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# Q Value Based Ablation Profile versus Topography-Guided LASIK: A Contralateral Comparative Study

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## ABSTRACT

**Background:** laser in situ keratomileusis (LASIK) has become the most widely used form of refractive surgery. The objective of this surgical technique was to modify the anterior corneal shape by ablating tissue from the stroma by means of the excimer laser after creating a hinged corneal flap. By this way, we were able to change the refractive status of the patient and provided better unaided vision. Continuous improvements in the original technique made the surgical procedure safer, more accurate and repeatable. These progressions are due to the development of novel technologies that are responsible for new surgical instrumentation , which makes the surgical procedure easier for the surgeon and better excimer laser ablation algorithms, which increase the optical quality of the ablation and thus the safety of the vision correction procedure. **Aim of work:** the aim of this study was to compare between Q value based ablation and topography-guided LASIK as regards safety, visual acuity, contrast sensitivity and high order aberration HOAs (spherical, coma and trefoil). **Patients and methods:** this study was conducted on 60 eyes of 30 patients, thirty eyes of them underwent topography guided LASIK and the other 30 underwent Q value based ablation. Preoperative CDVA (corrected distant visual acuity) was done. Postoperative UDVA and CDVA were measured. Postoperative high order aberrations were measured 3 months postoperatively. **Results:** our results showed that there was no statistically significant difference between both groups as regards UDVA, spherical equivalent, high order aberrations and Strehl ratio point spread function. **Conclusion:** topographic guided ablation and Q value based groups provided essentially equivalent outcomes after myopic LASIK, with statistically insignificant difference between both profiles, although both laser profiles have been found to be effective, safe and predictable.

**Recommendations:** we recommended doing more research regarding this study with larger number of cases and doing further investigations.

**Keywords:** Q value, LASIK , UDVA, CDVA.

## INTRODUCTION

Laser in situ keratomileusis (LASIK) has become the most widely used form of refractive surgery. The objective of this surgical technique is to modify the anterior corneal shape by ablating tissue from the stroma by means of the excimer laser after creating a hinged corneal flap. By this way, we are able to change the refractive status of the patient, providing better unaided vision. Continuous improvements in the original technique have made the surgical procedure safer, more accurate and repeatable. These progressions are due to the development of novel technologies that are responsible for new surgical instrumentation, which makes the surgical procedure easier for the surgeon and better excimer laser ablation algorithms, which increase the optical quality of the ablation and thus the safety of the vision correction procedure [(1)].

Wavefront-based treatments can be classified into two broad categories: wavefront-optimized and wavefront-guided algorithms. The wavefront-optimized approach considers an eye's refractive error and preoperative keratometry, in conjunction with the variable ablation depths of peripherally delivered laser pulses, to apply a precalculated aspheric ablation that aims to limit induced spherical aberrations and maintaining the original Q value of the cornea. The Wavefront-guided approach renders a customized treatment plan based on an eye's unique preoperative aberrometry with the intent of not only minimizing induced postoperative aberrations but also reducing or eliminating preoperative High Order Aberrations [(2)]**.** Topography-guided ablation is a form of customized ablation that uses current topography instead of a wavefront map as the basis for the treatment. It is found to be an effective way to treat irregular astigmatism, small optical zones, and decentered ablations in symptomatic post-LASIK patients. It maintains the prolate shape of the cornea, reduce corneal



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surface irregularities and result in better uncorrected visual acuity, better night vision and less induced postoperative wavefront aberrations. Topogrujknbvfdfeeef6ds0061aphy-guided ablation has been approved by FDA for treatment of virgin corneas undergoing LASIK [(3).]

It has been known for many years that any refractive treatment of the cornea must respect the preoperative and postoperative asphericity of the cornea. The anterior surface of the human cornea is physiologically not spherical, but rather like a conoid. On average, the central part of the cornea has a stronger curvature than the periphery or, in other words, the refractive power of the anterior corneal surface decreases from central toward peripheral. The term prolate cornea has been coined for this form and the opposite form is called oblate cornea. The physiologic asphericity of the cornea shows significant individual variation ranging from mild oblate to moderate prolate. It was therefore necessary to introduce a shape factor, the so-called Q-factor, to characterize the amount of asphericity of the cornea numerically. 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 allows the surgeon to define the intended Q-shift (postoperative Q-value minus preoperative Q-value) by specifying the desired asphericity target. The only preoperative data that custom-Q treatment uses in addition to the refractive data is a value of the mean corneal asphericity. It aims to change the mean asphericity by symmetrically adjusting the number of mid-peripheral laser pulses [(4).]

## AIM OF WORK

This study aimed to compare between Q value based ablation and Topography-guided LASIK as regards safety, visual acuity, contrast sensitivity and high order aberration HOAs (spherical, coma and trefoil).

## PATIENTS AND METHODS

A contralateral comparative study between Q value based ablation profile and Topography-Guided LASIK was performed at the Department of Refractive Surgery at El Watany Hospital, Ain Shams University" and The Research Institute of Ophthalmology as regards safety, visual acuity, contrast sensitivity and high order aberration HOAs (spherical, coma and trefoil). A total number of 60 eyes (30 patients: 17 males and 13 females) underwent laser in situ keratomileusis (LASIK).

The patients were categorized into two groups according to a random assignment by coin and toss in which one eye was treated with topographic-guided customized ablation (group A) and the other eye was treated with Q-factor customized profile (group B). All the patients in this study were given information about the surgical procedure and possible complications. Written informed consent was obtained from each subject. **The study was approved by the Ethics Board of Ain Shams University.**

**The Inclusion criteria** of this study were adult patients from the age of 18-60 years with stable refraction one year at least and myopic patients up to -9 D and astigmatism -4.5 D.

**Exclusion criteria** were any pathology of the eyes that might affect visual outcome (e.g. optic nerve disease), Age under 18 and above 60 years, asymmetric astigmatism detected in corneal topography, central corneal thickness less than 500 μm and residual stromal thickness of less than 300 μm, pregnant or lactating females, Intra operative complications, spherical and cylindrical error difference between both eyes <1.5 D, failure of iris registration and unstable refraction e.g. progressive myopia.

The LASIK treatment was performed with the wavelight Ex 500 Hz Excimer laser (Wavelight ALLEGRETTO platform, Alcon Laboratories) and the Alcon Wavelight FS200 Femtosecond laser. Central corneal thickness and the corneal flap design parameters were entered into the computer. The thickness of the corneal flap was set to 110 μm and the flap diameter was set to 9.0 mm. The optical treatment zone was 6.5 mm for both eyes. The suction ring was applied for eye fixation. Once the flap was created and opened, the central corneal stromal bed thickness was measured and compared with the preoperative corneal thickness to calculate the thickness of the corneal flap. The corneal stroma was then ablated by the excimer laser. The corneal bed was rinsed, and the corneal flap reset. Antibiotic anti-inflammatory saline eye drops were used during recovery.

A preoperative ophthalmological examination was performed in all patients that included ocular and medical history, measurement of Subjective refraction, UDVA (uncorrected distant visual acuity) and CDVA (corrected distant visual acuity) were measured, Intra ocular pressure measurement using "Applanation tonometry", Slit lamp examination of the anterior and posterior segments of the eyes was done and Corneal tomography was measured by Pentacam High Resolution HR (Oculus). Postoperative ophthalmological examination was done including UDVA and CDVA, Postoperative High order aberrations HOAs (total RMS and high order RMS spherical aberrations, coma and trefoil), Postoperative visual quality by assessing Strehl ratio PSF (point spread function) and contrast sensitivity curve by NIDEK OPD-SCAN III. All parameters were measured and analyzed to the final follow up visit 3 months postoperative.

***Statistical Analysis***

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when their distribution found parametric and median with inter-quartile range (IQR) when their distribution found non parametric while qualitative data were presented as number and percentages.

The comparison between two paired groups with quantitative data and parametric distribution was done by using Paired t-test while with non parametric data was done by using Wilcoxon Rank test.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

P > 0.05: Non significant
P < 0.05: Significant
P < 0.01: Highly significant.

**RESULTS**

**Table 1: comparison between topographic guided and Q value based regarding UDVA and CDVA preoperative**

| **Pre-Operative** | | **Topographic guided group** | **Q value based group** | **Test value** | **P-value** | **Sig.** |
|---|---|---|---|---|---|---|
| | | **No. = 30** | **No. = 30** | | | |
| UDVA Log Mar | Mean±SD | 0.59 ± 0.28 | 0.57 ± 0.30 | -0.254‡ | 0.800 | NS |
| | Range | 0.2 – 1.3 | 0.1 – 1.3 | | | |
| CDVA Log Mar | Mean±SD | 0.01 ± 0.03 | 0.01 ± 0.03 | -0.853‡ | 0.393 | NS |
| | Range | 0 – 0.1 | 0 – 0.1 | | | |
| spherical equivalent | Mean±SD | -2.91 ± 2.10 | -3.14 ± 2.22 | -0.222‡ | 0.824 | NS |
| | Range | -6.37 – -2.63 | -7.5 – -4.13 | | | |
| Km (mean k reading) | Mean±SD | 42.85 ± 1.56 | 42.97 ± 1.63 | -0.296• | 0.768 | NS |
| | Range | 39.35 – 46.35 | 39.4 – 46.65 | | | |

NS: non significant; S: significant; HS: highly significant
• Independent t-test; ‡: Mann Whitney test

The previous table showed that there was no statistically significant difference between topographic guided group and Q value based group regarding preoperative UDVA and CDVA logMAR with p-value = 0.8 and 0.3 respectively. There was no statistically significant difference in preoperative spherical equivalent between both groups with mean spherical equivalent -2.91 and -3.14 respectively with [p-value = 0.8] and mean k readings 42.85 and 42.97 respectively [p-value = 0.7]

**Table 2: Comparison between preoperative mean k readings of topographic guided group and Q value based group**

| Post Operative | | Topographic guided group No. = 30 | Q value based group No. = 30 | Test value‡ | P-value | Sig. |
|---|---|---|---|---|---|---|
| UDVA (log MAR) | Mean±SD<br>Range | 0.05 ± 0.06<br>0 – 0.2 | 0.21 ± 0.35<br>0 – 1 | -1.379 | 0.168 | NS |
| CDVA (log MAR) | Mean±SD<br>Range | 0.02 ± 0.04<br>0 – 0.1 | 0.21 ± 0.40<br>0 – 1 | -1.549 | 0.121 | NS |
| Spherical equivalent | Mean±SD<br>Range | 0.05 ± 0.46<br>-0.88 – 1 | 0.02 ± 0.48<br>-0.88 – 1.13 | 0.202 | 0.841 | NS |

NS: non significant; S: significant; HS: highly significant
ǂ: Mann Whitney test

The previous table showed that there was no statistically significant difference between topographic guided group and Q value based group regarding postoperative UNCVA and BCVA (logMAR) with p-value = 0.16 and 0.12 respectively. No statistically significant difference in postoperative spherical equivalent between both groups with mean spherical equivalent -0.25 and -0.19 respectively with [p-value = 0.9].

**Table 3: comparison between topographic guided and Q value based groups regarding postoperative high order aberrations and contrast sensitivity**

| | | Topographic guided group No. = 30 | ) value based group No. = 30 | Test value‡ | P-value | Sig. |
|---|---|---|---|---|---|---|
| HIGH RMS | Mean±SD<br>Range | 0.50 ± 0.39<br>0.1 – 1.51 | 0.52 ± 0.40<br>0.08 – 1.52 | 0.000 | 1.000 | NS |
| COMA | Mean±SD<br>Range | 0.19 ± 0.17<br>0.01 – 0.61 | 0.22 ± 0.20<br>0.02 – 1 | -0.828 | 0.408 | NS |
| TREFOIL | Mean±SD<br>Range | 0.34 ± 0.27<br>0.07 – 1.19 | 0.31 ± 0.20<br>0.03 – 0.78 | -0.123 | 0.902 | NS |
| Spherical operations | Mean±SD<br>Range | 0.17 ± 0.21<br>0.01 – 0.77 | 0.22 ± 0.32<br>0.01 – 1.19 | -0.591 | 0.555 | NS |
| STREHL RATIO | Mean±SD<br>Range | 0.11 ± 0.12<br>0.01 – 0.42 | 0.10 ± 0.13<br>0 – 0.54 | -0.672 | 0.501 | NS |

NS: non significant; S: significant; HS: highly significant
ǂ: Mann Whitney test

The previous table showed that there was no statistically significant difference between topographic guided group and Q value based group regarding postoperative high order aberrations and contrast sensitivity.

**Table 4: comparison between preoperative and postoperative UDVA, CDVA and spherical equivalent in topography guided group.**

| Topographic guided group | | Pre-Operative No. = 30 | Post-Operative No. = 30 | Test value‡ | P-value | Sig. |
|---|---|---|---|---|---|---|
| UDVA (Log Mar) | Mean±SD<br>Range | 0.59 ± 0.28<br>0.2 – 1.3 | 0.05 ± 0.06<br>0 – 0.2 | -4.792 | 0.001 | HS |
| CDVA (Log Mar) | Mean±SD<br>Range | 0.01 ± 0.03<br>0 – 0.1 | 0.02 ± 0.04<br>0 – 0.1 | -0.447 | 0.655 | NS |
| Spherical equivalent | Mean±SD<br>Range | -2.91 ± 2.10<br>-6.37 – 2.63 | 0.05 ± 0.46<br>-0.88 – 1 | 10.815 | 0.001 | HS |

NS: non significant; S: significant; HS: highly significant
ǂ: Willcoxon rank test

**Table 5: comparison between preoperative and postoperative UDVA, CDVA and spherical equivalent in Q value based group.**

| Q value based group | | Pre-Operative No. = 30 | Post-Operative No. = 30 | Test value | P-value | Sig. |
|---|---|---|---|---|---|---|
| UDVA (Log Mar) | Mean±SD<br>Range | 0.57 ± 0.30<br>0.1 – 1.3 | 0.21 ± 0.35<br>0 – 1 | -3.337 | 0.001 | HS |
| CDVA (Log Mar) | Mean±SD<br>Range | 0.01 ± 0.03<br>0 – 0.1 | 0.21 ± 0.40<br>0 – 1 | -2.535 | 0.011 | S |
| Spherical equivalent | Mean±SD<br>Range | -3.14 ± 2.22<br>-7.5 – 4.13 | 0.02 ± 0.48<br>-0.88 – 1.13 | 7.820 | 0.001 | HS |

NS: non significant; S: Ssgnificant; HS: highly significant
ǂ: Willcoxon rank test

## DISCUSSION

LASIK is the most frequently performed corneal refractive surgery for myopia. Although standard laser treatment eliminates conventional refractive errors, it can induce HOAs that adversely affect the postoperative quality of vision, especially with respect to deterioration of the contrast functions. Change in the corneal shape after LASIK toward an oblate pattern is believed to be responsible for inducing spherical aberrations and HOAs after refractive surgery. To enhance the functional outcomes of refractive corneal surgery, several ablation profiles have been designed; .Aspheric ablation profiles were designed to minimize further inducing spherical aberration by aiming to maintain the original Q value of the cornea [(1)].

**Tawfik *et al*.** in a comparative study of 400 eyes of 200 patients seeking laser refractive surgery were included in this study. The first group, which included 200 eyes, was treated with wavefront optimized ablation, while the second group, which also included 200 eyes, was treated with custom-Q ablation demonstrated that a Q-factor optimized ablation profile yielded visual, optical, and refractive results comparable to those of the wavefront- guided customized technique for corrections of myopia and myopic astigmatism. The Q-factor optimized ablation represents a customized approach that is much less time-consuming than the wavefront guided technique since it is based on preoperative corneal topography, it was concluded in the study that the Q-factor optimized profile has, therefore, the potential to replace currently used standard profiles for corrections of myopic astigmatism [(5)]**. Goyal *et al.*** in a comparative study between Aspheric LASIK and wavefront-guided found out that Aspheric LASIK has induced significantly less change in higher-order aberrations and maintained corneal asphericity better than wavefront-guided LASIK. The visual outcome and contrast sensitivity were better in the aspheric group at 6 months postoperatively. In a study of forty patients were randomly selected to receive wavefront-guided LASIK (wavefront-guided group) and aspheric LASIK (aspheric group) (40 eyes of 20 patients in each group) using the Technolas 217z excimer laser platform (Bausch & Lomb, Rochester, NY) [(6)]**. Toda *et al.*** in a prospective, randomized clinical study, 68 eyes of 35 patients undergoing LASIK were enrolled. Patients were randomly assigned to two treatment groups: wavefront guided ablation (using the I design aberrometer and STAR S4 IR Excimer Laser) and topography-guided ablation using the OPD-Scan aberrometer and EC-5000 CXII excimer laser (NIDEK), they concluded that both customized ablation systems used in LASIK achieved excellent results in predictability and visual function. The wavefront-guided ablation system may have some advantages in the quality of vision [(7)]. **Shetty *et al*.** in a prospective study to compare visual outcomes between wavefront-optimized and topography-guided ablation profiles in contralateral eyes with myopia, Sixty eyes of 30 patients WFO ablation was performed in one eye (WFO group) and TCAT in the fellow eye (TCAT group). The Wavelight FS200 femtosecond laser was used to create the flap and Allegretto Wave excimer laser was used for photoablation. The Pentacam HR and Allegretto Topolyzer were used to measure the corneal aberrations. Refractive visual outcomes were also compared, it was concluded that accuracy, safety, and efficacy were similar in the two groups TCAT and WFO ablation provided essentially equivalent outcomes after myopic LASIK, with induction of fewer lower order aberrations and higher order aberrations following TCAT ablation[(8).]

A study confirmed the role of topography-guided ablation in the treatment of irregular astigmatism induced by refractive surgery [(9)]. **Vinciguerra *et al.*** evaluated the outcomes of topography-guided PRK in 335 low to high myopic eyes. They reported UDVA of 20/20 or better in 98% of eyes at both 3 and 6 months.[(11)] Farooqui and Al-Muammar studied visual outcomes in 46 eyes of 23 patients who underwent topography-guided corneal customized LASIK using the CATz ablation profile in one eye and conventional LASIK using the NIDEK EC-5000 Advanced Vision Excimer laser system (NAVEX; NIDEK Co Ltd, Gamagori, Japan) in the fellow eye for myopia with or without astigmatism. They found no significant difference in UDVA between groups, although better night vision quality was reported in the topography guided customized LASIK eyes. Better night vision quality in their study was associated with less induced spherical aberration and coma postoperatively in the CATz treatment group . The demand for satisfactory, repeatable and safe results after refractive surgery has led to the development of several new laser platforms. The trend of evolution of modern lasers is towards increasing the repetition rate, decreasing the laser spot size, and linking of laser platforms with topography and wavefront analyzer systems [(13)].

In our study, a contralateral comparative study between Q value based ablation profile and Topography-Guided LASIK was performed at the department of refractive surgery at "El Watany Hospital", "Ain Shams University" and "The Research institute of ophthalmology" as regards safety, visual acuity, contrast sensitivity and high order aberration HOAs (spherical, coma and trefoil). A total number of 60 eyes (30 patients: 17 males and 13 females) underwent LASIK. The patients were divided into two groups according to a random assignment by coin and toss in which one eye was treated with Topographic-Guided customized ablation (group A) and the other eye was treated with Q-factor customized profile (group B), In both groups, preoperative corrected distance visual acuity (CDVA) was 0.01 ± 0.03 logMAR for topographic guided group and 0.01 ± 0.03 logMAR for Q value based group [P=.1], 3 months postoperative uncorrected distance visual acuity (UDVA) was 0.05 ± 0.06 logMAR for topographic guided group and 0.21 ± 0.35 logMAR for Q value based group [P=.1], the mean manifest refraction spherical equivalent for topographic guided group was -0.25 ± 0.73 and Q value based group was -0.19 ± 0.72.With no statistically significant difference between both groups.

Our results support previous findings regarding the safety and effectiveness of topography-guided ablation in normal eyes with low to moderate myopia with and without astigmatism.

On studying aberrations, we found that the high RMS, total RMS, spherical and coma values were not significantly different in both ablation profiles.

## CONCLUSION

Topographic guided ablation and Q value based groups provided essentially equivalent outcomes after myopic LASIK, with statistically insignificant difference between both profiles, although both laser profiles have been found to be effective, safe, and predictable.

## STUDY LIMITATIONS

Our study has certain limitations, the small sample size together with the short period of postoperative follow up and ability of comparing pre and postoperative high order aberrations and contrast sensitivity wasn’t feasible.

## RECOMMENDATIONS

We recommend doing more research regarding this study with larger number of cases and doing further investigations.

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