag fixation. If AQ: 3 the patient's posterior capsule was open, the viscoelastic was removed with the I&A cutter. If the posterior capsule was not open, viscoelastic was removed with the I&A unit. Miotic was used. The wound was sealed with balanced salt solution, a drop of *Iopidine* (Alcon, Fort Worth, TX), a drop of Tobradex (Alcon, Fort Worth, TX), and Pilopine gel instilled (Alcon, Fort Worth, TX). No patch was used. Statistical analysis was performed using StatMost (Version 2.5 for Windows; DataMost Corporation, Salt Lake City, UT) and SAS System for Windows (Release 6.11; SAS Institute Inc., Cary, NC).

Results

Sixteen secondary piggybacked implants have been performed. One case was excluded from analysis because of an incorrect surgical technique. That case received the secondary IOL placed posterior to the original IOL, rather than anterior, causing anterior shift of the original IOL and inducing high myopia. Of the remaining 15 cases, 7 were post-PK. Two of the PK cases received minus power IOLs to correct residual myopia. The remaining 13 cases received a secondary IOL to correct residual hyperopia.

Final postoperative data were used in all cases. Mean final postoperative visit was 7.5 months with a median of 8 months.

Mean spherical equivalents and mean absolute deviation from T1 emmetropia before and after surgery are presented in Table 1. Before surgery, the secondary cases implanted for residual hyperopia had a mean absolute deviation of 3.36 D (2.02) with a median of 3.25 D. The post-PK cases had a mean deviation of 3.41 D (1.15) with a median of 2.75 D. Overall, the entire cohort had a mean deviation of 3.38 D (1.62) with a median of 2.75 D.

After surgery, the cohort had a mean deviation of 1.21 D (0.90). Mean spherical equivalents were calculated separately for hyperopic and myopic cases. The mean spherical equivalent of the hyperopic cases before surgery was 3.20 D (1.65) and −1.03 D (1.13) after surgery. The mean spherical equivalent of the two myopic cases was −4.56 D (0.80) before surgery and −1.31 D (0.62) after surgery.

F1 Table 2 presents the refractive data for each case. Figure 1 presents the achieved refractive change for each case versus the preoperative spherical equivalent. Achieved refractive change was calculated by subtracting the postoperative spherical equivalent from the preoperative spherical equivalent. Cases within the solid lines achieved a postoperative refraction within the targeted range of −2.00 D to +0.50 D. All but three cases (80%) were within the targeted refractive range. Two of the cases were within 0.50 D of the target range and the remaining case was within 0.75 D of the target range. Figure 2 shows the postoperative refraction versus the F2 actual targeted refraction for each case. Most of the cases were within 1 D of the targeted refraction.

Snellen visual acuities are presented in Table 3. Before surgery, T3 7% (13) of the cases had uncorrected visual acuity of 20/40 or better. Sixty-four percent (9) were 20/100 or worse. After surgery, 50% (7) were 20/40 or better uncorrected and 21% (3) were 20/100 or worse.

Three cases had worse than 20/40 best-corrected vision after surgery. Two of those cases were PK cases with distorted corneal surfaces as determined from corneal topography. The third case had high astigmatism from a pterygium and keratitis. That case also was the only case to lose more than one line of best-corrected visual acuity. The patient's best-corrected visual acuity went from

Table 2.

	Preoperative Refraction	Target Refraction	Achieved Refraction
Hyperopic pseudophake	3.5	−1	−2.75
Hyperopic pseudophake	2.375	−0.5	0.25
Hyperopic pseudophake	1.875	−0.5	−1.625
Hyperopic pseudophake	3.25	−0.5	0.5
Hyperopic pseudophake	1.625	−0.5	−2.375
Hyperopic pseudophake	1.75	−0.5	−2
Hyperopic pseudophake	5	−2	−1.5
Hyperopic pseudophake	7.5	−1	0.25
Pseudophakic PK	2.375	−0.5	−0.375
Pseudophakic PK	2.5	−1	−0.375
Pseudophakic PK	2.75	0	0
Pseudophakic PK	2.5	−1	−2.25
Pseudophakic PK	−4	−2	−1.75
Pseudophakic PK	−5.125	−0.5	−0.875
Pseudophakic PK	4.625	−0.5	−1.25

PK = ●●●

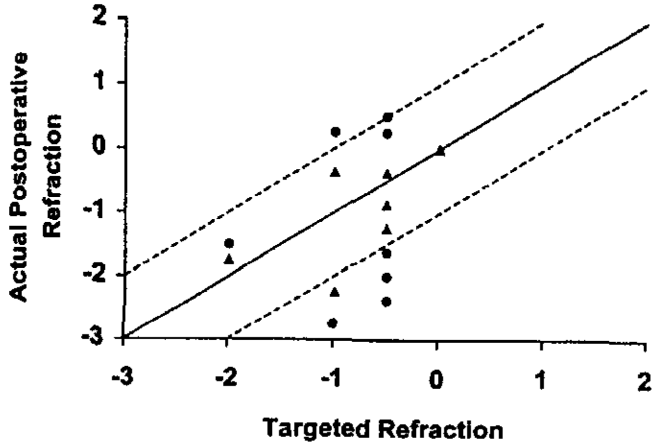

Figure 1. Achieved refractive change vs. the preoperative spherical equivalent. The mean refractive change was calculated by subtracting the postoperative spherical equivalent from the preoperative spherical equivalent. Postphotorefractive keratectomy cases are shown as triangles while the remaining cases are shown as circles.

20/80 before surgery to 20/400 after surgery. The patient died shortly after surgery before the keratitis could clear. No other surgical or postoperative complications were noted.

Discussion

Implanting a second IOL anterior to one already in place is an easy and relatively atraumatic procedure. In contrast, an IOL exchange involves removing the existing IOL before implanting a new one. The additional manipulation required for the removal process, particularly if the IOL is strongly fixated, increases the risk for complications.

Moreover, the predictability of the piggyback procedure can theoretically be greater than an IOL exchange. The accuracy of the power calculation for an exchange can be affected if the original IOL had been unknowingly mislabeled or if the new IOL ends up at a different plane than the original. The power calculation for a second implant depends only on the postoperative refraction. In the patients in this study, we used our own empirically derived formula and achieved reasonably close to our targeted refractive goal in almost all cases. We currently use the Holladay IOL Consultant software[6] to determine the IOL power. The Holladay software uses the preoperative refraction and proprietary equations.[7] We hope that the use of the Holladay II formula, which recently has become available, will improve our predictability further and allow us to refine our target to a narrower range of refractions.

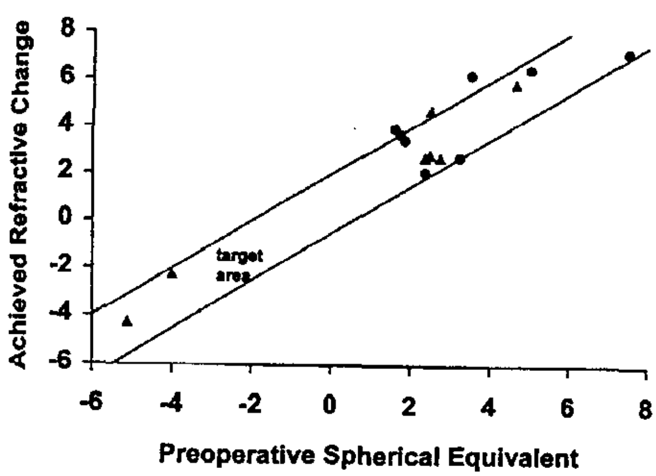

Figure 2. Postoperative refraction (spherical equivalent) vs. the targeted refraction. The solid line represents perfect correction. Cases within the dashed lines are within 1 diopter of perfect correction. The postphotorefractive keratectomy cases are shown as triangles while the remaining cases are shown as circles.

Table 3.

	Secondary Double IOLs for Residual Hyperopia (n = 8)	Secondary Double IOLs Post-transplant (n = 7)	All Secondary Cases (n = 15)
Preoperative uncorrected vision			
20/20–25	0/8	0/6	0/14
20/30–40	1/8 (12%)	0/6	1/14 (7%)
20/50–80	3/8 (38%)	1/6 (17%)	4/14 (28%)
<20/80	4/8 (50%)	5/6 (83%)	9/14 (64%)
Postoperative uncorrected vision			
20/20–25	2/7 (28%)	1/7 (14%)	3/14 (21%)
20/30–40	2/7 (28%)	2/7 (28%)	4/14 (28%)
20/50–80	2/7 (28%)	2/7 (28%)	4/14 (28%)
<20/80	1/7 (14%)	2/7 (28%)	3/14 (21%)
Preoperative best corrected vision			
20/20–25	3/8 (38%)	1/7 (14%)	4/15 (27%)
20/30–40	4/8 (50%)	3/7 (43%)	7/15 (47%)
20/50–80	1/8 (12%)	3/7 (43%)	4/15 (27%)
<20/80	0/8	0/7	0/15
Postoperative best corrected vision			
20/20–25	5/8 (62%)	2/7 (28%)	7/15 (47%)
20/30–40	2/8 (25%)	3/7 (43%)	5/15 (33%)
20/50–80	0/8	2/7 (28%)	2/15 (13%)
<20/80	1/8 (12%)	0/7	1/15 (7%)

IOLs = intraocular lenses.

Of course, predictability is dependent on proper surgical technique. Piggybacking IOLs successfully depends on anterior placement of the second IOL. As we discovered in the one case in which the second IOL was placed posteriorly, a posterior placement leads to unstable positioning within the eye, making accurate prediction of the ultimate refraction impossible. However, we do not believe that sulcus versus bag fixation of a second IOL significantly affects the power calculation, as there is only a 0.6-D difference (Holladay, personal communication), and thus we do not adjust our AQ: 4
calculations.

The secondary piggyback procedure is particularly effective in transplant cases for whom there are not a lot of viable options to correct significant, visually disabling, spherical refractive errors. Most of the pseudophakic PK cases we see have IOLs that were implanted years ago and that would be difficult to remove and exchange. For cases with myopic error, refractive surgery is an alternative, but is less predictable, especially in transplant patients. In our study, the piggyback procedure allowed 43% (3) of the transplant cases to see 20/40 or better uncorrected.

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Discussion
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Intolerable refractive errors after penetrating keratoplasty are very common because the surgeon has little control over the power of the transplanted cornea. Correcting these patients with a secondary intraocular lens anterior to the primary lens prevents the dangers and inaccuracies of lens exchange. Because there is no power removed from the eye during the secondary implant, the correct power for the implant can be calculated from the current refraction and K-readings using a refraction formula.[1] The axial length and the power of the existing lens are not necessary for intraocular lens power calculations from refraction.

Dr. Gayton reported the first piggyback implantation in 1993 and has since refined his technique to provide excellent results. Reducing the mean absolute deviation from 3.38 diopters (D) to 1.21 D indicates a threefold improvement in the residual refractive errors. Improving the uncorrected vision of 20/40 or better from 7% to 50% illustrates the efficacy of the procedure. Exclusion of one case because the secondary lens was placed posteriorly rather than anteriorly illustrates the evolution of this surgical technique and the need for precision in the surgery and the lens calculations.

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