A Contralateral, Randomized Comparison of Optimized Prolate Ablation and Conventional LASIK for Myopia With the NIDEK Excimer Laser Platform

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ABSTRACT

PURPOSE: To compare the refractive, visual acuity, topographic, and spherical aberration outcomes of LASIK using the Quest excimer laser platform with the optimized prolate ablation (OPA) profile (NIDEK Co Ltd) in one eye and conventional ablation profile in the fellow eye of the same patient.

METHODS: Thirty-seven myopic patients underwent LASIK bilaterally, with one eye randomized to receive OPA ablation (-3.88 ± 1.42 diopters [D], range: -1.53 to -7.50 D) and the fellow eye to receive conventional ablation (-3.89 ± 1.37 D, range: -1.75 to -7.00 D). Independent and paired t tests were used for testing differences between groups at last postoperative follow-up (6 or 12 months).

RESULTS: Postoperatively, 97% (32/33) of OPA eyes and 94% (31/33) of conventional eyes saw 20/20 or better without correction ($P>.05$). No eyes lost 2 or more lines of distance corrected visual acuity. Manifest refraction spherical equivalent was -0.16 D in the OPA group and -0.05 D in the conventional group ($P>.05$). Ocular spherical aberration was -0.003 μm in the OPA group and $+0.102$ μm in the conventional group ($P<.05$). Corneal asphericity was statistically lower after OPA (0.07 ± 0.26) compared to conventional ablation (0.30 ± 0.26) ($P<.001$). The mean programmed optical zone and achieved postoperative horizontal diameter of the effective optical zone were statistically significantly larger in the OPA group ($P<.05$).

CONCLUSIONS: Postoperative visual acuity and refractive outcomes were similar between groups. Laser in situ keratomileusis using the OPA profile for the correction of myopia induced significantly less corneal and ocular spherical aberration, resulted in normal postoperative asphericity in 94% of eyes, and larger horizontal diameter of the effective optical zone compared to the conventional profile. [*J Refract Surg.* 2012;28(7):453-461.] doi:10.3928/1081597X-20120621-01

Refraction-based, Munnerlyn formula, conventional excimer laser algorithms for myopia and astigmatism may induce higher order aberrations and oblate corneas due to loss of radial ablation efficiency as the ablation progresses to the corneal periphery, corneal remodeling from wound healing, and biomechanical changes.[1-4] The induction of positive spherical aberration reduces functional optical zones postoperatively, potentially causing a diminution in vision.[5-8] Recent laser algorithms use aspheric ablation profiles that reduce this induction.[9,10] The refractive, visual acuity, and aberrometry outcomes of these aspheric algorithms can be compared to conventional patterns to determine their relative safety, efficacy, and predictability.

The optimized prolate ablation (OPA) is a newly developed laser algorithm that has been incorporated into the NIDEK Quest excimer laser platform (NIDEK Co Ltd, Gamagori, Japan). The unique aspect of OPA is the combination of the patient's corneal topography data with corneal and ocular (entire eye) spherical aberration data to create an aspheric ablation profile that maintains a prolate cornea over the mesopic pupil. This strategy differs from "wavefront-optimized" algorithms, which use population averaged spherical aberration values rather than values specific to the eye being treated.[11] Optimized prolate ablation also differs from "wavefront-guided" treatments, because it addresses only spherical aberration, not other higher order aberrations. Some authors emphasize that wavefront-guided ablations are most useful for eyes with excessive preoperative higher order aberrations and not eyes with normal aberrometry.[12,13]

In this prospective comparison, we compare outcomes

between OPA and conventional ablation performed contralaterally in the same patients.

PATIENTS AND METHODS

The NIDEK Quest excimer laser platform was used for all treatments. The treatments for the two eyes were randomized using a randomization table.

Inclusion criteria were age of at least 18 years with −0.75 to −7.50 diopters (D) of physiologic spherical equivalent myopia with ≤2.00 D of manifest refractive astigmatism. All other inclusion and exclusion criteria have been previously described.[10] Retreatments were not permitted. All patients signed an informed consent, and the nature of the procedure was explained in detail. The study adhered to the tenets of the Declaration of Helsinki.

Baseline evaluation included measurement of uncorrected (UDVA) and corrected (CDVA) distance visual acuity (in Snellen and decimal notation), manifest and cycloplegic refractions under calibrated room illumination conditions by experienced technicians using ETDRS acuity charts, slit-lamp examination, and Goldmann tonometry. The OPD-Scan II (NIDEK Co Ltd) was used to measure photopic and mesopic pupillometry and three repeat measurements of corneal topography and ocular wavefront (6 mm; 8th radial order; dark adapted between measurements, physiologically dilated pupil). Central corneal pachymetry (Corneo-Gage Plus 50 MHz; Sonogage, Cleveland, Ohio) and indirect ophthalmoscopy were also performed.

The same evaluation as preoperatively was performed postoperatively at 1 (dilated funduscopy and pupillometry excluded), 3, 6, and 12 (dilated funduscopy included) months. Patients were masked to the ablation delivered to each eye. Laser in situ keratomileusis was performed with a single excimer laser by an experienced surgeon (A.M.E.D.). Corneal flaps (superior hinge; 110-μm depth; 9.2-mm diameter) were created with the IntraLase 150-kHz femtosecond laser (Abbott Medical Optics, Abbott Park, Illinois).

The OPA algorithm has been described previously.[9,10,14] Conventional ablation has a Gaussian beam profile and uses a Munnerlyn-based algorithm in the optical zone with an approximately linear transition zone.[15] Zero ocular spherical aberration was targeted in cases with positive preoperative ocular spherical aberration (n=18) and maintenance of ocular spherical aberration was targeted in cases with negative spherical aberration preoperatively (n=19). The Final Fit ablation planning software (version 1.13, NIDEK Co Ltd) was used for all conventional treatments with a well-established, personalized nomogram. Optimized prolate ablation software (version 1.00, NIDEK Co Ltd)

was used for planning OPA treatments. The OPA eyes were treated based on the NIDEK algorithm modified by a nomogram that was generated using a proprietary multiparametric regression formula in which 10 coefficients were entered to analyze the outcomes of 30 previously treated eyes (first patients worldwide). This nomogram ("Alaa II") increased the cylinder correction and changed spherical correction based on the magnitude of correction. All eyes were targeted for emmetropia postoperatively.[10]

The OPA group underwent treatment with a mean optical zone of 6.80±0.33 mm (range: 5.60 to 7.00 mm) and mean transition zone of 8.39±0.35 mm (range: 7.20 to 8.60 mm). In OPA, the diameter of the programmed optical zone was selected by taking the difference (automatically measured by the OPD-Scan II) between the mesopic pupil center and the coaxially sighted corneal light reflex and adding it to the mesopic pupil diameter. All eyes in the conventional group underwent treatment with a comparably sized mean optical zone of 6.48±0.11 mm (range: 6.00 to 6.50 mm) and mean transition zone of 7.54±0.25 mm (range: 7.00 to 8.50 mm). Programmed treatment zones were based on the requirement of a residual stromal bed ≥300 μm with the largest ablation diameter possible. A 200-Hz infrared eye tracker was used to center the laser ablation midway between the photopic pupil center and coaxially sighted corneal light reflex measured by the OPD-Scan II in all eyes. The tracker remained active during ablation to maintain this centration. Centration closer to the visual axis rather than the line of sight or pupil center was used based on previous experience and the manufacturer's recommendation. Intraoperative cyclotorsion was actively compensated during ablation with the online active torsion correction function.[9,10]

Postoperative medications were topical moxifloxacin (Vigamox; Alcon Laboratories Inc, Ft Worth, Texas) and prednisolone acetate 1% (Predforte; Allergan Inc, Irvine, California) four times daily for 1 week.

DATA ANALYSIS

Between-group comparison was conducted for refractive outcomes, visual acuity, corneal and whole eye spherical aberration, corneal asphericity (Q), horizontal diameter of the effective optical zone, and classification of postoperative corneas based on the Corneal Navigator corneal disease screening software (NIDEK Co Ltd). An ellipsoid model was used to determine Q at 4.50 mm.

Mean values with standard deviation and range were calculated as appropriate. Visual acuity values were converted to logMAR for analysis. Horizontal diameter of the effective optical zone was measured manually

by placing cursors along the horizontal diameter at the point where a 1.50-D change was noted from the central corneal power using the axial corneal topography map with the Klyce-Smolek scale and color scheme.[16] Corneal statistical analyses were conducted preoperatively and at last follow-up (6 or 12 months postoperatively) using Datagraph-med software (Ingenieurbüro Pieger GmbH, Wendelstein, Germany) or Microsoft Excel (Microsoft Corp, Redmond, Washington). If a patient presented at 6 and 12 months, the 12-month data were used. Differences between groups were tested with the independent and paired t tests. $P<.05$ was considered statistically significant.

RESULTS

PREOPERATIVE DATA

Mean age of the cohort was 26.3 ± 4.66 years (range: 19 to 38 years), and 20 (61%) patients were women. All preoperative parameters were similar between groups ($P>.05$, all cases) (Table A, available as supplemental material in the PDF version of this article).

POSTOPERATIVE DATA

At last follow-up, 33 (89%) patients were available for examination (31 at 6 months; 24 at 12 months). Four patients were lost to follow-up. These 4 patients did not differ from the cohort in preoperative, surgical, or postoperative variables (Table A). No intra- or postoperative complications were reported.

REFRACTIVE AND VISUAL ACUITY OUTCOMES

The difference in postoperative manifest refraction spherical equivalent (MRSE) was statistically significant (but clinically similar) between groups ($P<.05$) (Table). Attempted versus achieved refractive correction, refractive accuracy, and refractive astigmatism were similar between groups (all $P>.05$) (Figs 1, 2, and 3, Table).

Postoperative UDVA was similar between groups (Fig 4, $P>.05$). No eyes lost more than 1 line of CDVA (Fig 5). Stability was similar in both groups (Fig 6). No statistical or clinical differences were noted in safety, refractive, and visual acuity outcomes between groups.

HIGHER ORDER ABERRATIONS

One patient was excluded from analysis due to inadequate pupil dilation (<6 mm) pre- and postoperatively. Paired data were analyzed for each follow-up examination. Ocular and corneal spherical aberration were statistically significantly lower in the OPA group compared to the conventional group at every postoperative follow-up ($P<.05$ all cases; $P<.001$ at last follow-

up) (Table, Figs 7 and 8). The deviation from intended ocular spherical aberration (assuming maintenance of spherical aberration in the conventional group) was statistically significantly different at all postoperative follow-up examinations, favoring the OPA group ($P<.05$ all cases, $P<.001$ at 3 and 12 months) (Fig 9). No correlation was noted between induced spherical aberration and refractive correction in both groups ($R^2=0.017$ for the OPA group; $R^2=0$ for the conventional group).

CORNEAL TOPOGRAPHY AND ASPHERICITY

Corneal asphericity was statistically significantly less oblate in the OPA group (0.07 ± 0.26) compared to the conventional group (0.30 ± 0.26) ($P<.001$) (Table). Corneal asphericity became more oblate with higher preoperative refractive error after OPA. Postoperative Q was >0.40 in only two OPA-treated eyes. Preoperative MRSE and postoperative Q were statistically correlated for both groups (Fig 10).

Preoperatively, the Corneal Navigator classified all corneas as "normal." Postoperatively, the Corneal Navigator classified 77% of eyes in the conventional group and 46% of eyes in the OPA group as "myopic refractive surgery," with the remaining classified as "normal" corneas ($P<.0001$) (Fig 11).

Horizontal diameter of the effective optical zone was statistically significantly larger in the OPA group compared to the conventional group across the refractive range treated in this study ($P<.05$ all cases) (Fig 12). The programmed optical zone between groups was similar ($P>.05$). The difference in the horizontal diameter of the effective optical zone and the optical zone programmed into the laser was not correlated to preoperative keratometry in either group.

The mean difference between the horizontal diameter of the effective optical zone and the optical zone programmed into the laser was $+0.377$ mm (larger) for the OPA group and -0.672 mm (smaller) for the conventional group ($P<.001$).

DISCUSSION

Prospective, randomized, contralateral eye studies are an excellent study design because they take advantage of the fact that two eyes (corneas) of one patient are more likely to react similarly to a treatment (excimer laser ablation) than two eyes of two different patients.

REFRACTIVE OUTCOME

We found that LASIK with OPA is safe and effective for the treatment of low to moderate myopia with or without astigmatism. Although the difference in postoperative MRSE between the groups statistically

TABLE

Pre- and Last Postoperative Follow-up Parameters of 37 Patients Who Underwent LASIK With Optimized Prolate Ablation in One Eye (OPA Group) and Conventional Ablation (Conventional Group) in the Fellow Eye

Parameter	Group	Mean±Standard Deviation (Range)		P Value†
		Preoperative*	Postoperative	
UDVA (logMAR)	OPA	1.24±0.38 (0.50 to 2.00)	0.072±0.09 (−0.20 to 0.18)	>.05
	Conventional	1.24±0.35 (0.50 to 2.00)	0.056±0.075 (−0.20 to 0.10)	
CDVA (logMAR)	OPA	0.052±0.051 (−0.14 to 0.02)	0.083±0.063 (−0.20 to 0.0)	.05
	Conventional	0.051±0.049 (−0.10 to 0.04)	0.072±0.061 (−0.20 to 0.0)	
Sphere (D)	OPA	−3.62±1.42 (−7.50 to −1.00)	−0.05±0.24 (−0.75 to 0.75)	.05
	Conventional	−3.59±1.31 (−6.75 to −1.25)	0.05±0.16 (−0.25 to 0.50)	
Cylinder (D)	OPA	0.52±0.46 (0.00 to 2.00)	−0.20±0.24 (0.75 to 0.75)	>.05
	Conventional	0.61±0.49 (0.00 to 2.00)	−0.19±0.23 (0.00 to 0.75)	
MRSE (D)	OPA	−3.88±1.40 (−7.50 to −1.53)	−0.16±0.23 (−1.00 to 0.25)	<.05
	Conventional	−3.90±1.35 (−7.00 to −1.75)	−0.05±0.18 (−0.50 to 0.37)	
Postop MRSE within ±0.50 D (%)	OPA	—	97	>.05
	Conventional	—	100	
Corneal asphericity	OPA	−0.14±0.11	0.07±0.26	<.001
	Conventional	−0.14±0.09	0.30±0.26	
Ocular spherical aberration (μm)	OPA	−0.03±0.13 (−0.34 to 0.19)	−0.02±0.115 (−0.25 to +0.12)	<.001
	Conventional	−0.01±0.12 (−0.27 to 0.38)	+0.07±0.08 (−0.05 to +0.27)	
Corneal spherical aberration (μm)	OPA	0.27±0.07 (0.08 to 0.40)	0.36±0.14 (−0.01 to +0.72)	<.001
	Conventional	0.27±0.07 (0.05 to 0.41)	0.47±0.12 (0.13 to +0.64)	
Normal classification using Corneal Classification screening software (%)	OPA	100	54	<.0001
	Conventional	100	23	

UDVA = uncorrected distance visual acuity, CDVA = corrected distance visual acuity, MRSE = manifest refraction spherical equivalent
**No statistical difference in all preoperative parameters.*
†Difference between groups.
Note. Spherical aberrations are reported for the entire eye (ocular) and cornea at 6-mm diameter to the 8th Zernike order. Corneal asphericity, commonly referred to as "Q" value, is reported for a 4.50-mm diameter.

favored the conventional group, the mean numerical difference (−0.16 D OPA and −0.05 D conventional) was not clinically meaningful.

The refractive—but not the topographic—results in this study were similar to recent outcomes for wavefront-guided, wavefront-optimized, and aspheric LASIK that treated similar or larger sample sizes (range: 37 to 358 eyes) and similar MRSE (Table B, available as supplemental material in the PDF version of this article). Direct comparison to previous studies is difficult due to the lack of standardization and differing preoperative selection criteria. A comparative study of myopic wavefront-guided LASIK reported a mean postoperative MRSE of −0.17 D for the LADARVision (Alcon Laboratories Inc) and −0.14 for the Star CustomVue (Abbott Medical Optics Inc), which is similar to our study (−0.16±0.23 D).[17] A literature review by the American Academy of Ophthalmology (AAO) of wavefront-guided LASIK with 4 lasers with a similar sample size as ours and follow-up data ranging from 1 to 6 months reported an average of 87% of eyes within ±0.50 D of intended MRSE, which is substantially lower than our results of 97% of eyes after OPA.[18] However, some of these studies used preselection criteria based on the preoperative higher order aberration, which may affect outcomes.[18] A contralateral eye study[19] (N=27 patients) of wavefront-optimized and wavefront-guided LASIK with the Allegretto (Alcon Laboratories Inc), with a preoperative
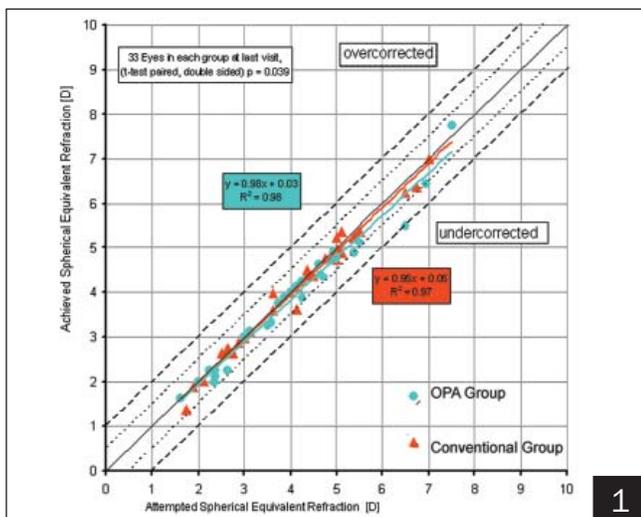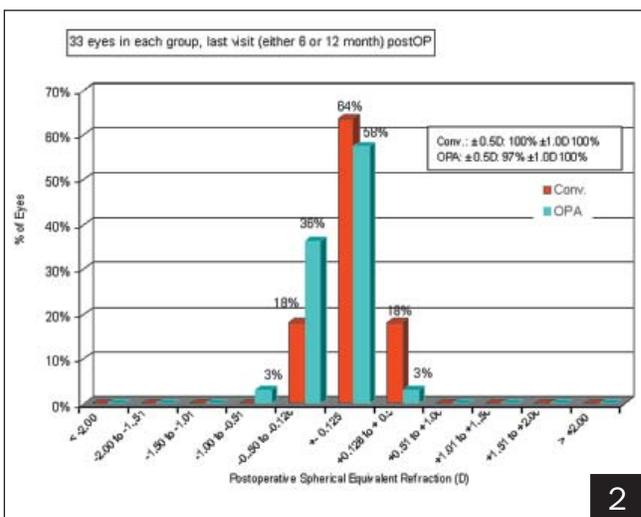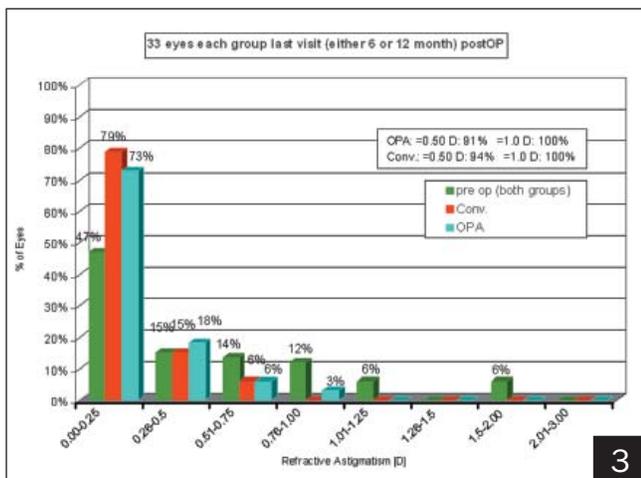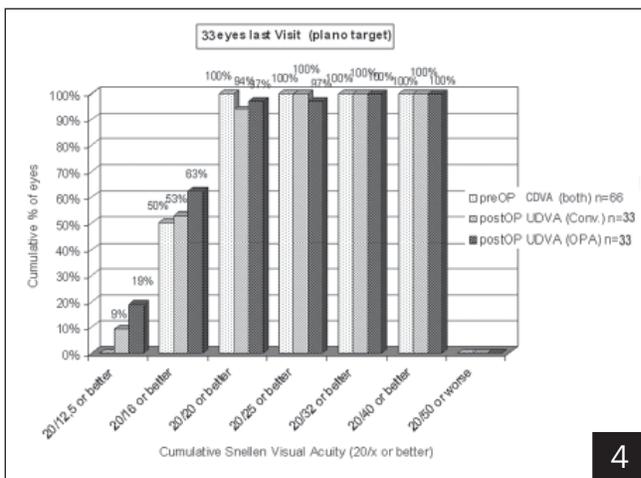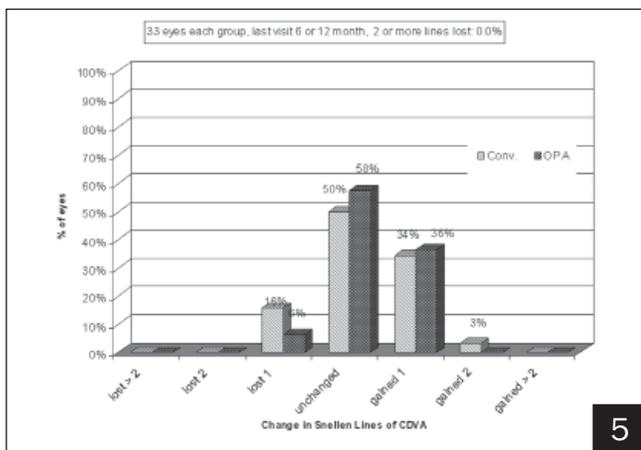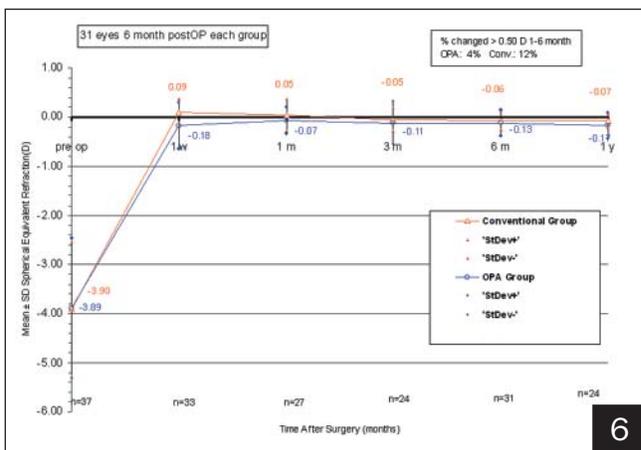
Figure 1. Attempted versus achieved manifest refraction spherical equivalent at last postoperative follow-up. The scattergram demonstrates a coefficient of determination (R^2) of 0.98 for the OPA group and 0.97 for the conventional group ($P>.05$). **Figure 2.** Accuracy of manifest refraction spherical equivalent. No statistically significant difference was noted between groups ($P>.05$, paired t test). **Figure 3.** Refractive astigmatism. Attempted versus achieved refractive astigmatism was similar for both groups. **Figure 4.** Uncorrected distance visual acuity (UDVA) (CDVA = corrected distance visual acuity). No statistically significant difference was noted between groups ($P>.05$, paired t test). **Figure 5.** Change in corrected distance visual acuity (CDVA). No eye lost more than one Snellen line of CDVA ($P=.05$). **Figure 6.** Stability of spherical equivalent refraction. Stability was excellent after 1 month and was similar between groups.
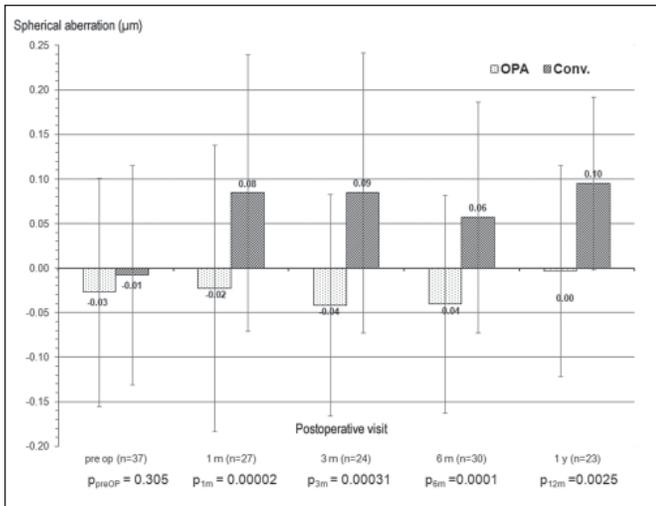
Figure 7. Ocular (whole eye) spherical aberration over time of patients who underwent LASIK with optimized prolate ablation (OPA) in one eye and conventional ablation (conv) in the fellow eye. Spherical aberration was statistically lower and similar to preoperative in the OPA group at all postoperative follow-up points ($P<.05$, paired t test).
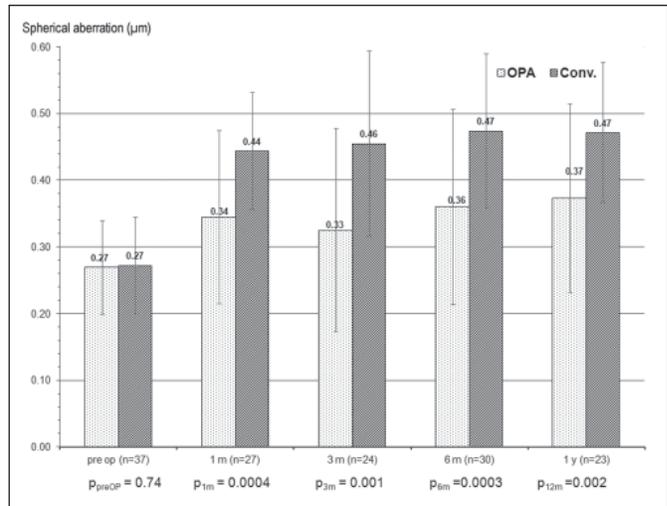

Figure 8. Corneal spherical aberration over time of patients who underwent LASIK with optimized prolate ablation (OPA) in one eye and conventional ablation (conv) in the fellow eye. Spherical aberration was statistically lower in the OPA group at all postoperative follow-up points ($P<.05$, paired t test).
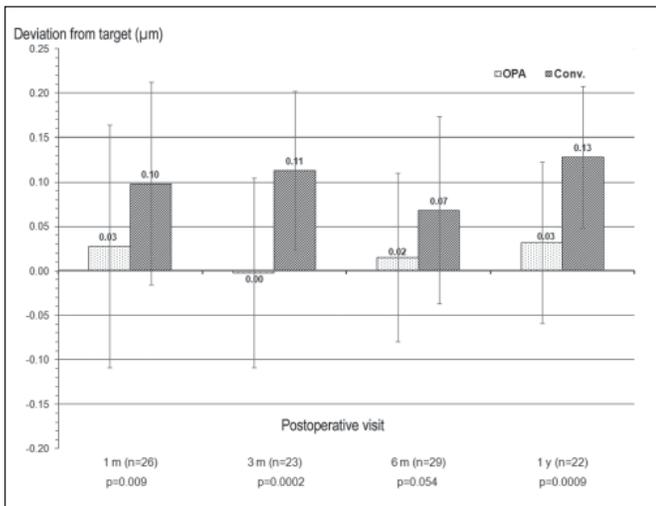

Figure 9. Deviation from intended ocular spherical aberration in eyes after myopic LASIK with optimized prolate ablation (OPA) in one eye and conventional (conv) ablation in the fellow eye.
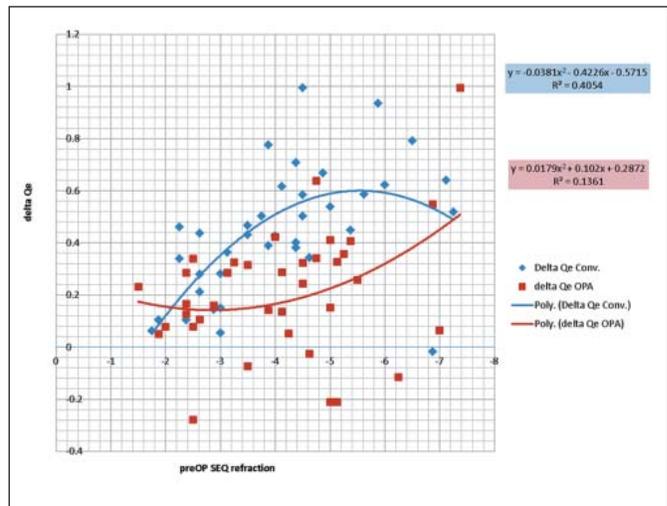

Figure 10. Change in corneal asphericity (delta Q) as a function of pre-operative spherical equivalent (preop SEQ) refraction.

MRSE similar to ours (-4.36 ± 1.22 D), reported 89% of eyes were within ±0.50 D of attempted MRSE, which is lower than our results, with 94% of eyes in the OPA group having MRSE between -0.50 and 0.125 D of the intended refraction. The OPA group had twice the number of eyes within -0.50 to -0.126 D of the intended refraction, with 20% more eyes in this group achieving UDVA 20/16 or better, indicating a trend toward greater accuracy.

VISUAL ACUITY

Postoperative UDVA in the OPA group was en-couraging: 64% saw 20/16 or better. These results exceed outcomes reported by the AAO for wavefront-optimized LASIK,[18] with only 44% achieving UDVA 20/16 or better, and for wavefront-guided LASIK, with <10% of eyes achieving UDVA 20/16 or better.[19] Larger treatment zones in OPA were designed to create and maintain a functionally prolate cornea and to ensure adequate coverage of the mesopic pupil. An improvement in vision due to larger treatment zones has been reported.[17]

Safety was demonstrated by no loss of two or more lines of CDVA in either group.
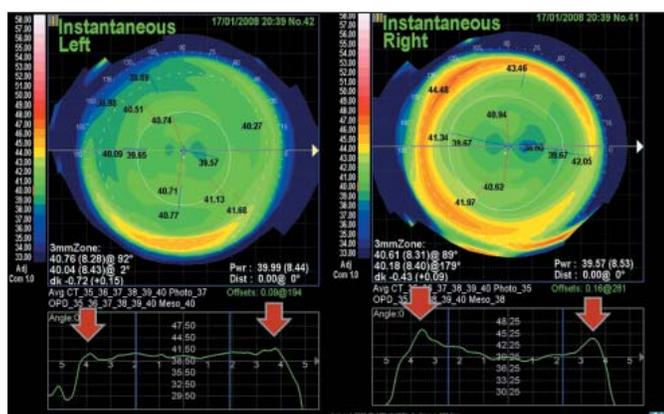
Figure 11. Sample instantaneous (local) curvature corneal topographies at 6 months postoperatively of a patient who underwent optimized prolate ablation in the left eye and conventional ablation in the right eye. The red arrows indicate the cross-section. The postoperative OPA topography is considerably less oblate (Q=0.22) than conventional topography (Q=0.44).
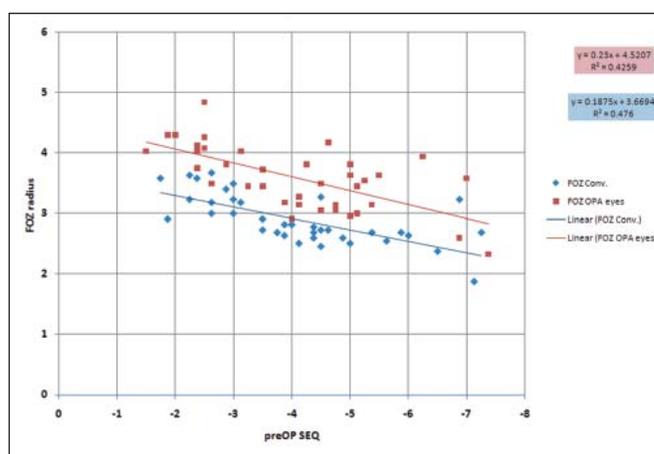

Figure 12. Preoperative spherical equivalent refraction (SEQ) compared to postoperative horizontal diameter of the effective optical zone (after myopic LASIK with optimized prolate ablation [OPA] in one eye and conventional [Conv] ablation in the fellow eye). Horizontal diameter of the effective optical zone was consistently larger in the OPA eyes.

CORNEAL TOPOGRAPHY AND SPHERICAL ABERRATION

Statistically significant differences were noted in postoperative spherical aberration between the two algorithms, with better outcomes in OPA-treated eyes. At last follow-up, ocular spherical aberration increased by 0.03 µm in the OPA group compared to 0.11 µm in the conventional group, despite similar preoperative magnitudes of ocular spherical aberration in both groups (P<.05). Postoperative corneal spherical aberration was two times larger in the conventional group compared to the OPA group (P<.05). The better outcome after OPA is expected because the ablation algorithm specifically targets little to no induction of spherical aberration whereas conventional ablation does not incorporate treatment of spherical aberration. Of note was the lack of a similar increase in the magnitude of ocular spherical aberration compared to the (statistically insignificant) increase in postoperative corneal spherical aberration. Two recent studies have attributed this difference in changes between postoperative corneal and ocular spherical aberration to an (undetermined) compensatory mechanism that allows internal aberrations to continue to compensate for and reduce the impact of the induced corneal wavefront changes after LASIK.[20,21]

Postoperative spherical aberration has been associated with glare and halos.[6,7] Hence, algorithms such as OPA that reduce or eliminate postoperative spherical aberration may be advantageous, pending comparative studies of dysphotopsia between OPA and conventional ablation. The reduced induction of ocular spherical aberration after OPA treatment is similar to or better than previous studies[22-25] of wavefront-guided and aspheric algorithms treating a similar MRSE. How-ever, this comparison must be interpreted with caution as we reported spherical aberration for a 6-mm pupil, whereas others[17] report varying pupil diameters.

Another potential advantage of OPA is the larger horizontal diameter of the effective optical zone compared to the conventional algorithm. The larger horizontal diameter of the effective optical zone does not impinge on the mesopic pupil diameter, and therefore may also reduce scotopic symptoms postoperatively.[2,3,6] In the current study, the horizontal diameter of the effective optical zone decreased with increasing amounts of attempted correction. This observation verifies the previous observation by Holladay and Janes[8] of smaller effective optical zones resulting from higher attempted myopic corrections using conventional ablation. This observation indicates that larger horizontal diameters of the effective optical zone have resulted due to OPA.

Although keratometry may affect refractive outcomes,[26] it is not through an effect on the horizontal diameter of the effective optical zone as shown in this study. One caveat remains—currently, no standardized method of determining the functional or effective optical zones exists. Our method of measuring the horizontal diameter of the effective optical zone is one of several proposed mechanisms of measuring functional optical zones that range from mathematically and computationally intensive methods based on wavefront aberrations[27] or simply measuring corneal contour.[28] We elected to follow Tabernero et al's[27] advice on the topic and selected a method that would be clinically easy to implement, practical, and have direct correlation to corneal topography. Axial corneal topography with the Klyce-Smolek scale was used, as the clinical utility of this topographic scale has been reported.[16]

Additionally, the Klyce-Smolek scale is a standardized scale that is available on the majority of corneal topographers and hence easily accessible.[16,29]

Corneal asphericity became more positive with higher preoperative refractive error after OPA. This trend concurs with a recent investigation[4] of wavefront-guided treatment with the VISX S4 IR (Abbott Medical Optics). However, the range of postoperative asphericity after OPA (−0.50 to +0.75) corresponded to values for normal, virgin corneas (−0.50 to +0.40).[30] Only two OPA-treated eyes had postoperative asphericity >0.40. Postoperative asphericity after OPA (0.07) was similar to the mean reported for a normal myopic population (−0.09)[30] with 94% of eyes remaining prolate.

One drawback of this study is the small sample size. However, using the criteria of ±0.12 μm standard deviation for spherical aberration at 6 months (based on our actual data), a sample size calculation indicated that 22 eyes per group would be required to determine a difference of ±0.05 μm spherical aberration between groups—our study had 24 eyes at 12 months and 33 at last follow-up. We further mitigated the small sample size by the randomized, contralateral eye treatment design. The loss of 4 patients to follow-up decreases the strength of this study, but all other patients were followed for at least 6 and 12 months.

The use of different optical zones between groups may be considered an unfair comparison. This study is not a comparison of "same zone" OPA and conventional ablations, rather it is a comparison of how the two techniques are used clinically, with OPA having an advantage because of the larger optical zone and better aspheric ablation contours. The volume of tissue removal with both algorithms is the same centrally and greater peripherally with OPA. The peripheral cornea is generally thicker than the center hence this difference is clinically negligible.

The data in this study indicate that OPA treatments with the NIDEK Quest for myopia and myopic astigmatism are safe and effective and provide similar visual acuity compared to conventional ablation. Optimized prolate ablation treatment resulted in better postoperative corneal topography that was similar to preoperative topography, larger horizontal diameter of the effective optical zone, decreased induction of spherical aberration, and near normal postoperative asphericity in 94% of eyes.

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TABLE A

Pre- and Postoperative Data for Patients Lost to Follow-up

Patient	Eye	Preoperative			Last Postop F/U (mo)	Postoperative		
		UDVA*	Refraction	CDVA*		UDVA*	Refraction	CDVA*
1	Right	CF	−4.25 −1.00 × 88	20/20	3	20/25	0.25 −0.50 × 75	20/20
	Left	CF	−3.25 −1.00 × 75	20/20+	3	20/20	0.25	20/16
2	Right	20/400	−2.50 −0.50 × 140	20/20	3	20/20	0 −0.25 × 125	20/16
	Left	20/400	−3.25 −0.25 × 50	20/20	3	20/20	0 −0.50 × 50	20/16
3	Right	20/160	−2.25 −0.50 × 179	20/16	3	20/20	Plano	20/20
	Left	20/200	−2.50 −0.25 × 80	20/16	3	20/20	0 −0.25 × 180	20/20
4	Right	20/400	−2.25 −0.50 × 180	20/20+	3	20/20	0.25 −0.25 × 100	20/20+
	Left	20/400	−1.25 −0.50 × 174	20/20−	3	20/20+	0.25	20/20+

UDVA = uncorrected distance visual acuity, CDVA = corrected distance visual acuity, F/U = follow-up, CF = counting fingers
*Snellen notation.

TABLE B

Published Reports of Refractive Outcomes and Spherical Aberration After LASIK for Low to Moderate Myopia and Myopic Astigmatism

Study (Year)	Laser/Laser Profile	Study Type	Preop MRSE (D)	Preop Cylinder (D)	MRSE Within 0.50 D (%)	Mean MRSE (D)	Loss of ≥2 Lines of CDVA	Gain of ≥2 Lines of CDVA	Change in Ocular SA (µm)	Change in Corneal SA (µm)
El Danasoury et al (current study)	NIDEK Quest/OPA	Prospective, contralateral, randomized	−3.88±1.40 (−1.53 to −7.50)	0.52±0.46 (0 to 2.00)	97	−0.16±0.23 (−1.00 to 0.25)	0	0	+0.03*	+0.11
Binder & Rosenshein[17] (2007)	Alcon LADARVision/WG	Retrospective	−3.24±1.39 (−0.88 to −6.63)	0.82±0.59 (0.50 to 2.50)	NR	0.17±0.33 (NR)	<5	0	+0.09†	NR
Binder & Rosenshein[17] (2007)	AMO CustomVue/WG	Retrospective	−3.57±1.61 (−0.63 to −6.75)	0.90±0.49 (0.50 to 2.50)	NR	−0.14±0.42 (NR)	<5	0	+0.10†	NR
Arbelaez et al[23] (2010)	SCHWIND Amaris/Aspheric ablation	Prospective, nonrandomized	−3.47±1.56 (−0.50 to −7.38)	0.69±0.67 (0.0 to 5.00)	96	0.21±0.21 (−0.88 to +0.50)	0	8.4	NR	0.08
Padmanabhan et al[19] (2008)	Alcon Allegretto/WO	Prospective, nonrandomized	−4.45±1.25 (NR)	NR	89	NR	0		+0.22‡	NR
Padmanabhan et al[19] (2008)	Alcon Allegretto/WG	Prospective, contralateral, nonrandomized	−4.28±1.17 (NR)	NR	93	NR	0		−0.02‡	NR
Blum et al[25] (2009)	Zeiss Meditec MEL 80/Aspheric ablation	Prospective, nonrandomized	−4.04±1.39 (−1.50 to −7.25)	0.50±0.60 (0 to 2.00)	94	−0.06	0	16	NR	NR
Barreiro et al[24] (2009)	Technolas Zyoptix/WG	Prospective, randomized	−3.22±1.50 (0 to −6.00)	0.44±0.36 (0 to 1.25)	88	0.28±0.31 (0 to 1.25)	0	2	<0.10	NR

MRSE = manifest refraction spherical equivalent, CDVA = corrected distance visual acuity, SA = spherical aberration, OPA = optimized prolate ablation, WG = wavefront-guided, NR = not reported, WO = wavefront-optimized
*Reported for a 6.00-mm pupil diameter.
†Reported for a ≤6.50-mm pupil diameter.
‡Reported for a 7.00-mm pupil diameter.
Note. Spherical aberration measurements are reported for the 4th radial order.