

Custom-Q vs Wavefront Optimized Lasik Ablation Treatment Profile in High Myopic Asian Eyes

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Abstract

Purpose: To compare the change in asphericity and other Higher Order Aberration (HOA) in Custom-Q vs. Wavefront Optimized (WFO) LASIK ablation profile patients in an Asian population.

Setting: Prospective matched-cohort study in refractive center.

Method: Thirty-four eyes of 17 patients with myopia seeking laser correction at Nobel Clinic in Taipei, Taiwan were enrolled in a prospective cohort study. Utilizing the latest WaveLight®EX500 Excimer Laser (Alcon, Inc., Switzerland), each patient received both Custom Q (CQ) and WFO LASIK ablation treatments (CQ on OD and WFO on OS). Each patient was measured thrice, as follows: (1) Before the Lasik procedure, (2) 1 week after the procedure, and (3) 1 month after the procedure.

Results: The custom-Q ablation group comprised a mean SE of -5.32 diopter (D), and the WFO ablation group comprised a mean SE of -5.41 diopter (D). Their frequencies with which Custom-Q and WFO achieved postoperative Uncorrected Distance Visual Acuity (UCDVA) were not statistically different from each other ($P>0.05$). No statistically significant differences were found in contrast sensitivity, astigmatism, coma, and trefoil. However, the change of spherical aberration was higher in the WFO ablation profile. Patient questionnaire shows a mild preference for Custom-Q over WFO.

Conclusion: Custom-Q and WFO LASIK provided similar results in myopic refractive correction and achieved post op UCDVA and contrast sensitivity. However, Custom-Q produced less changes in asphericity and HOA changes; Asian patients showed marginal preference for Custom-Q in terms of optic quality.

Introduction

Cornea Refractive surgery depends on the change of surface curvature to implement a new eye refractive status. Aberration is introduced when attempts are made to change the surface. One such aberration was Spherical Aberration (SA). Cornea SAs stay constant throughout life, whereas the lens introduces a progressive increase in SA with increasing age. SAs are perceived as halos around lights, and cause glare symptoms. Glare halos and dysphotopsia are the most frequent complaints of patients after LASIK surgery. Glare and halos affect vision quality and induce a loss of low light contrast sensitivity [1]. Therefore, patients would benefit if we avoid introducing more SA during refractive surgery. With the introduction of an aberrometer, Higher Order Aberrations (HOAs) can be measured in patients and subsequently treated. These HOAs most frequently include spherical aberration. Cornea and trifol treatments for these HOAs evolve with different protocols. Wavefront-Guided (WFG) treatment aims to address all HOA, whereas wavefront-optimized WFO only treats the SA.

As WFG treatment treats all HOAs, it is time consuming to gather all HOA data. Another problem in treating all HOAs is that it involves treating a large amount of cornea, thereby leaving the patient with a thinner cornea. Therefore, only eliminating the SA is considered beneficial for some patients. However, we have yet to find out the extent of SA treatment. The wave light Allegretto (wave light AG enlarger Germany) Excimer laser provides two different treatment models. As for surgeon adjustment, we adjusted for patients' original pre-surgical SA, because theoretically, this will induce less change to the eye and produce more patient satisfaction.

To describe the SA or a sphericity of the cornea surface, the wave light Allegretto system used Q-values. A negative Q-value describes a prolate surface, whereas a positive Q value describes an oblate surface [2].

Our study aimed to compare the WFO model vs. CQ model of the wave light Allegretto system.

This study is similar to an evaluation of a one-size-fits-all SA or a customized SA according to the patient's original data. In the CQ model, the intended Q shift (Q target) was set for the Q value that the patient has on their pre-op Q value. The laser model claimed to change the aspherical by adjusting the number of mid-peripheral laser pulses [3]. By evaluating Q value, SA Total, HOA and third order HOA, and pre and post operation data, we aimed to compare the differences in these two laser models.

In refractive surgical procedure, e.g., femto-assisted LASIK (SMILE), we aimed for a target result with zero High Order Aberrations (HOAs). However, in cataract surgery, we are starting to use trifocal Intraocular Lenses (IOLs), which are IOLs that provided some working vision for people with near, intermediate, and far vision. Most of the time, the ophthalmology surgeon determines the needs and wants of the patients, i.e., some wanted near vision, whereas others wanted far vision. Some working class patients wanted intermediate computer screen vision. One patient insisted on IOL with an end point of -2.0D for his long hours of computer use; he was willing to sacrifice his far distant vision (for driving), because he does not need to drive all the time. Such decisions require guess work and interview with the patients. If the decision is wrong, patients are not happy with the results.

The wavefront optimized ablation has an aspheric profile in which the amount of asphericity is not adjustable. Similarly, the Custom-Q ablation is also an aspheric ablation, but it considers the ability of the surgeon to define the intended Q-shift by specifying a desired asphericity target.

Stojanovic et al. [2] compared the performance between WFO and custom-Q by using two independent samples, and the difference in postoperative change in Q-values with marginal significance ($P=0.049$) was found, but no such difference was found in HOAs, low contrast visual acuity, or classic outcome parameters. Considering the improvement in LASIK equipment, would WFO still have an advantage over Custom-Q? The aim of this study is to compare the performance between WFO treatment and Custom-Q treatment

under the latest WaveLight®EX500 Excimer Laser (Alcon, Inc., Switzerland). To avoid the between-individual variation, we designed a pairwise comparison study by applying both treatments on the same patient (Custom-Q on OD and WFO on OS).

Materials and Methods

Thirty-four eyes of 17 patients with myopia seeking laser correction at Nobel Clinic in Taipei, Taiwan were enrolled in a prospective cohort study. Inclusion criteria were as follows: Aged 20 years old or older; did not use contact lens for 2 weeks before baseline examination; and manifested refraction spherical equivalent between -1.0 and -10.0 diopters (D) with <-3.50D of refractive astigmatism. Exclusion criteria were keratoconus or keratoconus suspect and previous eye surgery.

Utilizing the latest WaveLight®EX500 Excimer Laser (Alcon, Inc, Switzerland), each patient received both Custom Q and WFO LASIK ablation treatments (CQ on OD and WFO on OS). The target refraction in all eyes was emmetropia. Manifest refraction, adjusted with a modified manufacturer's nomogram, was used as the programming basis of all treatment. LASIK flaps were created using the 150kHz Intra Lasei FS (Abbott Medical Optics, Santa Ana, CA). Main outcome measure parameters included residual refractive error, Uncorrected Distance Visual Acuity (UCDVA), contrast sensitivity, Q-value asphericity, HOAs, and subjective patient optic quality questionnaire. Each patient was measured thrice in the same refractive center, as follows: (1) Before the Lasik procedure, (2) 1 week after the procedure, and (3) 1 month after the procedure.

Zernike polynomial divided the eye aberrations into high and low. Low order aberrations are defocus ones, such as myopia, hyperopia, astigmatism, and presbyopia. High order aberrations have relatively unfamiliar names, such as coma(z31), trefoil(z33), spherical aberration(z40), Wavefront diameter (in mm), and Wavefront HOAs. They were calculated by using Zernike polynomial with unit as root mean square and were denoted as Coma_Z31, Trefoil_Z33, Sph_Aberration_Z40, WF_Diam, and WF_HOA, respectively in Table 1.

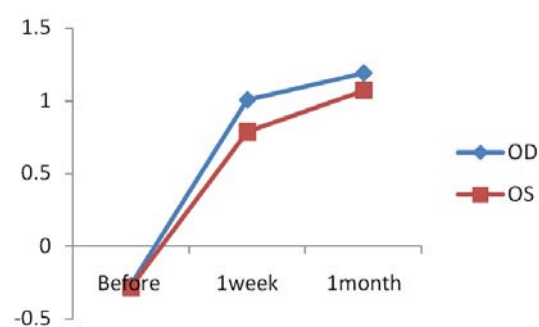
Table 1: Three measurements on OD and OS from 17 patients: Before procedure, 1 week after the procedure, and 1 month after procedure.

		Before		One-week-after		One-month-after	
		Mean	Std	Mean	Std	Mean	Std
Age (All, N=17)		31.412	6.135	-	-	-	-
Age (Female, N=11)		30.909	6.316	-	-	-	-
Age (Male, N=6)		32.333	6.25	-	-	-	-
Q-value	OD	-0.268	0.119	1.007	0.914	1.192	0.681
	OS	-0.283	0.131	0.788	0.971	1.071	0.828
WF_Diam_mm	OD	5.614	0.504	5.638	0.681	5.359	0.639
	OS	5.625	0.759	5.5	0.688	5.344	0.806
WF_High_Orde_Aberr	OD	0.282	0.134	0.472	0.205	0.391	0.139
	OS	0.293	0.149	0.446	0.177	0.399	0.222
Coma_Z31	OD	0.155	0.093	0.299	0.216	0.246	0.135
	OS	0.161	0.116	0.273	0.193	0.274	0.199
Trefoil_Z33	OD	0.152	0.092	0.195	0.09	0.174	0.074
	OS	0.148	0.085	0.177	0.075	0.151	0.095
Sph_Aberration_Z40	OD	0.082	0.097	0.068	0.192	0.015	0.136
	OS	0.063	0.131	0.019	0.201	0.003	0.182

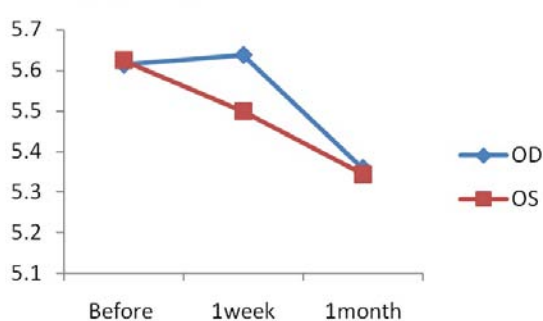
Table 2: Wilcoxon signed rank tests on the examination of differences in Q-value and HOA components improvement between CQ (OD) and WFO (OS).

Wilcoxon Signed Rank Test	Diff_1_week			Diff_1_month		
	Mean	Std	p-value	Mean	Std	p-value
Q-value	0.223	0.513	0.027	0.057	0.407	0.268
WF_Diam_mm	0.202	0.82	0.053	0.111	0.671	0.536
WF_High_Order_Aberr	0.042	0.164	0.361	0.026	0.208	0.587
Coma_Z31	0.036	0.201	0.448	0.014	0.122	0.766
Trefoil_Z33	0.014	0.089	0.7	0.001	0.1	0.495
Sph_Aberration_Z40	0.05	0.131	0.134	-0.002	0.221	0.966

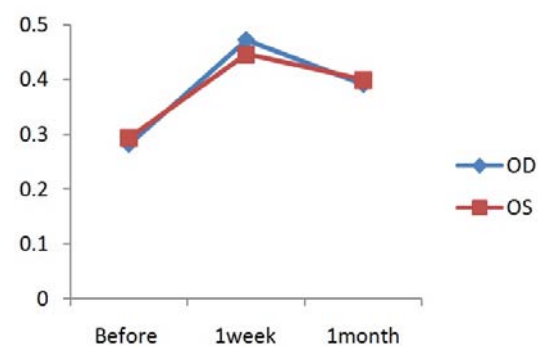
1a. Q-value



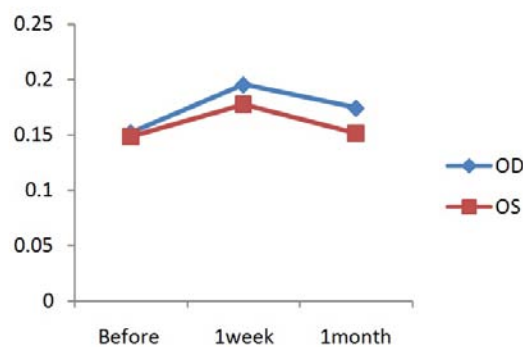
1b. W_F_Diam_mm



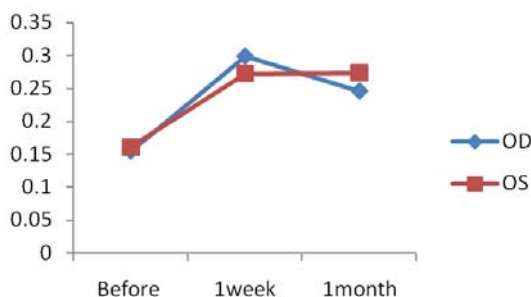
1c. WF_High_Order_Aberr



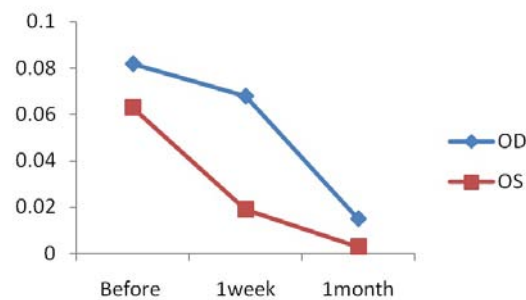
1d. Trefoil_Z33



1e. Coma_Z31



1f. Sph_Aberration_Z40

**Figure 1:** Comparison of secular trends between OD and OS, on Custom-Q (1a), Wavefront diameter in mm (1b), Wavefront high order aberrations (1c), trefoil_z33 (1d), coma_z31 (1e), and spherical.

The 1 week improvements in Q-value due to procedure on each eye were measured according to the increments between the measurements before and 1 week after the procedure (diff_1_week). The 1 month improvement was the difference between the measurement before and 1 month after the procedure (diff_1_month). We then compared the performance of CQ and WFO according to their 1week improvements, which were measured by the difference between the 1 week improvements of OD and OS: OD(diff_1_week)-OS(diff_1_week); and the one-month-improvements: "OD(diff_1_month)-OS(diff_1_month)" respectively. We used Wilcoxon Signed-Rank Test to compare the differences to cope with the small sample size and the dependency between the paired data of OD and OS.

Results

Seventeen patients' completed the measurements on both OD and OS for the three stages. The average age is 31.57 years old, with no difference between genders. The initial averaged Q-values (Table 1, column 3) of OD and OS were -0.268 and -0.283, respectively. Other initial measurements of OD and OS were 5.614 and 5.625 for WF_Diam_mm, 0.282 and 0.293 for WF_High_Order_Aberr, and 0.155 and 0.161 for Coma_Z31. Pairwise t-tests indicated that the initial measurements between OD and OS showed no difference. At 1week after the treatment, the Q-values increased to 1.007 and 0.788. After 1month, they further increased to 1.192 and 1.071, respectively. Figure 1 compares the secular trends between OD and OS, on Q-value, Wavefront diameter in mm, Wavefront high order aberrations, Trefoil_z33, Coma_z31, and Spherical aberration_z40. Figure-1a shows obvious improvements (increments) of on Q_value 1week or 1month after LASIK procedures of both OD and OS; this result was expected. Figures -1c and -1e also show an increase in Wavefront HOAs and Coma_Z31 after surgery. Trefoil_Z33 showed no obvious change after surgery (Figure 1d). Wavefront diameter in Figure-1b and Sph_Aberration_Z40 in Figure-1f decreased after surgery.

We used Wilcoxon Signed Rank Tests to compare the difference in improvement between OD and OS. Table 2 shows that Custom-Q had significantly better short-term (1week after procedure) improvement than WFO (p-value=0.027). However, for the longer term (1month after), the deviance diminished to less than half (p-value=0.268). Further analysis on each of the 5 major HOA components (WF_Diam_mm, WF_High_Order_Aberr, Coma_Z31, Trefoil_Z33, and Sph_Aberration_Z40) showed no significant difference between CQ and WFO.

Discussion

Some researchers concluded that wavefront-guided customized ablation produced better results [4]. Researchers accepted that HOA has a significant role in the worsening of visual quality of all the HOAs, SA is the most common. The refractive surgery ablation profile itself will induce SA. Therefore, a treatment for SA (along with the refraction correction) is imminent. However, the amount of correction for SA has been in question. Stojanovic et al [2] showed that CQ ablation results include a mean post-operation asphericity closer to the pre-operative status as compared with WFO, but the difference was only marginally statistically significant (P=0.049).

The Q-Target was not reached, even though the Q Target was set at double the WFO Q target (-0.6 vs. -0.3) [2]. With increasing myopic correction, the ablation profile results in an increasingly oblate (more Q plus) condition. WFO profile uses a target Q-value that is universal, and the value is obtained from the average value of a population database. By contrast, CQ profile allows the surgeon to set a target Q value. In our case, we chose the pre-op data with Q value as the Target Q. Therefore, comparing CQ and WFO, CQ is small compared with a standard deviations database with WFO as the mean database.

In our study, we aimed to lower inter-personal difference by comparing the Left and Right eye in a same day treatment procedure, based on the fact that the two eyes are most likely mirror images of one another. Considering that CQ treatment uses up more cornea tissue, we used CQ on thicker cornea and WFO on thinner cornea. In results, the custom-Q ablation group comprised a mean SE of -5.32 diopter, and the WFO ablation group comprised a mean SE of -5.41 diopter. The frequency at which Custom-Q and WFO achieved postoperative UCDVA were not statistically different from each other (P>0.05). There were neither no statistically significant differences in contrast sensitivity, astigmatism, coma, and trefoil. However, the change of spherical aberration was higher in WFO ablation profile. Patient questionnaire results showed a mild preference for Custom-Q over WFO.

The non-significant difference in satisfactory rate or difference between HOA or any of the refractive data corroborate our assumption that treating all the spherical aberration is not essential. More effort should be aimed at treating all the lower order aberration to obtain the best satisfactory results. Custom-Q and WFO LASIK provided similar results in myopic refractive correction, and achieved post op UCDVA and contrast sensitivity. However, Custom-Q produced less changes in asphericity and HOA changes. Asian patients showed a marginal preference for Custom-Q for optic quality.

Quoting Jack Holliday's comments [5] on older presbyopic patients: "If they want to depend less on readers, they will benefit from small negative spherical aberration". It was shown that small negative SAs help extend the depth of field for the patients. Thus, in older presbyopia patients, this might be helpful for their failing near vision, thereby decreasing their dependence on their readers.

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