Comparison Between the Wavefront-Optimizedand Custom-Q Aspheric Ablation Profiles in Myopic Eyes With Two Different Q-targets:
A Contralateral Eye Study

Timoteo González-Cruces, DO, MSc; Alberto Villarrubia, MD;
Álvaro Sánchez Ventosa, MD; Elisa Palacín Miranda, MD; Rosa Castillo Eslava, DO; Aurora Gomera Martinez, DO; José Alberto García Párrizas, DO; Pablo Torres Huelva, DO;Jose María Sánchez-González, DO, MSc, PhD; Antonio Cano-Ortiz, MD, PhD

ABSTRACT

PUROSE: To compare two aspheric ablation profiles in myopic refractive surgery using different asphericity targets.

METHODS: Patients underwent laser in situ keratomileusis (LASIK) with the WaveLight EX500 laser platform (Alcon, WaveLight Laser Technologie). Asymmetric surgery was performed, programming the wavefront-optimized (WFO) ablation profile in one eye and the custom-Q (CQ) profile in the contralateral eye. The patients were divided into two groups following a systematic randomization method. The Q-target programmed for the preoperative Q group was equal to the preoperative asphericity of the CQ profile, and for the -0.6 Q-target group, the Q-target was set to -0.6.

RESULTS: The study included 100 patients (200 eyes). Both groups had comparable safety and efficacy indexes greater

The continuously evolving ophthalmic industry together with ongoing advances in biomedical research have made corneal refractive ablation surgery the technique of choice in low and medium myopia surgery. Several authors have reported high safety and efficacy indexes in both laser in situ keratomileusis (LASIK)[1,2] and photorefractive keratectomy.[3,4] However, the main challenge for clinicians and engineers is to control higher order aberrations

than 1. A similar oblate shift in postoperative asphericity was seen in both groups regardless of the ablation profile and programmed Q-target. Asphericity was 0.33 ± 0.34 and 0.35 ± 0.29 ($P = .18$) in the preoperative Q group and 0.26 ± 0.28 and 0.26 ± 0.27 ($P = .89$) in the -0.6 Q-target group for WFO and CQ, respectively. A lower spherical aberration was found with CQ compared to WFO when the Q-target was set to -0.6: 0.211 ± 0.121 versus 0.144 ± 0.114 ($P < .01$). However, no statistically significant differences were found when the preoperative Q-target was used.

CONCLUSIONS: WFO and CQ treatments are similar in terms of refractive and visual outcomes. CQ offers greater control over the increase in positive spherical aberration after myopic refractive surgery, but it does not represent an advantage over WFO in the oblate shift in postoperative asphericity regardless of the Q-target programmed.

[*J Refract Surg.* 2022;38(11):698-707.]

(HOAs) generated by central myopic ablation, which are responsible for the decrease in visual quality and dysphotopic phenomena in mesopic environments.[5] Specifically, an increase in postoperative positive spherical aberrations has been reported.[6] This finding is closely associated with the oblate corneal geometry induced by refractive surgery.[7,8] As a result, ablation algorithms used by excimer lasers have been implemented in the past decade, moving from standard multizone profiles to wavefront-guided or topography-guided profiles.

Several studies[9-11] have shown the superiority of these new patterns of guided ablation in relation to the induction of HOAs. Nonetheless, no statistically significant differences in refractive or high-contrast visual acuity have been found.[12] The approach of these new guidance systems is to minimize the effect of HOAs induced by ablation surgery, generate surfaces with smoother transitions, and respect the physiological geometry of the cornea. In the same way, the latest generations of excimer laser platforms have incorporated optimized ablation patterns into their standard (not personalized) treatments to improve postoperative corneal profiles. The WaveLight excimer laser platforms, the 400-Hz and the EX500 (Alcon, WaveLight Laser Technologie AG), have a standardized treatment modality called wavefront optimized (WFO). Compared to conventional treatments, this modality performs an additional ablation in the periphery to correct the positive spherical aberration induced by central myopic correction.[13]

The next level of customization in refractive treatment offered by this platform is custom-Q (CQ). In this option, the ablation pattern is determined by the topographic parameters of each patient and allows the surgeon to establish a target asphericity in each case. Although the CQ profile is presented as a higher degree of personalization in treatment, its advantage over standardized patterns is controversial in the scientific literature. Although some authors have suggested that CQ treatment is superior to WFO when the programmed target asphericity is -0.6,[14] others have not found statistically significant differences between the two procedures.[9] In addition, the possibility of setting a custom asphericity target with the CQ mode creates the need to define an optimal asphericity target. Intra-subject ran- domized comparative studies are necessary to avoid all possible biases and to determine the best approach to programming target values in the CQ modality.

This study aimed to determine an optimal asphe- ricity target and to compare the WFO ablation profile with the CQ profile using two different Q-targets.

PATIENTS AND METHODS

A prospective randomized cohort study of 200 eyes of 100 myopic patients who underwent LASIK surgery at Hospital La Arruzafa, Cordoba, Spain, was conducted from February to December 2021. All patients had surgery with the aspheric WFO and CQ ablation profiles of the WaveLight EX500 laser platform. A systematic random- ization method was used in which patients with an even- numbered medical record underwent surgery with the CQ profile in their right eye and the WFO profile in their left eye. Those with an odd-numbered medical record under- went WFO in their right eye and CQ in their left eye.

In the first 50 patients (100 eyes) included in the study (preoperative Q group), the postoperative Q-target was programmed to be equal to the preoperative physiolog- ical Q in the eye in which the CQ treatment was per- formed. A second group of 50 patients (100 eyes) (-0.6 Q-target group) underwent CQ treatment with a final Q-target of -0.6 (independent of delta DQ = Q-target – preoperative Q) in one eye and WFO in the contralat- eral eye. The manufacturer recommends a maximum final target of Q equal to -0.6. As a result, DQ was not used as a target. In this latter group, an adjustment in the CQ treatment nomogram was made to compensate for the increased central ablation (myopic hypercorrection) that results from an increase in corneal prolaticity. The sphere target needed to be modified to match the central ablation depth generated before the increased Q-target.

Inclusion criteria were: patients older than 21 years of age with refractive stability (at least 2 years), manifest refraction spherical equivalent between -6.00 and -0.50 diopters (D) and astigmatism of 3.00 D or less, healthy eyes, normal intraocular pressure (10 to 21 mm Hg), and corrected distance visual acuity (CDVA) of at least 0.10 logMAR. All patients were instructed to discontinue contact lens use for at least 1 week for soft lenses and 1 month for rigid gas permeable contact lenses prior to baseline examination. Exclusion criteria were: anisome- tropia greater than 1.00 D in the spherical equivalent, previous eye surgery, irregular astigmatism, corneal thickness of less than 500 µm, highest topographic el- evation point on the posterior corneal surface, within the 3-mm area around the thinnest point on pachymetry, greater than 16 µm (Pentacam AXL; Oculus Optikgeräte GmbH), or any topographic suspicion of corneal ectasia. All patients signed an informed consent after an explanation of the nature and possible consequences of the study and were made aware of surgical (pho- torefractive keratectomy or Implantable Collamer Lens [STAAR Surgical] surgery) and non-surgical (glasses or contact lenses) alternatives to correct their myopia. The study was approved by the ethics committee of Reina Sofia Hospital, Cordoba, Spain, and adhered to the tenets of the Declaration of Helsinki.

The preoperative examination consisted of manifest cycloplegic and noncycloplegic refraction, Scheimpflug corneal tomography (Pentacam AXL), corneal reflection topography (Topolyzer Vario; Alcon Laboratories, Inc), pupillometry (Colvard infrared pupillometer; OASIS Medical, Inc), Goldmann applanation tonometry, slit- lamp inspection of the anterior segment, and mydriatic examination of the posterior pole. All procedures were performed according to pachymetric safety criteria: stromal corneal bed of greater than 300 µm and a percent tissue altered index of less than 0.40. The patients were examined 1 day and 1 month after surgery. At the 1-month postoperative visit, all preoperative examinations were repeated. The visual and topographic parameters analyzed were: uncorrected distance visual acuity (UDVA), residual spherical equivalent and refractive astigmatism, asphericity (Q) at 6 mm and total corneal aberration at 6 mm as the root mean square (RMS) spherical aberration (Z^4), RMS total coma aberration (Z^3), and RMS HOAs.

SURGICAL TECHNIQUE

0 ±1

All procedures were performed by experienced surgeons using topical anesthesia (double anesthetic, tetracaine 0.1% and oxybuprocaine 0.4%, Colircusi; Alcon Laboratories, Inc). Antibiotics were used preoperatively, consisting of one drop of moxifloxacin (Vigamox; Alcon Laboratories, Inc) every 5 minutes starting 20 minutes before surgery. An IntraLase iFS femtosecond laser (Abbott Medical Optics) was used to create the corneal flap. In all cases, the programmed flap thickness was 110 µm, with a superior hinge, energy of 0.80 µJ, and programmed diameter varying between 8 and 9.2 mm depending on the white-to-white diameter.

The Allegretto WaveLight EX500 laser platform, a flying-spot laser with a less than 0.95 spot diameter, was used for photoablation with an initial energy of 1.52 mJ. Infrared images of the iris were captured with the Topolyzer Vario topographer to control static and dynamic cyclotorsion during surgery. In addition, the physiological Q-value provided preoperatively by the Topolyzer was taken as reference to personalize aspheric treatment. All treatments were centered on the pupil and all surgeries were programmed for emmetropia using the treatment nomogram provided by the manufacturer. Antibiotic and corticosteroid treatment consisted of one drop of 0.1% dexamethasone and 0.3% tobramycin (Tobradex; Novartis) every 4 hours during the first week after surgery.

STATISTICAL ANALYSIS

Microsoft Excel software (Microsoft Corporation) was used for the database compiled and IBM SPSS Statistics software, version 25 (SPSS, Inc), for the analysis of described and inferential statistics. A paired two-sided *t* test or Wilcoxon signed-rank test was performed between the different variables, depending on the parametric or non-parametric nature of the data. The Shapiro-Wilk test was used to check the distribution of the sample. An inferential study of the baseline parameters was done to verify the homogeneity of the preoperative variables and to avoid possible intra-subject bias.

RESULTS

In the preoperative study of homogeneity in the contralateral eyes for both the preoperative Q group (mean age: 29.60 ± 6.07 years) and -0.6 Q-target group (mean age: 32.28 ± 7.62 years), no intra-subject differences were found in any of the parameters evaluated (**Table 1**).

In terms of postoperative visual analysis, both groups had a similar safety index for both ablation profiles regardless of the programmed Q-target. The safety index was 1.08 ± 0.13 and 1.08 ± 0.16

(*P* = .95) in the preoperative Q group and 1.04 ± 0.14 and 1.01 ± 0.14 (*P* = .17) in the -0.6 Q-target group for the eyes treated with WFO and CQ, respectively. In addition, nearly 90% of the eyes in both groups had a postoperative CDVA equal to or greater than the preoperative value and no eye lost more than two lines of visual acuity (**Figure 1**). The loss of one line of visual acuity is considered normal because it may be associated with the inherent variability of the test.

Regarding postoperative UDVA, between 96% and 98% of the eyes in both groups remained within one line of preoperative CDVA (**Figures 2-3**). The efficacy index was 1.08 ± 0.19 and 1.08 ± 0.21 (*P* = .85) in the preoperative Q group and 1.02 ± 0.19 and 1.00 ± 0.20 (*P* = .49) in the -0.6 Q-target group for the eyes treated with WFO and CQ, respectively.

The refractive results were also similar in both groups for both treatment profiles (**Figure 4**). All eyes included in the study had a refractive result within ±1.00 D. In the preoperative Q group, 94% of the eyes treated with WFO and 98% of those treated with CQ were within ±0.50 D, whereas in the -0.6 Q-target group, 98% of the eyes treated with WFO and 90% of those treated with CQ were within ±0.50 D (**Figure 5**). Postoperative spherical equivalent refraction obtained in the -0.6 Q-target group showed a worse predictability (8 percentage points) for the CQ treatment (target -0.6) in comparison with the standard treatment WFO.

Concerning topographic and aberrometric analysis, no differences were found between the two ablation profiles in either group. Postoperative asphericity displayed a similar oblate shift in both groups regardlessof the ablation profile and the programmed Q-target. CQ treatment showed a lower spherical aberration compared to WFO when the Q-target programmed was -0.6: 0.211 ± 0.121 versus 0.144 ± 0.114, respectively (*P* < .01). However, no statistically significant differences were found between ablation profiles when the preoperative Q-target was used (**Table 2**).

DISCUSSION

The mathematical characterization of the anterior corneal surface may resemble a conical section that is primarily defined by the apical radius of curvature and a peripheral flattening factor called the Q-factor. In virgin corneas, this flattening factor is negative (Q < 0), which describes a prolate ellipse where the apical radius is less than the peripheral radius. In patients who

Figure 3. Uncorrected distance visual acuity (UDVA). CDVA = corrected distance visual acuity

have undergone myopic LASIK, the central cornea is flattened to reduce the total dioptric power. As a result, the physiological geometry of the cornea changes from a prolate (Q-factor < 0) to an oblate (Q-factor > 0) shape. This trend toward a positive increase in asphericity is closely related to the amount of corneal tissue removed. In addition, this oblate shift produces an increase in positive spherical aberration, which contributes to the presence of glare, halos, and dysphotopic phenomena that decrease vision quality in these patients.

The Allegretto WaveLight laser has two aspheric ab- lation profiles designed to minimize the oblate shift in- duced by myopic ablation. WFO has a non-personalized aspheric profile, based on theoretical eye models, that performs up to 35% ablation in the midperiphery of the optical zone compared to conventional treatments, with the aim of achieving a smoother transition zone.[15] The removed tissue in the midperiphery increases as the myopic treatment increases regardless of the initial topographic values, reaching up to 11 µm for a sphere of -8.00 D. This treatment does not increase the depth of central ablation compared to classic profiles but its shape. The CQ profile is based on the same aspheric ab- lation principle; however, it considers the topographic features provided by the Topolyzer topographer in each case. It also enables the surgeon to customize the treat- ment by adjusting the Q-target. Several studies have compared visual and topographic results between these two myopic ablation profiles, but conclusions remain controversial.

Tawfik et al[14] found greater asphericity control in the CQ group compared to the WFO group, showing postoperative mean Q-values of 0.03 ± 0.77 and 0.06 ± 0.44, respectively. Nevertheless, although statistically significant differences were shown (*P* = .02), they were not clinically relevant. In addition, the small differ- ences between the two groups (mean WFO Q – mean CQ profile Q = 0.03) compared to the large dispersion of data (effect size) suggests that the conclusions were not supported by the results, because the statistical power of the hypothesis contrast was far from ideal. A large sample would be needed to achieve robust statis- tical power. Similarly, Stojanovic et al[16] found greater asphericity control when performing CQ compared to WFO, but the differences between both groups were only marginally statistically significant (*P* = .049). Mai et al[17] found no statistically significant differences in asphericity, HOAs, or refractive outcomes between both groups, programming a Q-target equal to the preopera- tive Q-value. Regarding hyperopia treatment, Amigó et al[18] obtained better results in terms of spherical aber- ration and postoperative asphericity in the customized group, programming a Q-target of 0, compared to the WFO group. These authors obtained a spherical aberra- tion value in the aspheric-customized LASIK group of 0.04 ± 0.18 µm versus -0.39 ± 0.23 for the WFO profile, whereas postoperative asphericity was -0.04 ± 0.25 µm and -0.52 ± 0.22, respectively (P □ .05).

In the current study of contralateral myopic eyes, the authors found no statistically significant differences between postoperative oblate shift for either aspheric treatment (WFO or CQ) regardless of the programmed Q-target. In the preoperative Q group, the mean postop- erative asphericity was 0.33 ± 0.34 and 0.35 ± 0.29 for the eyes treated with WFO and CQ, respectively (P = .184). In the -0.6 Q-target group, the results were identi- cal: 0.26 ± 0.28 and 0.26 ± 0.27 for the eyes treated with WFO and CQ, respectively (P = .889). The outcomes obtained suggest that customized treatment offers no advantage over conventional WFO treatment in terms of postoperative control of oblate aspheric shift.

A common finding in all published studies is the in- crease in asphericity reported in the postoperative pe- riod despite the use of aspheric profiles independently of the programmed Q-target.[14,16,17,19] The discrepancy be- tween postoperative topographic observations and theo- retical predictions is known. Several authors have rec- ognized the difficulty of interpreting asphericity valuesafter myopic refractive surgery[20,21]: the asphericity value is highly dependent on the diameter of analysis, where a more prolate surface (Q < 0) is obtained when the area of analysis increases in distance from the corneal vertex.[13] Furthermore, asphericity is not symmetrical in the four main hemimeridians. There may be differences of up to 0.50 points between the hemimeridians, so their aver- age may not represent the actual corneal asphericity.[22] The anterior corneal surface may also undergo modifica- tions after ablation due to biomechanical changes and epithelial remodeling not predicted by theoretical mod- els. Gatinel et al[21] found a linear relationship between the apical radius value and the Q-value, and therefore the measurement of asphericity in patients treated with refractive surgery may be conditioned by apical corneal flattening. Although the conical section is a good approximation to the corneal profile, it does not accurately represent the anterior corneal surface, and its differences should be defined through the RMS error of curvature.[23] Due to the drawbacks in the quantification of ana- tomical corneal changes through topographic findings, Amigó et al[20] suggested the analysis of corneal spherical aberration as a good indicator of the change produced in the Q-factor after surgery. Aberrometric outcomes from published research with WFO and CQ aspheric profiles show no statistically significant differences in spheri- cal aberration before and after surgery,[18] unlike other conventional classic profiles. The results of this study show a slight increase in positive spherical aberration in patients treated with WFO. However, the eyes in the preoperative Q group treated with CQ (target Q equal to preoperative Q) showed no statistically significant dif- ferences with preoperative values: 0.182 ± 0.068 µm pre-operatively versus 0.199 ± 0.117 µm postoperatively (*P* = .194). In addition, the eyes in the -0.6 Q-target group obtained positive spherical aberration values lower than the preoperative values: 0.191 ± 0.062 µm preoperatively versus 0.144 ± 0.114 µm postoperatively (*P* = .006). This indeed demonstrates the power of these aspheric profiles in controlling HOAs and in not inducing positive spheri- cal aberration despite postoperative oblate shift.

The current study has some limitations, such as the short-term follow-up and cross-sectional design. Fur- thermore, stratification of change in Q-value (pre-post) based on level of attempted myopic correction was not evaluated. Nonetheless, to the best of our knowledge, this is the first study to compare WFO and CQ treatment with two different Q-targets. In addition, the study had a larger sample size than previous compara- tive studies of both aspheric ablation profiles. Further research with evaluation of total ocular aberrometry and a longer follow-up period is required.

WFO and CQ treatments are similar with respect to re- fractive and visual outcomes. CQ provides greater control over the increase in positive spherical aberration after my- opic refractive surgery. However, it does not represent an advantage over WFO in the oblate shift in postoperative asphericity regardless of the programmed Q-target.

REFERENCES

1. Yuen LH, Chan WK, Koh J, Mehta JS, Tan DTA; SingLasik Research Group. A 10-year prospective audit of LASIK out- comes for myopia in 37,932 eyes at a single institution in Asia. *Ophthalmology*. 2010;117(6):1236-1244.e1. https://doi. org/10.1016/j.ophtha.2009.10.042 PMID:20153899
2. Zhang Y, Shen Q, Jia Y, Zhou D, Zhou J. Clinical outcomes of SMILE and FS-LASIK used to treat myopia: a meta-analysis. *J Refract Surg*. 2016;32(4):256-265. https://doi.org/10.3928/1081597X-20151111-06 PMID:27070233
3. Alasmari M, Alfawaz A. Transepithelial photorefractive keratec- tomy to treat mild myopia. *Int Ophthalmol*. 2021;41(7):2575-2583. https://doi.org/10.1007/s10792-021-01816-y PMID:33761045
4. Adib-Moghaddam S, Soleyman-Jahi S, Sanjari Moghaddam A, et al. Efficacy and safety of transepithelial photorefractive keratectomy. *J Cataract Refract Surg*. 2018;44(10):1267-1279. https://doi.org/10.1016/j.jcrs.2018.07.021 PMID:30172569
5. Sarkar S, Bharadwaj SR, Reddy JC, Vaddavalli PK. Lon- gitudinal changes in optical quality, spatial vision, and depth vision after laser refractive surgery for myopia. *Op- tom Vis Sci*. 2020;97(5):360-369. https://doi.org/10.1097/ OPX.0000000000001513 PMID:32413008
6. Smadja D, Santhiago MR, Mello GR, Touboul D, Mrochen M, Krueger RR. Corneal higher order aberrations after myopic wave- front-optimized ablation. *J Refract Surg*. 2013;29(1):42-48. https:// doi.org/10.3928/1081597X-20121210-03 PMID:23311740
7. Zhang R, Wei H, Jhanji V, et al. Comparison of corneal aber- rations and refractive outcomes after

small-incision lenticule extraction and femtosecond-assisted laser-assisted in situ ker- atomileusis. *Int Ophthalmol*. 2021;41(7):2521-2531. https:// doi.org/10.1007/s10792-021-01810-4 PMID:33783676

8. Bottos KM, Leite MT, Aventura-Isidro M, et al. Corneal asphericity and spherical aberration after refractive surgery. *J Cataract Refract Surg*. 2011;37(6):1109-1115. https://doi.org/10.1016/j.jcrs.2010.12.058 PMID:21596254Roe JR, Manche EE. Prospective, randomized, contralateral eye comparison of wavefront-guided and wavefront-optimized laser in situ keratomileusis. *Am J Ophthalmol*. 2019;207:175- 183. https://doi.org/10.1016/j.ajo.2019.05.026 PMID:31173739
9. Ozulken K, Yuksel E, Tekin K, Kiziltoprak H, Aydogan S. Comparison of wavefront-optimized ablation and topography- guided Contoura ablation with LYRA protocol in LASIK. *J Re- fract Surg*. 2019;35(4):222-229. https://doi.org/10.3928/108159 7X-20190304-02 PMID:30984979
10. Kim J, Choi S-H, Lim DH, Yang CM, Yoon G-J, Chung T-Y. Topography-guided versus wavefront-optimized laser in situ keratomileusis for myopia: surgical outcomes. *J Cataract Refract Surg*. 2019;45(7):959-965. https://doi.org/10.1016/j. jcrs.2019.01.031 PMID:31196580
11. Li S-M, Kang M-T, Wang N-L, Abariga SA. Wavefront excimer laser refractive surgery for adults with refractive errors. *Co- chrane Database Syst Rev*. 2020;12:CD012687. https://doi.org/10.1002/14651858.CD012687.pub2 PMID:33336797
12. Koller T, Iseli HP, Hafezi F, Mrochen M, Seiler T. Q-factor cus- tomized ablation profile for the correction of myopic astigma- tism. *J Cataract Refract Surg*. 2006;32(4):584-589. https://doi.org/10.1016/j.jcrs.2006.01.049 PMID:16698476
13. Tawfik A, Eid AM, Hasanen R, Moftah IAN. Q-value custom- ized ablation (custom-Q) versus wavefront optimized ablation for primary myopia and myopic astigmatism. *Int Ophthalmol*. 2014;34(2):259-262. https://doi.org/10.1007/s10792-013-9828-1 PMID:23912691
14. Mrochen M, Donitzky C, Wüllner C, Löffler J. Wavefront-op- timized ablation profiles: theoretical background. *J Cataract Refract Surg*. 2004;30(4):775-785. https://doi.org/10.1016/j.jcrs.2004.01.026 PMID:15093638
15. Stojanovic A, Wang L, Jankov MR, Nitter TA, Wang Q. Wave- front optimized versus custom-Q treatments in surface ablation for myopic astigmatism with the WaveLight ALLEGRETTO la-ser. *J Refract Surg*. 2008;24(8):779-789. https://doi.org/10.3928/1081597X-20081001-03 PMID:18856231
16. Mai ELC, Lian I, Lin C, Chang C. Custom-Q vs wavefront op- timized lasik ablation treatment profile in high myopic Asian eyes. *SM Ophthalmol J*. 2018;4(1):2-5.
17. Amigó A, Bonaque-González S, Guerras-Valera E. Con- trol of induced spherical aberration in moderate hyper- opic LASIK by customizing corneal asphericity. *J Refract Surg*. 2015;31(12):802-806. https://doi.org/10.3928/108159 7X-20151111-03 PMID:26653724
18. Ghoreishi SM, Naderibeni A, Peyman A, Rismanchian A, Eslami F. Aspheric profile versus wavefront-guided ablation photorefractive keratectomy for the correction of myopia using the Allegretto Eye Q. *Eur J Ophthalmol*. 2009;19(4):544-553. https://doi.org/10.1177/112067210901900405 PMID:19551667
19. Amigó A, Bonaque-González S. Q Factor Presbylasik. Funda- mentals and therapeutic approach. *J Emmetropia*. 2012;3:167-171. https://www.researchgate.net/publication/251485236
20. Gatinel D, Hoang-Xuan T, Azar DT. Determination of corneal asphericity after myopia surgery with the excimer laser: a math- ematical model. *Invest Ophthalmol Vis Sci*. 2001;42(8):1736-1742. PMID:11431436

21. Kezirian GM. Q-factor customized ablations. *J Cataract Refract Surg*. 2006;32(12):1979-1980. https://doi.org/10.1016/j.jcrs.2006.07.033
22. Calossi A. Corneal asphericity and spherical aberration. *J Re- fract Surg*. 2007;23(5):505-514. https://doi.org/10.3928/1081- 597X-20070501-15 PMID:17523514

TABLE 1

Refractive and Topographic Preoperative Analysis[a]

Parameter	Wavefront Optimized (n = 50)	Custom-Q (Preoperative Target) (n = 50)	*P*
Preoperative Q group			
Age (y)	29.60 ± 6.07 (18 to 48)	29.60 ± 6.07 (18 to 48)	NA
Sex male/female, n	22/28	22/28	NA
Spherical equivalent (D)	-3.42 ± 1.38 (-6.50 to -0.88)	-3.43 ± 1.39 (-5.88 to -0.75)	.70
Cylinder (D)	-0.92 ± 1.07 (-5.00 to 0.00)	-0.77 ± 0.82 (-4.00 to 0.00)	.44
CDVA (logMAR)	-0.013 ± 0.036 (-0.08 to 0.10)	-0.013 ± 0.041 (-0.08 to 0.15)	.65
Asphericity (Q) (6 mm)	-0.25 ± 0.10 (-0.53 to -0.05)	-0.25 ± 0.10 (-0.56 to -0.03)	.87
RMS corneal spherical aberration Z^{4}_{0}(µm)	0.176 ± 0.068 (0.04 to 0.31)	0.182 ± 0.068 (0.04 to 0.36)	.54
RMS total corneal coma aberration $Z^{3}_{\pm 1}$(µm)	0.147 ± 0.096 (0.1 to 0.40)	0.138 ± 0.083 (0.00 to 0.33)	.47
RMS corneal HOAs (6 mm) (µm)	0.323 ± 0.089 (0.16 to 0.63)	0.322 ± 0.082 (0.18 to 0.46)	.89
Parameter	**Wavefront Optimized (n = 50)**	**Custom-Q (-0.6 Q-target) (n = 50)**	***P***
-0.6 Q-target group			
Age (y)	32.28 ± 7.62 (19 to 50)	32.28 ± 7.62 (19 to 50)	NA
Sex male/female, n	20/30	20/30	NA
Spherical equivalent (D)	-3.19 ± 1.37 (-6.38 to -0.45)	-3.30 ± 1.13 (-5.88 to -1.50)	.42
Cylinder (D)	-0.92 ± 0.75 (-3.50 to 0.00)	-0.87 ± 0.85 (-4.00 to 0.00)	.36
CDVA (logMAR)	-0.027 ± 0.046 (-0.08 to 0.15)	-0.025 ± 0.047 (-0.08 to 0.15)	.65
Asphericity (Q) (6 mm)	-0.23 ± 0.08 (-0.47 to -0.07)	-0.22 ± 0.09 (-0.49 to -0.07)	.23
RMS corneal spherical aberration Z^{4}_{0}(µm)	0.181 ± 0.061 (0.04 to 0.32)	0.191 ± 0.062 (0.07 to 0.34)	.15
RMS total corneal coma aberration $Z^{3}_{\pm 1}$(µm)	0.180 ± 0.093 (0.1 to 0.39)	0.175 ± 0.103 (0.03 to 0.58)	.69
RMS corneal HOAs (6 mm) (µm)	0.341 ± 0.096 (0.17 to 0.73)	0.358 ± 0.126 (0.20 to 0.88)	.10

CDVA = corrected distance visual acuity; D = diopters; HOAs = higher order aberrations; NA = not applicable; RMS = root mean square

[a] *Values are presented as mean ± standard deviation (range) except for sex.*

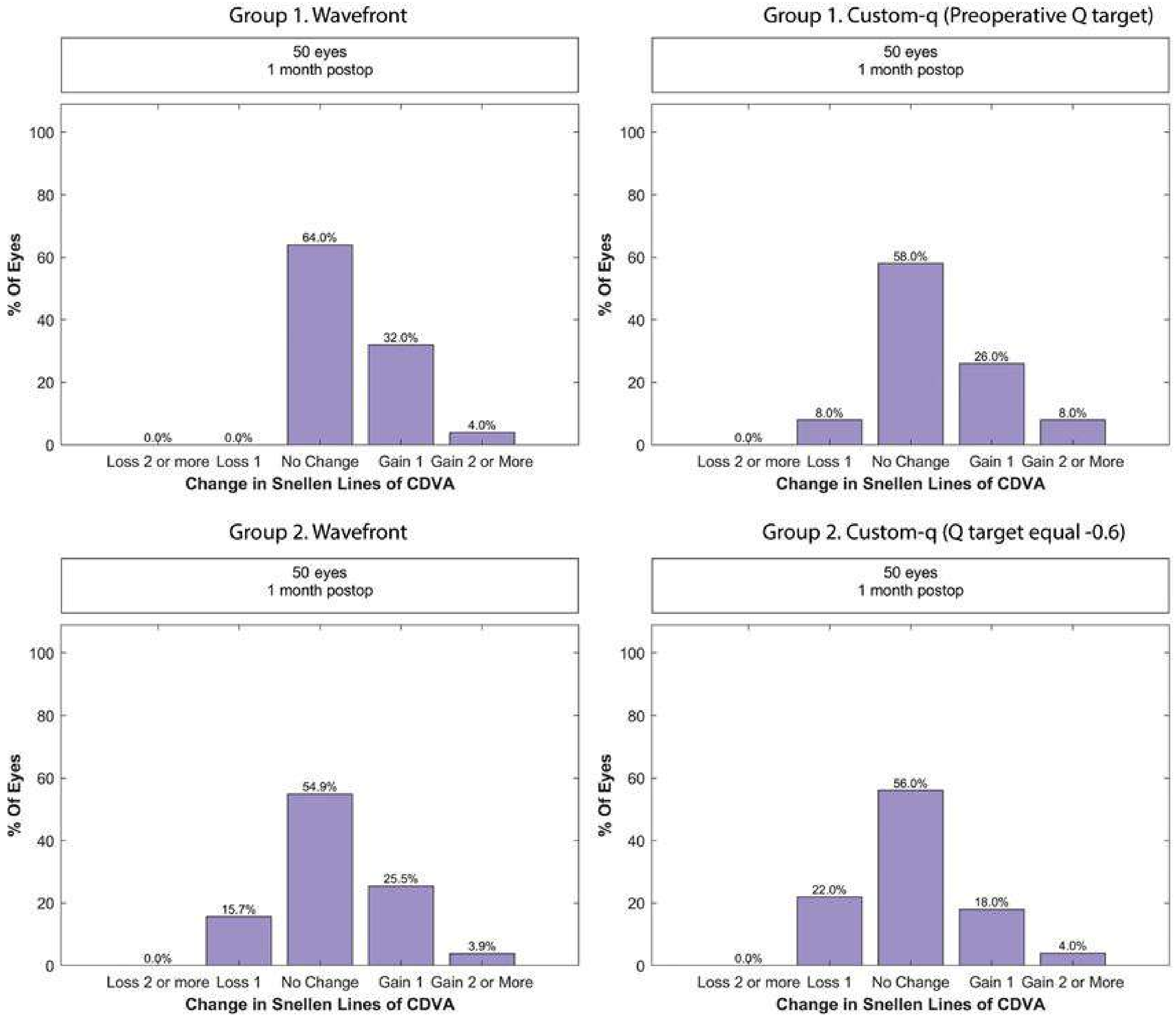
TABLE 2

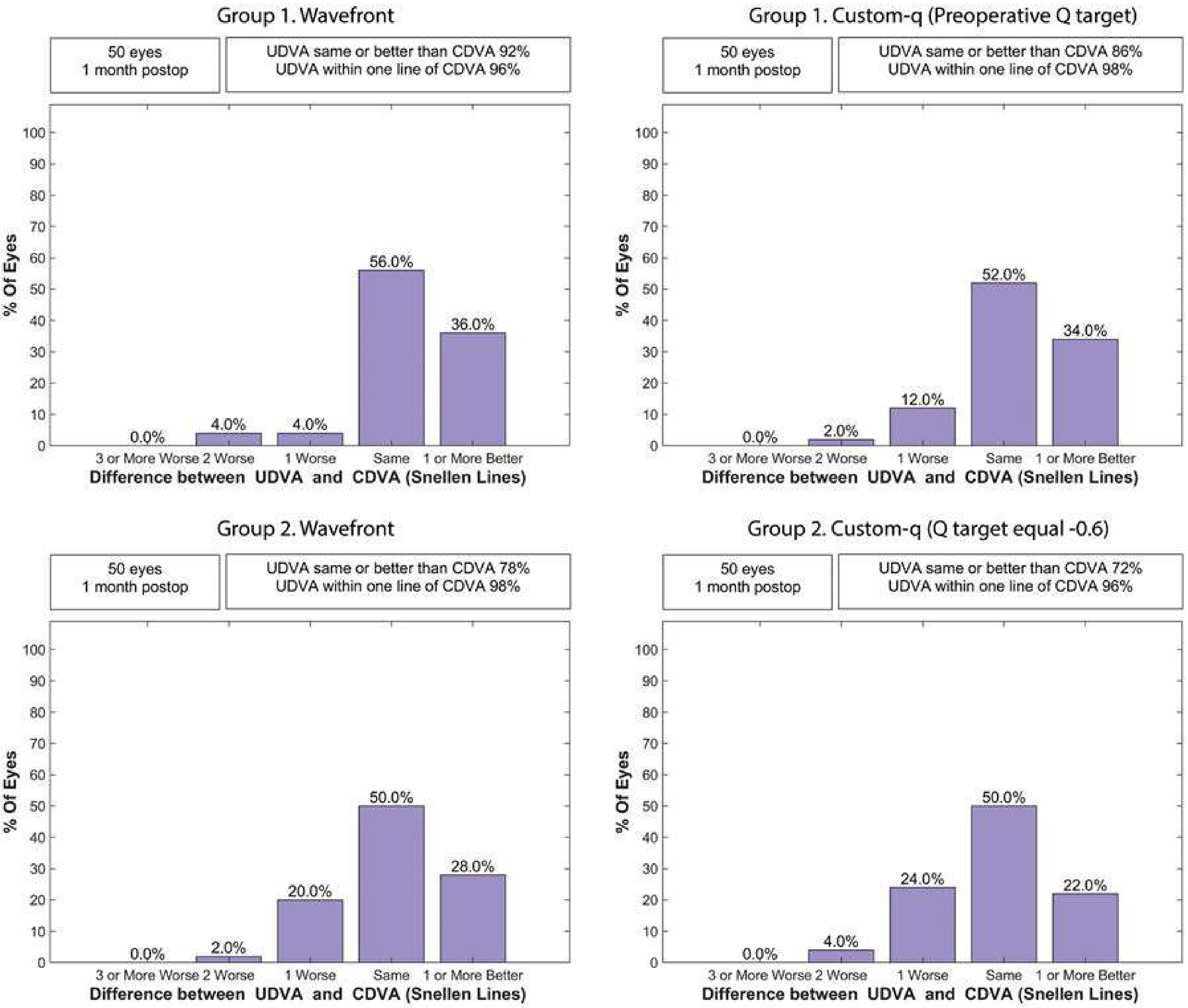
Preoperative vs Postoperative Outcomes[a]

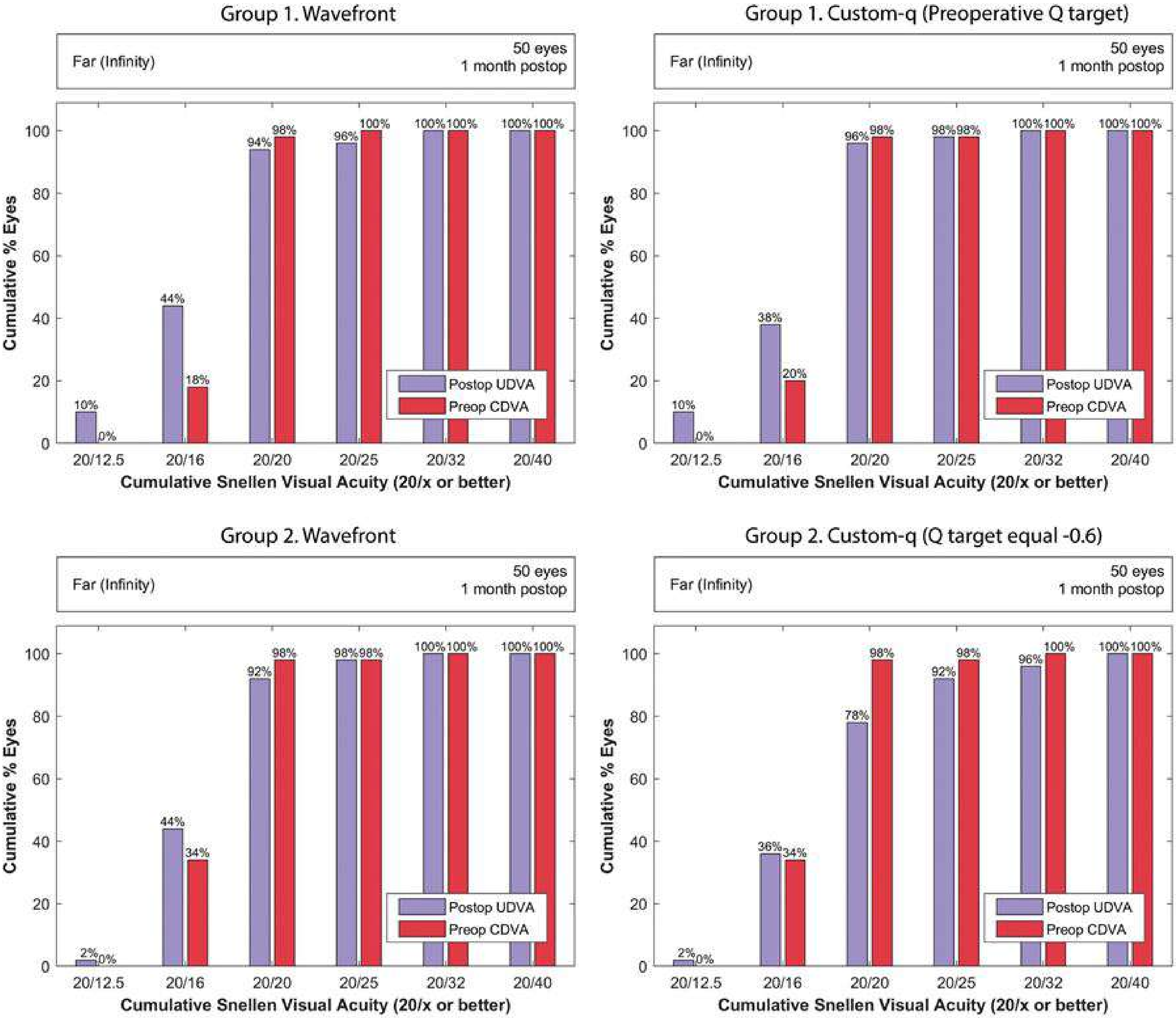
	WFO (n = 50)				CQ (Preoperative Target) (n = 50)				PostoperativeWFO vs CQ
Characteristic	**Preoperative**	**Postoperative**	***P***		**Preoperative**	**Postoperative**	***P***		***P***
Preoperative Q group									
Residual spherical equivalent (D)	NA	-0.01 ± 0.18 (-0.75 to 0.75)	NA		NA	-0.01 ± 0.14 (-0.50 to 0.75)	NA		.79
Residual refractive cylinder (D)	NA	-0.03 ± 0.12 (-0.50 to 0)	NA		NA	-0.06 ± 0.22 (-1.25 to 0.00)	NA		.28
UDVA (logMAR)	NA	-0.038 ± 0.072 (-0.18 to 0.15)	NA		NA	-0.036 ± 0.069 (-0.18 to 0.19)	NA		.66
Asphericity (Q) (6 mm)	-0.25 ± 0.10 (-0.05 to -0.53)	0.33 ± 0.34 (-0.24 to 1.31)	< .001		-0.25 ± 0.10 (-0.03 to -0.56)	0.35 ± 0.29 (-0.21 to 0.99)	< .001		.18
RMS corneal spherical aberration Z^4_0 (µm)	0.176 ± 0.068 (0.04 to 0.31)	0.208 ± 0.108 (-0.03 to 0.46)	.016		0.182 ± 0.068 (0.04 to 0.36)	0.199 ± 0.117 (-0.05 to 0.44)	.194		.28
RMS total corneal coma aberration $Z^3_{\pm1}$ (µm)	0.147 ± 0.096 (0.1 to 0.40)	0.293 ± 0.175 (0.06 to 0.88)	< .001		0.138 ± 0.083 (0.00 to 0.33)	0.290 ± 0.163 (0.02 to 0.82)	< .001		.86
RMS corneal HOAs (6 mm) (µm)	0.323 ± 0.089 (0.16 to 0.63)	0.479 ± 0.161 (0.10 to 1.03)	< .001		0.322 ± 0.082 (0.18 to 0.46)	0.511 ± 0.151 (0.21 to 1.00)	< .001		.38
	WFO (n = 50)				CQ (-0.6 Q-target) (n = 50)				PostoperativeWFO vs CQ
Characteristic	**Preoperative**	**Postoperative**	***P***		**Preoperative**	**Postoperative**	***P***		***P***
-0.6 Q-target group									
Residual spherical equivalent (D)	NA	-0.06 ± 0.15 (-0.75 to 0.00)	NA		NA	-0.12 ± 0.25 (-0.88 to 0.00)	NA		.09
Residual refractive cylinder (D)	NA	-0.05 ± 0.17 (-0.75 to 0.00)	NA		NA	-0.08 ± 0.25 (-1.25 to 0.00)	NA		.67
UDVA (logMAR)	NA	-0.027 ± 0.046 (-0.08 to 0.15)	NA		NA	0.003 ± 0.093 (-0.18 to 0.30)	NA		.04
Asphericity (Q) (6 mm)	-0.23 ± 0.08 (-0.07 to -0.47)	0.26 ± 0.28 (-0.32 to 0.92)	< .001		-0.22 ± 0.09 (-0.07 to -0.49)	0.26 ± 0.27 (-0.45 to 0.84)	< .001		.89
RMS corneal spherical aberration Z^4_0 (µm)	0.181 ± 0.061 (0.04 to 0.32)	0.211 ± 0.121 (-0.23 to 0.44)	.025		0.191 ± 0.062 (0.07 to 0.34)	0.144 ± 0.114 (-0.11 to 0.44)	.006		< .01
RMS total corneal coma aberration $Z^3_{\pm1}$ (µm)	0.180 ± 0.093 (0.1 to 0.39)	0.236 ± 0.141 (0.02 to 0.59)	.006		0.175 ± 0.103 (0.03 to 0.58)	0.265 ± 0.187 (0.03 to 0.99)	< .001		.19
RMS corneal HOAs (6 mm) (µm)	0.341 ± 0.096 (0.17 to 0.73)	0.454 ± 0.131 (0.21 to 0.84)	< .001		0.358 ± 0.126 (0.20 to 0.88)	0.473 ± 0.187 (0.24 to 1.34)	< .001		.74

CQ = Custom-Q; D = diopters; HOAs = higher order aberrations; NA = not applicable; RMS = root mean square; UDVA = uncorrected distance visual acuity; WFO = wavefront-optimized

[a] *Values are presented as mean ± standard deviation (range).*


Group 1. Wavefront
50 eyes
1 month postop
% Of Eyes
0
20
40
60
80
100
0.0%
0.0%
64.0%
32.0%
4.0%
Loss 2 or more
Loss 1
No Change
Gain 1
Gain 2 or More
Change in Snellen Lines of CDVA
Group 1. Custom-q (Preoperative Q target)
50 eyes
1 month postop
% Of Eyes
0
20
40
60
80
100
0.0%
8.0%
58.0%
26.0%
8.0%
Loss 2 or more
Loss 1
No Change
Gain 1
Gain 2 or More
Change in Snellen Lines of CDVA
Group 2. Wavefront
50 eyes
1 month postop
% Of Eyes
0
20
40
60
80
100
0.0%
15.7%
54.9%
25.5%
3.9%
Loss 2 or more
Loss 1
No Change
Gain 1
Gain 2 or More
Change in Snellen Lines of CDVA
Group 2. Custom-q (Q target equal -0.6)
50 eyes
1 month postop
% Of Eyes
0
20
40
60
80
100
0.0%
22.0%
56.0%
18.0%
4.0%
Loss 2 or more
Loss 1
No Change
Gain 1
Gain 2 or More
Change in Snellen Lines of CDVA

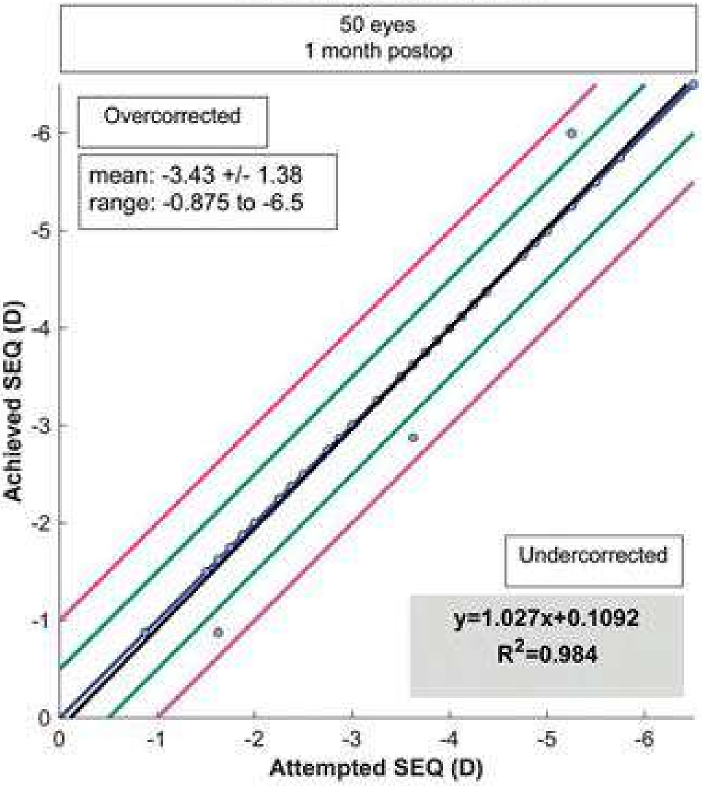

Group 1. Wavefront
50 eyes
1 month postop
UDVA same or better than CDVA 92%
UDVA within one line of CDVA 96%
% Of Eyes
100
90
80
70
60
50
40
30
20
10
0
0.0%
4.0%
4.0%
56.0%
36.0%
3 or More Worse
2 Worse
1 Worse
Same
1 or More Better
Difference between UDVA and CDVA (Snellen Lines)
Group 1. Custom-q (Preoperative Q target)
50 eyes
1 month postop
UDVA same or better than CDVA 86%
UDVA within one line of CDVA 98%
% Of Eyes
0.0%
2.0%
12.0%
52.0%
34.0%
3 or More Worse
2 Worse
1 Worse
Same
1 or More Better
Difference between UDVA and CDVA (Snellen Lines)
Group 2. Wavefront
50 eyes
1 month postop
UDVA same or better than CDVA 78%
UDVA within one line of CDVA 98%
% Of Eyes
0.0%
2.0%
20.0%
50.0%
28.0%
3 or More Worse
2 Worse
1 Worse
Same
1 or More Better
Difference between UDVA and CDVA (Snellen Lines)
Group 2. Custom-q (Q target equal -0.6)
50 eyes
1 month postop
UDVA same or better than CDVA 72%
UDVA within one line of CDVA 96%
% Of Eyes
0.0%
4.0%
24.0%
50.0%
22.0%
3 or More Worse
2 Worse
1 Worse
Same
1 or More Better
Difference between UDVA and CDVA (Snellen Lines)

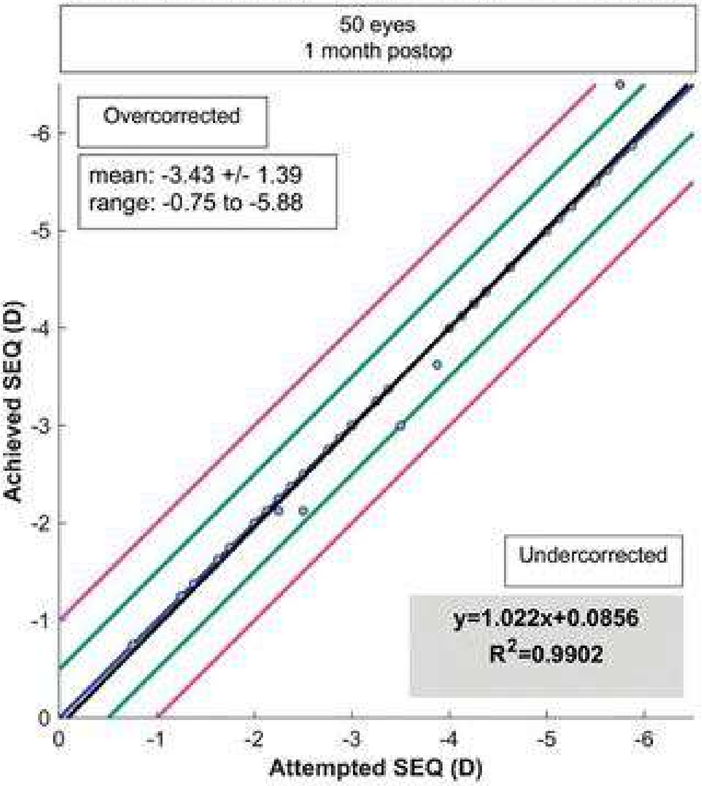

Group 1. Wavefront

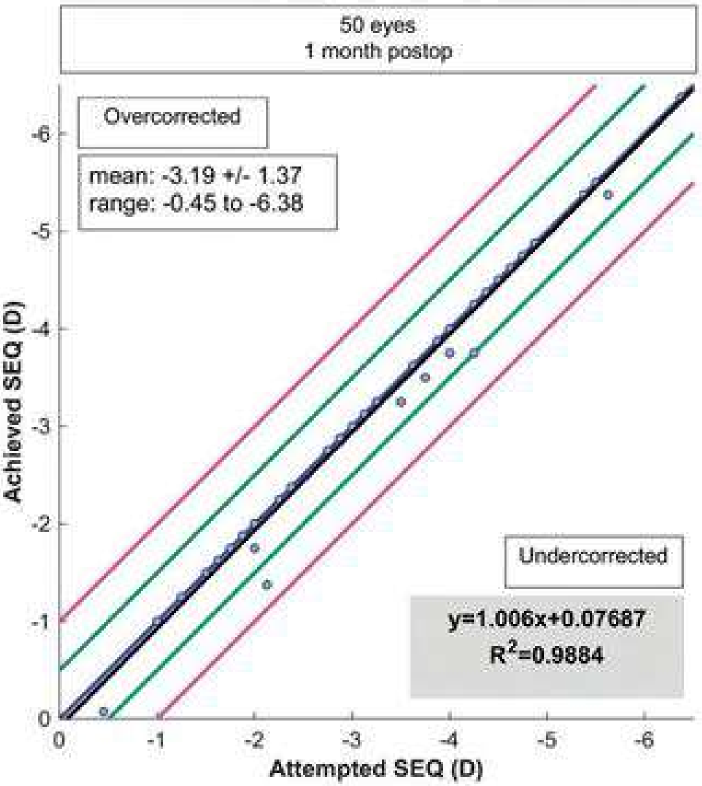
Group 1. Custom-q (Preoperative Q target)

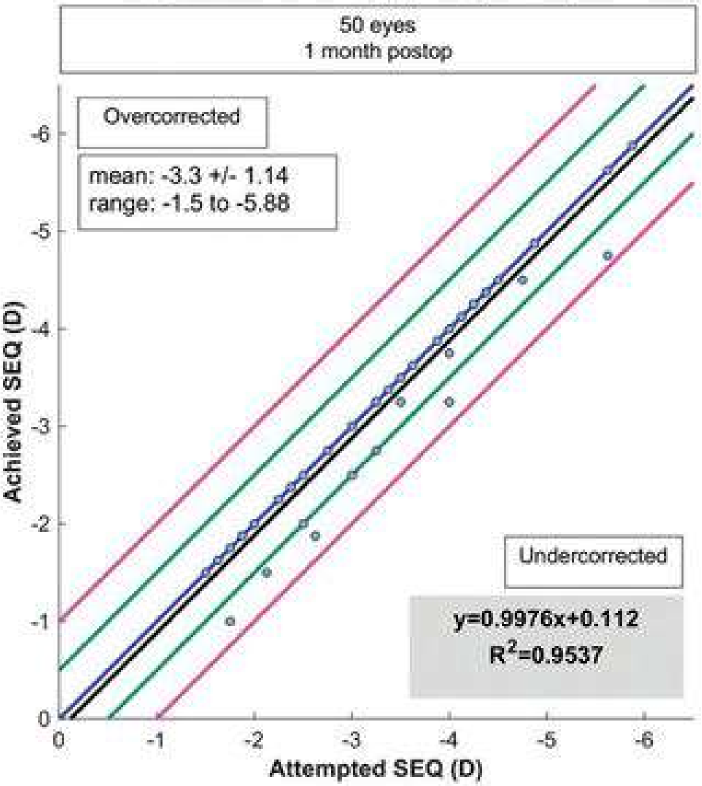
Group 2. Wavefront

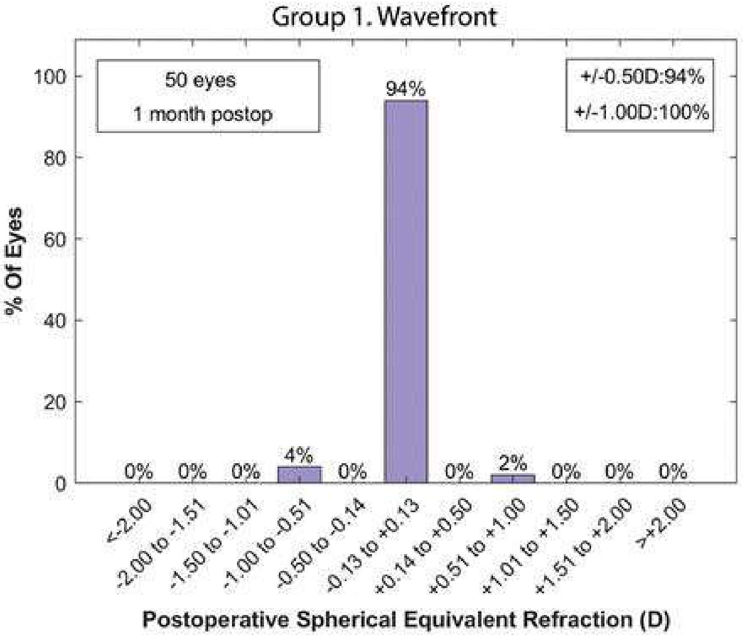
Group 2. Custom-q (Q target equal -0.6)

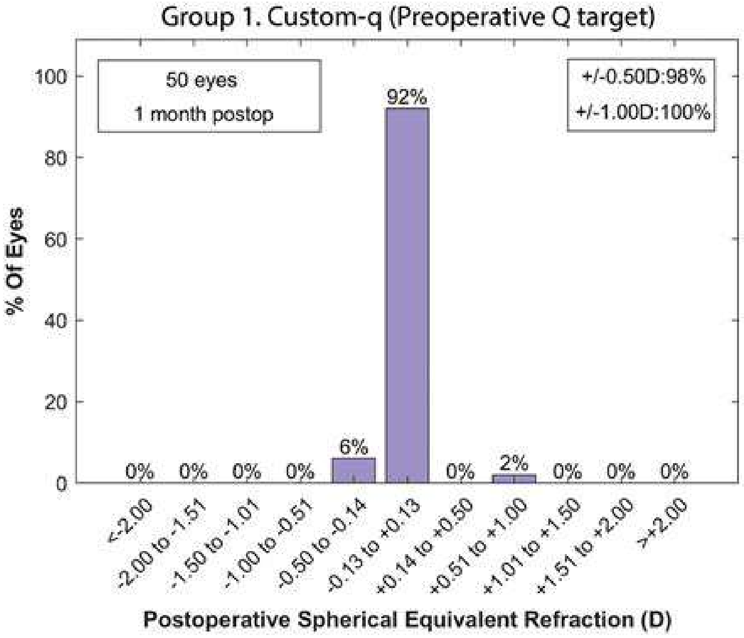

Group 1. Wavefront

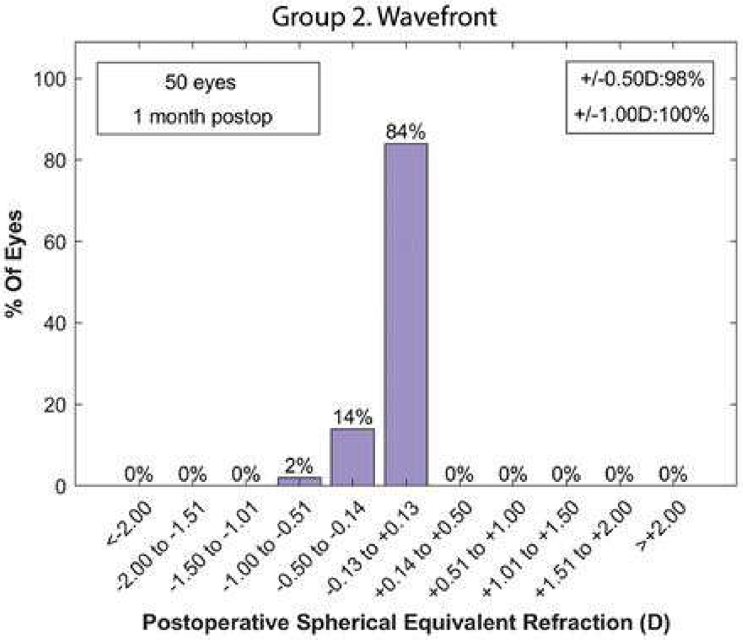

Group 1. Custom-q (Preoperative Q target)

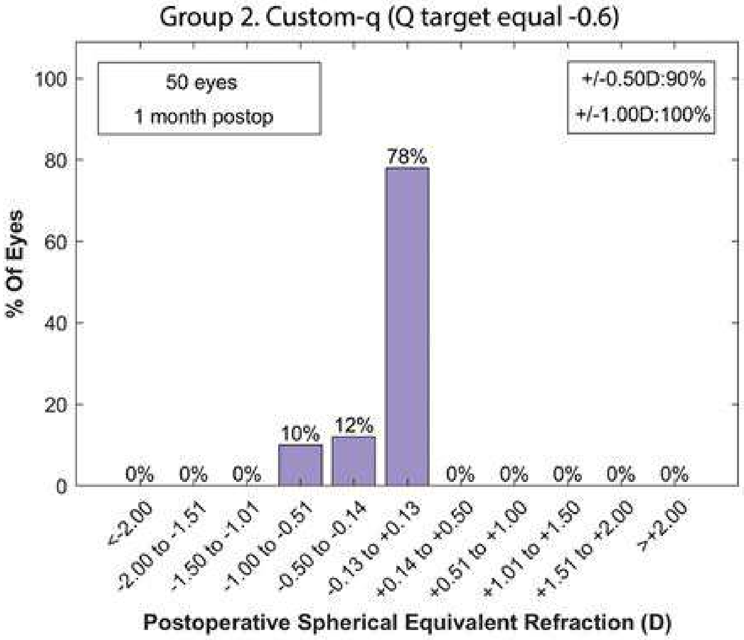

Group 2. Wavefront


Group 2. Custom-q (Q target equal -0.6)


Group 1. Wavefront
50 eyes
1 month postop
+/-0.50D:94%
+/-1.00D:100%
% Of Eyes
0
20
40
60
80
100
0%
0%
0%
4%
0%
94%
0%
2%
0%
0%
0%
<-2.00
-2.00 to -1.51
-1.50 to -1.01
-1.00 to -0.51
-0.50 to -0.14
-0.13 to +0.13
+0.14 to +0.50
+0.51 to +1.00
+1.01 to +1.50
+1.51 to +2.00
>+2.00
Postoperative Spherical Equivalent Refraction (D)


Group 1. Custom-q (Preoperative Q target)
50 eyes
1 month postop
+/-0.50D:98%
+/-1.00D:100%
% Of Eyes
0
20
40
60
80
100
0%
0%
0%
0%
6%
92%
0%
2%
0%
0%
0%
<-2.00
-2.00 to -1.51
-1.50 to -1.01
-1.00 to -0.51
-0.50 to -0.14
-0.13 to +0.13
+0.14 to +0.50
+0.51 to +1.00
+1.01 to +1.50
+1.51 to +2.00
>+2.00
Postoperative Spherical Equivalent Refraction (D)


Group 2. Wavefront
50 eyes
1 month postop
+/-0.50D:98%
+/-1.00D:100%
% Of Eyes
0
20
40
60
80
100
0%
0%
0%
2%
14%
84%
0%
0%
0%
0%
0%
<-2.00
-2.00 to -1.51
-1.50 to -1.01
-1.00 to -0.51
-0.50 to -0.14
-0.13 to +0.13
+0.14 to +0.50
+0.51 to +1.00
+1.01 to +1.50
+1.51 to +2.00
>+2.00
Postoperative Spherical Equivalent Refraction (D)


Group 2. Custom-q (Q target equal -0.6)
50 eyes
1 month postop
+/-0.50D:90%
+/-1.00D:100%
% Of Eyes
0
20
40
60
80
100
0%
0%
0%
10%
12%
78%
0%
0%
0%
0%
0%
<-2.00
-2.00 to -1.51
-1.50 to -1.01
-1.00 to -0.51
-0.50 to -0.14
-0.13 to +0.13
+0.14 to +0.50
+0.51 to +1.00
+1.01 to +1.50
+1.51 to +2.00
>+2.00
Postoperative Spherical Equivalent Refraction (D)