Effect of excimer laser repetition rate on outcomes after photorefractive keratectomy

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PURPOSE: To compare the refractive outcomes after photorefractive keratectomy (PRK) for low to moderate myopic corrections using 2 excimer lasers with different repetition rates (200 Hz and 400 Hz).

SETTING: University refractive surgery center.

METHODS: This retrospective study included all consecutive patients who underwent PRK using the 200 Hz or the 400 Hz Allegretto laser platform (WaveLight Laser Technologie AG). Thirty-five patients (70 eyes) and 29 patients (58 eyes) had PRK with the 200 Hz platform and the 400 Hz platform, respectively, using the same surgical technique.

RESULTS: The mean follow-up was 13.22 months ± 1.16 (SD) (range 11 to 15 months). No intraoperative or early postoperative (eg, late reepithelialization) complications were found in either group. At 1 year, 66 eyes (94.2%) in the 200 Hz group and 56 eyes (96.6%) in the 400 Hz group were within ±1.00 diopter of the attempted correction. At 3 months, 20 eyes (29%) in the 200 Hz group and 27 eyes (46%) in the 400 Hz group had mild or moderate corneal haze ($P = .03$). These corneas showed progressive clearing over subsequent months without statistically significant differences in haze formation between the 2 groups. Twelve months after PRK, all corneas in both groups were clear.

CONCLUSION: Photorefractive keratectomy for the treatment of low to moderate refractive errors using a 200 Hz or 400 Hz excimer laser gave comparable results.

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Excimer laser refractive surgery has become a common medical practice around the world. Improvements in excimer laser technology have led to reproducible and safe results. The improvements include the introduction of highly sophisticated tracking systems,[1] a decreased laser-beam spot size,[2] linking of laser platforms with topography and wavefront analyzer systems,[3] and an increased repetition rate.[4]

Photorefractive keratectomy (PRK) was the first widely used refractive procedure. Although alternatives such as laser in situ keratomileusis (LASIK) have been introduced,[5,6] PRK remains an excellent option for the correction of low to moderate myopia.[7] The main drawback of PRK is haze formation, which is the result of excessive corneal healing after surgery.[8–10] Several studies correlate post-PRK haze formation with high attempted corrections,[11] small ablation zones,[12] and individual predisposing factors to an abnormal corneal healing process.[13]

The purpose of this study was to evaluate retrospectively the refractive outcomes after PRK using 2 excimer lasers with different repetition rates (200 Hz and 400 Hz).

PATIENTS AND METHODS

Patient Population

This retrospective study included all consecutive patients who had PRK using the 200 Hz or the 400 Hz

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Allegretto laser platform (WaveLight Laser Technologie AG) between February 2004 and January 2006. Inclusion criteria were myopia less than −5.50 diopters (D) with astigmatism less than 1.00 D, attempted optical treatment zone 6.5 mm, and age between 18 and 50 years.

Sixty-four patients (128 eyes) were included in this study. Thirty-five patients (70 eyes) had PRK with the 200 Hz Allegretto excimer laser and 29 patients (58 eyes), with the 400 Hz Allegretto excimer laser. All PRK procedures were performed by the same surgeon (I.G.P.) using the same surgical technique.

Clinical Examination

A complete ophthalmic examination was performed preoperatively in all patients. The examination included manifest refraction, cycloplegic manifest refraction, corneal topography, central corneal pachymetry (50 MHz Corneo-Gage, Sonogage, Inc.), and biomicroscopy. Patients with signs of ocular disease such as active anterior segment disease, previous intraocular or corneal surgery, a history of herpes keratitis, a diagnosis of autoimmune disease, systemic connective tissue disease or atopic syndrome, or corneal topographic findings suspicious for keratoconus were excluded.

All patients were appropriately informed of risks and benefits before surgery, and all gave written informed consent in accordance with institutional guidelines and the Declaration of Helsinki.

Surgical Technique

Two minutes after topical corneal anesthesia was administered, mechanical epithelial debridement of the central 7.5 mm of the cornea (previously marked with a 7.5 mm epithelial trephine) was performed using a rotating soft brush. This was followed by myopic photoablation using the 200 Hz Allegretto laser or the 400 Hz Allegretto laser. No adjuvant mitomycin-C was applied.

At the end of the procedure, all patients received tobramycin and dexamethasone (TobraDex) 4 times daily for 4 days and diclofenac sodium 0.1% (Denaclof) 4 times a daily for 2 days. A bandage soft contact lens (Night and Day, Ciba Vision Corp.) was kept in place until full corneal reepithelialization. After reepithelialization, patients were treated with fluorometholone sodium 2% (FML) 4 times daily for 4 weeks. The corticosteroid was tapered by 1 drop each week. No additional steroid drops were prescribed in patients with haze formation.

Follow-up Examinations

Patients were monitored daily until complete epithelial healing. At the time of reepithelialization, the therapeutic contact lenses were removed. Preoperative and postoperative (at 1, 3, 6, and 12 months) follow-up included uncorrected visual acuity (UCVA) (Snellen), best spectacle-corrected visual acuity (BSCVA) (Snellen), manifest refraction, corneal topography, complications, and subjective symptoms.

Anterior stromal haze was graded subjectively during slitlamp biomicroscopy and reported as 1 of 5 standardized categories: clear (grade 0), trace (haze seen only by indirect broad tangential illumination, grade 0.5), mild (haze with minimal density seen with difficulty with direct and diffuse illumination, grade 1), moderate (haze easily visible with direct focal slit illumination, grade 2), marked (haze markedly obscuring iris detail, grade 3), and severe (completely opaque stroma in the area of ablation that completely obscures the details of intraocular structures, grade 4).[14]

Statistical Analysis

Results are presented as mean ± SD. To test possible relationships between the 2 laser systems and the haze effect, contingency tables and chi-square statistics were used. A P value less than 0.05 was considered statistically significant.

RESULTS

The mean age of the 26 men and 38 women was 29.85 ± 6.13 years (range 19 to 47 years). The mean follow up was 13.22 ± 1.16 months (range 11 to 15 months). The mean preoperative corneal pachymetry was 540.19 ± 35.32 µm (range 473 to 599 µm) in the 200 Hz group and 539.95 ± 35.32 (range 453 to 606 µm) in the 400 Hz group. The mean spherical equivalent (SE) attempted correction was −2.93 D ± 1.16 (SD) (range −5.25 to −0.88 D) and −2.89 ± 1.04 D (range −5.13 to −0.63 D), respectively (P = .77). The mean stromal ablation, calculated based on the laser's algorithm, was 44.33 ± 18.06 µm (range 13 to 79 µm) in the 200 Hz group and 43.45 ± 15.55 µm (range 9 to 77 µm) in the 400 Hz group.

Predictability

The predictability for both lasers was defined by the achieved to attempted correction SE at 12 months. At this time, 66 eyes (94.2%) in the 200 Hz group and 56 eyes (96.6%) in the 400 Hz group were within ±1.00 D of the attempted correction. The mean predictability was 0.21 ± 0.49 D (range −1.00 to 1.75 D) and 0.29 ± 0.36 D (range −0.50 to 1.50), respectively (Figure 1).

Visual Outcomes

The mean UCVA improved significantly in all eyes in both groups (preoperative, counting fingers to 20/40; last follow-up, 20/40 to 20/10). Fifty-six eyes (80%) in the 200 Hz group and 48 eyes (83%) in the 400 Hz group had a UCVA of 20/20 or better at the last follow-up examination. The BSCVA remained unchanged or improved in all eyes in both groups. In the 200 Hz group, 64 eyes (91%) had unchanged BSCVA and 6 eyes gained 1 to 2 lines. In the 400 Hz group, 54 eyes (93%) had unchanged BSCVA and 4 eyes gained 1 to 2 lines.

Adverse Effects and Postoperative Complications

No intraoperative complications (eg, delayed epithelial healing or infections) occurred in either group. One month postoperatively, 22 eyes (31%) in the 200 Hz group and 20 eyes (34%) in the 400 Hz group had mild (grade 1) corneal haze (P = .43) (Table 1).

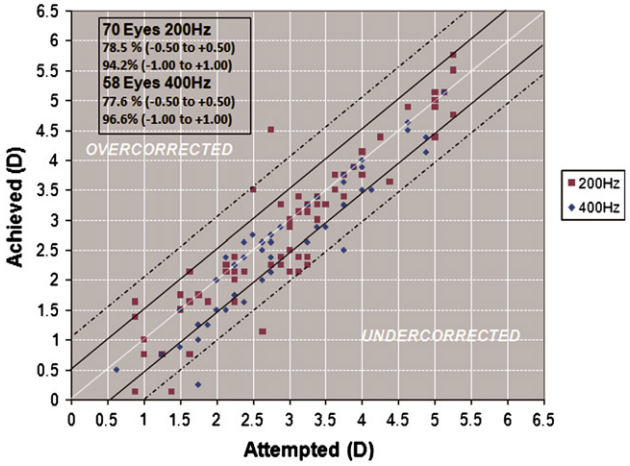

Figure 1. Predictability scattergram showing achieved versus attempted refractive correction at 12 months.

At 3 months, 20 (29%) and 27 eyes (46%), respectively, had mild (grade 1) or moderate (grade 2) corneal haze ($P = .03$). Corneas with reported haze showed progressive clearing over subsequent months, and there were no statistically significant differences in haze formation at 6 months (12 eyes [17%] in the 200 Hz group versus 15 eyes [26%] in the 400 Hz group) ($P = .17$). At 12 months, all corneas in both groups were clear. Except for haze formation, no adverse effects were observed in any patient in either group.

DISCUSSION

The demand for satisfactory, repeatable, and safe results after refractive surgery has led to the development of several new laser platforms. The trends of modern lasers are to increase the repetition rate, decrease the laser spot size, and improve the delivery systems. This study examined the outcomes of 2 excimer lasers (after myopic PRK for low to moderate myopia) with different repetition rates.

Table 1. Mean haze rate in the 2 groups during the follow-up.

	Mean Haze Grade, n (%)				
Postop Period/Group	0 to 0.5	1	2	3	4
1 month					
200 Hz group*	48 (69)	22 (31)	0	0	0
400 Hz group†	38 (66)	20 (34)	0	0	0
3 months					
200 Hz group	50 (71)	14 (20)	6 (9)	0	0
400 Hz group	31 (54)	17 (29)	10 (17)	0	0
6 months					
200 Hz group	58 (83)	10 (14)	2 (3)	0	0
400 Hz group	43 (74)	12 (21)	3 (5)	0	0
12 months					
200 Hz group	70 (100)	0	0	0	0
400 Hz group	58 (100)	0	0	0	0

*n = 70
†n = 58

According to the manufacturer's specifications, the difference in the repetition rate between the 2 lasers in this study is 200 Hz; the order of magnitude is ×2 (200 Hz and 400 Hz). Even though both lasers integrate flying-spot technology to avoid thermal loading of the cornea,[15] increasing the ablation rate over a certain threshold could eliminate the advantage of the flying spot.

In the current study, both lasers had comparable results for low to moderate myopic correction by PRK. No significant difference in predictability was found between the lasers. At the 3-month postoperative examination, there was a statistically significant difference in the incidence of haze, which normally reaches its maximum level between the second and third month.[16] Eyes that had PRK using the 400 Hz laser platform had a 46% incidence of mild to moderate haze, whereas eyes that had PRK using the 200 Hz laser platform had a 29% incidence. This finding could be explained by the differences in induced corneal thermal effect by the 2 lasers. Thermal loading of the cornea during PRK and other factors have been implicated in the etiology of haze formation.[17] Many studies in the literature report a temperature rise during photoablation.[17,18] In general, it appears as though the tissue immediately adjacent to the excimer photoablation increases in temperature to about 40°C.[19] Elevation of the corneal stromal temperature to this level may be responsible for denaturation of adjacent collagen tissue and explain, in part, pseudomembrane formation, decreased corneal clarity, and development of haze after PRK.[19]

Based on these findings, cooling the cornea may reduce the thermal consequences of PRK.[20–24] Furthermore, excimer lasers with adjustable repetition rates according to treatments (case by case) in the future will likely reduce the incidence of haze formation after PRK. In contrast, for LASIK treatments, an increased repetition rate seems crucial in maintaining corneal hydration and minimizing external influences during surgery, especially in high attempted corrections.

Despite the differences in haze formation in our 2 study groups, no statistically significant differences were found in the final refractive outcome. All eyes in both groups had a clear cornea at the 1-year follow-up examination. It seems that the possible effect of the excimer repetition rate in haze formation after PRK does not have a significant clinical impact in low to moderate myopic corrections. With higher attempted corrections, the repetition rate could have an effect on haze formation and final outcomes.

Our study is limited by the small sample of eyes included, the retrospective nature of its design, the lack of high attempted corrections, the possible idiopathic predisposition of individual patients to haze formation, and the additional repetition rate differences (eg, laser spot size) between the 2 excimer lasers.

In conclusion, PRK using the 200 Hz or the 400 Hz laser platform had good predictability and safety up to 1 year of follow-up without progressive time-dependent sight-threatening complications. Future prospective comparative randomized contralateral studies with more patients and higher attempted corrections are needed to elucidate the possible impact of the excimer laser repetition rate on PRK refractive outcomes.

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