Topography-guided CATz Versus Conventional LASIK for Myopia With the NIDEK EC-5000: A Bilateral Eye Study

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ABSTRACT

PURPOSE: To evaluate the difference in visual acuity, subjective night vision glare, and higher order aberrations in eyes with myopia with or without astigmatism operated with topography-guided customized corneal LASIK and conventional LASIK.

METHODS: This contralateral study includes 46 eyes (23 patients) that underwent topography-guided corneal customized LASIK using the customized aspheric treatment zone (CATz) ablation profile in one eye and conventional LASIK using the NIDEK EC-5000 Advanced Vision Excimer laser system (NAVEX) in the other eye for myopia with or without astigmatism. Patients were masked to which eye underwent topography-guided CATz or conventional LASIK. Postoperative glare and root-mean-square (RMS) values for total higher order aberrations were measured at 1 and 3 months and compared between the two eyes.

RESULTS: No significant difference was noted in uncorrected visual acuity between the two groups at 1 and 3 months postoperatively. Of all patients, 81% stated glare was higher in conventionally treated eyes than in the CATz-treated eyes at 1 and 3 months postoperatively. The RMS values for total coma (0.2385 vs 0.1522) and spherical aberration (0.2381 vs 0.1058) in conventionally treated and CATz-treated eyes were significantly higher in conventionally treated eyes (P=.029 and P=.004, respectively) at 3-month follow-up.

CONCLUSIONS: Topography-guided corneal customized LASIK with the CATz profile gave better night vision quality as compared to conventional LASIK with expanded treatment zone. Better night vision quality was associated with less induced spherical aberrations and coma postoperatively in the CATz treatment group. [*J Refract Surg*. 2006;22:741-745.]

Laser in situ keratomileusis (LASIK) for myopia is well known for its ability to reduce refractive error and the dependency of patients on spectacles or contact lenses. Acceptable uncorrected visual acuity results that are achieved with LASIK have led to high patient satisfaction rates. However, a number of patients are unsatisfied due to decreased night vision quality and reduced contrast sensitivity. Night vision complaints such as glare, halos, and difficulty in driving at night have been reported in 16% to 40% of patients after LASIK surgery.[1-5] In a survey of patients dissatisfied with refractive surgery results, 43.5% reported glare and night vision disturbance as the reason for their dissatisfaction.[6]

Many instruments have been described and used for the quantification of night vision complaints; however, none can be set as a gold standard for reliable testing[3,7-9] due to the complex nature of the phenomenon. A functional magnetic resonance imaging study has shown that postoperative refractive surgery glare and halos are associated with abnormal cortical stimulation.[10] Reduction in night vision complaints over time is in part due to the central nervous system adaptation and this neural plasticity varies among individuals.[11] Conventional LASIK surgery causes a rise in higher order corneal aberrations,[12,13] therefore, it is presumed that topography-guided ablation profile intended to maintain the prolate shape of the cornea and reduce corneal surface irregularities may result in better uncorrected visual acuity, better night vision quality, and less induced wavefront aberrations postoperatively.

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The two goals of this study were to subjectively assess the qualitative difference in the nocturnal glare between the two eyes and to assess the difference in the higher order aberrations between the two groups.

PATIENTS AND METHODS

STUDY DESIGN

In a randomized prospective study, 23 patients underwent LASIK for myopia with or without astigmatism with either topography-guided customized LASIK using the NIDEK Customized Aspheric Treatment zone (CATz) ablation profile (NIDEK, Gamagori, Japan) or conventional treatment with the NIDEK Advanced Vision Excimer Laser Platform (NAVEX). One eye of each patient was randomly assigned to topography-guided treatment and the other eye to conventional LASIK with a treatment zone 1.0- to 1.5-mm larger than scotopic pupil diameter. The LASIK nurse randomly picked the floppy for topography-guided treatment before surgery. The other eye was treated conventionally. Patients underwent informed consent including information about the two treatment methods used in this study. All patients were masked to the treatments each eye received.

Patients of either sex with myopia or myopic astigmatism with no systemic or ocular disease and no history of previous ocular surgery were included in the study. Preoperative subjective glare perception at night and to single source of light was equal in two eyes. Contact lens wear was discontinued 2 weeks prior to the examination. Both eyes were eligible for CATz ablation, which is an ablation profile generated by NIDEK FinalFit software consisting of an aspherical treatment pattern and simultaneous correcting for the corneal surface irregularities responsible for wavefront aberrations. For aspheric correction ablation profile 5 or 6 was chosen, depending on the ablation depth and residual bed thickness. Corneal irregularities were extracted without lens and multipoint ablation was set to treat 80% of irregularities. Eyes were randomly assigned to either of the two treatment methods, ie, CATz and conventional sphero-cylindrical ablation with expanded transition zone.

Preoperative evaluation included a record of ocular and systemic history, uncorrected visual acuity (UCVA), and manifest and cycloplegic refractions. Slit-lamp microscopy and fundus examination were performed on each patient to exclude ocular diseases. Corneal wavefront error, topography, and refraction were measured using the NIDEK OPD-Scan software version 1.11b, and FinalFit program version 1.11 (NIDEK) was used to create the shot data for CATz treatments. The root-mean-square (RMS) values for total higher order aberrations, total trefoil, total coma, and total spherical aberrations were computed by OPD-Scan and were compared between the two groups. Maximum optical zone of 6.5 mm was used in cases where scotopic pupil diameter was >6.5 mm. The transition zone diameter in the CATz group was between 8 and 9 mm, and in the conventional group, the transition zone was 1.0 to 1.5 mm larger than the scotopic pupil diameter. Scotopic pupil diameters were recorded using the Colvard infrared pupillometer (Oasis Inc, Glendora, Calif). Corneal thickness was measured with the DGH500 ultrasonic pachymeter (DGH Technologies, Exton, Pa). A Moria M2 microkeratome (Moria, Antony, France) was used in all cases using a 130-μm head. Laser ablation was performed using the NIDEK EC-5000 excimer laser upgraded for multipoint ablation.

Follow-up examinations were performed 1 day, 1 week, 1 month, and 3 months postoperatively. Follow-up between weeks 3 and 5 was considered 1-month follow-up and between weeks 10 and 14 was considered 3-month follow-up. At each follow-up, UCVA and best spectacle-corrected visual acuity (BSCVA) were recorded. Subjective response of the patients comparing the night vision in two eyes and glare effect to a single source of light was recorded.[14,15] Complete anterior segment and fundus examinations were performed. Corneal topography and wavefront aberrometry were performed with the OPD-Scan. For aberrometry, small pupils were dilated with 2.5% phenylephrine eye drops in addition to a single drop of 1% tropicamide when needed to complete the seven-ring count within the measurement area.

Patients with significant difference between subjective, cycloplegic, and OPD-Scan refraction were not included for study. Patients with intra- or postoperative complications such as diffuse lamellar keratitis (DLK), significant striae, or epithelial detachment were excluded from the study.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS 10.0.7 for Windows (SPSS Inc, Chicago, Ill). Paired sample *t* test was performed to measure the difference between the two groups with a confidence interval (CI) of 95%. A *P* value of <.05 was considered significant.

RESULTS

Data from 23 patients (16 women and 7 men) were analyzed after excluding 1 patient who developed a spontaneous epithelial detachment in 1 eye before 1-month follow-up and another patient who developed grade I DLK in 1 eye on postoperative day 1. All surgeries

TABLE 1

Pre- and Postoperative Visual Acuity Results at 1 and 3 Months Postoperatively in Eyes That Underwent CATz and Conventional LASIK for Myopia

	Mean±SD (Range)		
Visual Acuity	CATz	Conventional	*P* Value
Preoperative BSCVA	0.97±0.11 (0.6 to 1.2)	0.96±0.11 (0.6 to 1.2)	.604
UCVA at 1 month	1.1±0.16 (0.9 to 1.5)	1.1±0.24 (0.8 to 1.5)	.723
UCVA at 3 months	1.1±0.18 (1 to 1.5)	1.1±0.20 (1 to 1.5)	.552

SD = standard deviation, BSCVA = best spectacle-corrected visual acuity, UCVA = uncorrected visual acuity

TABLE 2

Pre- and Postoperative Refraction at 1 and 3 Months Postoperatively in Eyes That Underwent CATz and Conventional LASIK for Myopia

Manifest Refraction	Sphere (Mean±SD) (Range)	95% CI	Cylinder* (Mean±SD) (Range)	*P* Value
Preoperative				
CATz	−3.14±1.38 (−1.00 to −6.00)	0.472	−0.65±0.70 (0.00 to −2.50)	.892
Conventional	−3.17±1.45 (−0.50 to −6.25)		−0.57±0.60 (0.00 to −2.50)	
1 month				
CATz	0.14±0.27 (1.00 to −0.25)	1.252	−0.17±0.23 (0.00 to −0.75)	.418
Conventional	0.03±0.27 (0.75 to −0.50)		−0.19±0.29 (0.00 to −0.75)	
3 months				
CATz	0.08±0.16 (0.50 to 0.00)	0.561	−0.08±0.16 (0.00 to −0.50)	2.171
Conventional	0.04±0.18 (0.50 to −0.25)		−0.21±0.26 (0.00 to −0.75)	

SD = standard deviation, CI = confidence interval
**Refraction in minus cylinder form.*

were performed by one surgeon (M.A.F.). Mean patient age was 25.3±5.3 years. A total of 21 (92%) patients completed 1-month follow-up and 12 (52%) patients completed 3-month follow-up.

Preoperative spherical refraction in the CATz group was −3.14±1.38 diopters (D) and −3.17±1.45 D in the conventional group. Preoperative mean cylindrical refraction was −0.65±0.7 D in the CATz group and −0.57±0.60 D in the conventional group. Mean preoperative BSCVA was 0.97±0.11 in the CATz group and 0.96±0.11 in the conventional group. Mean scotopic pupil diameter was 6.4±0.62 mm and 6.5±0.74 mm in the CATz and conventional groups, respectively. The differences in preoperative refraction, visual acuity, and pupil diameter were not statistically significant ($P \geq .05$).

At 1- and 3-month follow-up, mean UCVA was 1.1 in both groups (Table 1). Spherical and cylindrical refraction at 1 month was 0.14±0.27 D and −0.17±0.23 D, respectively, in the CATz group and 0.03±0.27 D and −0.19±0.29 D, respectively, in the conventional group. At 3 months, spherical and cylindrical refraction was 0.08±0.16 D and −0.08±0.16 D, respectively, in the CATz group, and 0.04±0.18 D and −0.21±0.26 D, respectively, in the conventional group (Table 2).

At 1 month, night glare was reported to be comparatively higher in the conventional LASIK group, 17 (81%) eyes, whereas 3 (14%) patients had more glare in customized treatment eyes. One (5%) patient stated the glare was the same in both eyes. At 3-month follow-up, 11 (92%) patients stated glare was higher in conventionally treated eyes; no patient reported the glare to be higher in CATz treatment eyes. One (8%) patient reported the glare to be the same in both eyes (Table 3).

Differences in preoperative total higher order aberrations, total coma, total trefoil, and spherical aberrations were not statistically significant ($P \geq .05$) (Table 4). At

TABLE 3

Comparison of Excessive Night Glare From a Single Source of Light at 1 and 3 Months Postoperatively in Eyes That Underwent CATz and Conventional LASIK

Time After Surgery	No. Eyes (%) With Glare: CATz	Conventional	Equal in Both Eyes
1 month (n=21)	3 (14)	17 (81)	1 (5)
3 months (n=12)	0 (0)	11 (92)	1 (8)

TABLE 4

Preoperative Higher Order Aberrations in Eyes That Underwent CATz and Conventional LASIK*

HOA	CATz	Conventional	*P* Value
Total HOA	0.2789±0.1124	0.2863±0.1210	.762
Total coma	0.1655±0.0801	0.1422±0.0687	.239
Total trefoil	0.1985±0.1200	0.2094±0.1264	.682
Spherical	0.0846±0.0494	0.0992±0.0534	.140

HOA = higher order aberrations
**Represented as mean±standard deviation.*

TABLE 5

Higher Order Aberrations at 1 Month Postoperatively in Eyes That Underwent CATz and Conventional LASIK*

HOA	CATz	Conventional	*P* Value
Total HOA	0.3915±0.2860	0.3879±0.1475	.964
Total coma	0.1911±0.1920	0.2293±0.1100	.491
Total trefoil	0.2717±0.2122	0.1929±0.1081	.135
Spherical	0.1011±0.0617	0.1808±0.1214	.004†

HOA = higher order aberrations
**Represented as mean±standard deviation.*
†Statistically significant (<.05).

TABLE 6

Higher Order Aberrations at 3 Months Postoperatively in Eyes That Underwent CATz and Conventional LASIK*

HOA	CATz	Conventional	*P* Value
Total HOA	0.3712±0.1428	0.4533±0.1686	.221
Total coma	0.1522±0.0807	0.2385±0.1008	.029†
Total trefoil	0.2793±0.1557	0.4395±0.5546	.338
Spherical	0.1058±0.0629	0.2381±0.1235	.004†

HOA = higher order aberrations
**Represented as mean±standard deviation.*
†Statistically significant (<.05).

1-month follow-up, no statistically significant difference was noted in total higher order aberration, mean coma, or trefoil between the two groups (*P*=.964, *P*=.491, and *P*=.135, respectively). The mean total spherical aberrations in the conventional group (0.1808) were significantly higher than those in the CATz group (0.1011) (*P*=.004) (Table 5). Three months postoperatively, no statistically significant difference was noted in total higher order aberration and trefoil between the groups. The conventional group had significantly higher mean coma (0.2385) and spherical aberrations (0.2381) at 3 months compared to the CATz group (mean coma 0.1522 and spherical aberrations 0.1058) (*P*=.029 and *P*=.004, respectively) (Table 6).

DISCUSSION

Night vision complaints after LASIK surgery are considerably reduced with the availability of larger optical zones and treatment zones. Macsai et al[16] report that the NIDEK EC-5000 excimer laser with its large optical zone of 6.5 mm and a transition zone 1 mm larger than the scotopic pupil size resulted in reduced incidence of postoperative glare reported by 6.3% of patients at 3 months compared to preoperative glare reported by 31.2% of patients. Glare phenomenon after LASIK was reported to be associated with an increase in postoperative spherical aberrations.[17] Topography-guided and wavefront-guided ablation profiles are expected to give improved visual acuity and better night vision quality. Mastropasqua et al[18] reported in their study of 30 patients who underwent wavefront-guided photorefractive keratectomy (PRK) using the Meditec MEL 70 excimer laser and WASCA work station (Carl Zeiss Meditec, Jena, Germany) in one eye and conventional PRK in the other eye showed no significant difference in the visual outcomes between the two groups. The increase in the higher order aberrations, specifically trefoil, coma, and spherical aberration, was significantly smaller in the wavefront-guided treatment group than the conventional group. Nuijts et al[19] reported marginally lower visual outcome in Bausch & Lomb Zyoptix (Rochester, NY) wavefront-guided treated eyes compared to contralateral Plano-scan treated eyes. In a simultaneous bilateral comparison of wavefront-guided

and conventional LASIK using the Bausch & Lomb Zyoptix platform, Kim et al[20] showed no difference in visual acuity outcomes. The rise in higher order aberrations, such as trefoil, coma, and spherical aberration, were less in wavefront-guided treated eyes than conventionally treated eyes but the differences did not attain statistical significance. The majority of patients preferred the wavefront-treated eyes due to better quality of night vision.[20]

In our study, we compared topography-guided treatment in one eye with conventional treatment in the other eye, and we did not find a difference in visual acuity between the two groups. The night vision quality was better in >80% of eyes with CATz ablation profiles at 1 month and in >95% of patients at 3 months. This better night vision quality appears to be due to significantly lower induction of higher order aberrations seen postoperatively in the customized treatment group than the conventional group. High mean coma at 3 months corresponds with worse night vision in conventionally treated eyes. The NIDEK FinalFit software and CATz treatment provided reliably accurate visual outcome and better night vision quality. The goal of routinely achieving superior objective and subjective vision following customized corneal LASIK requires more research involving the relationship between corneal higher order aberrations and internal or lenticular higher order aberrations,[21] as well as consideration of the role of corneal biomechanical adjustments.[22] More studies with longer follow-up are needed to evaluate corneal response to customized ablation.

REFERENCES

1. Schein OD, Vitale S, Cassard SD, Steinberg EP. Patient outcome of refractive surgery: the refractive status and vision profile. *J Cataract Refract Surg*. 2001;27:665-673.
2. Hersh PS, Steinert RF, Brint SF. Photorefractive keratectomy versus laser in situ keratomileusis: comparison of optical side effects. *Ophthalmology*. 2000;107:925-933.
3. Pop M, Payette Y. Risk factor for night vision complaint after LASIK for myopia. *Ophthalmology*. 2004;111:3-10.
4. Bailey MD, Mitchell GL, Dhaliwal DK, Boxer Wachler BS, Zadnik K. Patient satisfaction and visual symptoms after laser in situ keratomileusis. *Ophthalmology*. 2003;110:1371-1378.
5. McGhee CN, Craig JP, Sachdev N, Weed KH, Brown AD. Functional, psychological and satisfaction outcomes of laser in situ keratomileusis for high myopia. *J Cataract Refract Surg*. 2000;26:497-509.
6. Jabbur NS, Sakatani K, O'Brien TP. Survey of complications and recommendations for management in dissatisfied patients seeking a consultation after refractive surgery. *J Cataract Refract Surg*. 2004;30:1867-1874.
7. Lackner B, Pieh S, Schmidinger G, Hanselmayer G, Dejaco-Ruhswurm I, Funovics MA, Skorpik C. Glare and halo phenomenon after laser in situ keratomileusis. *J Cataract Refract Surg*. 2003;29:444-450.
8. Guell JL, Pujol J, Arjona M, Diaz-Douton F, Artal P. Optical Quality Analysis System (OQAS): instrument for objective clinical evaluation of ocular optical quality. *J Cataract Refract Surg*. 2004;30:1598-1599.
9. Fan-Paul NI, Li J, Miller JS, Florakis GJ. Night vision disturbances after corneal refractive surgery. *Surv Ophthalmol*. 2002;47:533-546.
10. Malecaze FJ, Boulanouar KA, Demonet JF, Guell JL, Imbert MA. Abnormal activation in the visual cortex after corneal refractive surgery for myopia: demonstration by functional magnetic resonance imaging. *Ophthalmology*. 2001;108:2213-2218.
11. Wilson SE. Wave-front analysis: are we missing something? *Am J Ophthalmol*. 2003;136:340-342.
12. Oshika T, Miyata K, Tokunaga T, Samejima T, Amano S, Tanaka S, Hirohara Y, Mihashi T, Maeda N, Fujikado T. Higher order wavefront aberrations of cornea and magnitude of refractive correction in laser in situ keratomileusis. *Ophthalmology*. 2002;109:1154-1158.
13. Mrochen M, Kaemmerer M, Mierdel P, Seiler T. Increased higher order optical aberrations after laser refractive surgery: a problem of subclinical decentration. *J Cataract Refract Surg*. 2001;27:362-369.
14. Carlsson L, Knave B, Lennerstrand G, Wibom R. Glare from outdoor high mast lighting: effect on visual acuity and contrast sensitivity in comparative studies of different floodlighting systems. *Acta Ophthalmol Suppl*. 1984;161:84-93.
15. El Danasoury MA. Prospective bilateral study of night glare after laser in situ keratomileusis with single zone and transition zone ablation. *J Refract Surg*. 1998;14:512-516.
16. Macsai MS, Stubbe K, Beck AP, Ravage ZB. Effect of expanding the treatment zone of the Nidek EC-5000 laser on laser in situ keratomileusis outcomes. *J Cataract Refract Surg*. 2004;30:2336-2343.
17. Chalita MR, Chavala S, Xu M, Krueger RR. Wavefront analysis in post-LASIK eyes and its correlation with visual symptoms, refraction and topography. *Ophthalmology*. 2004;111:447-453.
18. Mastropasqua L, Nubile M, Ciancaglini M, Toto L, Ballone E. Prospective randomized comparison of wavefront guided and conventional photorefractive keratectomy for myopia with the Meditec MEL 70 laser. *J Refract Surg*. 2004;20:422-431.
19. Nuijts RM, Nabar VA, Hament WJ, Eggink FA. Wavefront-guided versus standard laser in situ keratomileusis to correct low to moderate myopia. *J Cataract Refract Surg*. 2002;28:1907-1913.
20. Kim T, Yang S, Tchah H. Bilateral comparison of wavefront-guided versus conventional laser in situ keratomileusis with Bausch and Lomb Zyoptix. *J Refract Surg*. 2004;20:432-438.
21. Mrochen M, Jankov M, Bueeler M, Seiler T. Correlation between corneal and total wavefront aberrations in myopic eyes. *J Refract Surg*. 2003;19:104-112.
22. Roberts C. Biomechanics of the cornea and wavefront-guided laser refractive surgery. *J Refract Surg*. 2002;18:S589-S592.