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Comparison of Corneal Centering in Photorefractive Keratectomy

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The present study compares three centering methods for excimer laser photorefractive keratectomy (PRK, VISX 20/20™) by analyzing the corneal topography. The subjects were grouped according to three different centering methods used in the procedure: an ablation using a light reflex from the patient's cornea pursued by both eyes of the surgeon (Group 1, n=49); an ablation using a red light reflex from the patient's cornea pursued by the surgeon's left eye only while the right eye remained closed (Group 2, n=27); an ablation using the patient's center of the pupil pursued by the surgeon's left eye only while the right eye remained closed (Group 3, n=21). The mean distance from the center of ablation zone to the center of the pupil were; 0.69±0.45 mm for Group 1, 1.05±0.48 mm for Group 2 and 0.63±0.28 mm for Group 3. The degree of deviation in Group 2 was significantly greater than in Group 1 or Group 3. The deviation was greater in the right eyes than the left eyes in Group 2 only. The decentration of the right eye in Group 2 was due to angle Kappa with misalignment of the fixation light and viewing tube containing reticule.

Key Words: Centering method, photorefractive keratectomy, topography

Proper centering of the surgical zone on the cornea is important in corneal refractive surgery (Steinberg and Waring, 1983; Uozato and Guyton, 1987; Cavanaugh *et al.*, 1993a; Cavanaugh *et al.*, 1993b; Spadea *et al.*, 1993; Amano *et al.*, 1994; Casebeer, 1995). An improper centering of the surgical zone may produce glares, a decreased best-corrected visual acuity and decreased contrast sensitivity (Steinberg and Waring, 1983; Uozato and Guyton, 1987; Casebeer, 1995).

In radial keratotomy where the optic zone is as small as 3~4 mm in diameter, the importance of the proper centering methods has been emphasized (Steinberg and Waring, 1983; Uozato and Guyton, 1987). Various centering methods have been suggested for the microscope during corneal surgical procedures (Steinberg and Waring, 1983; Uozato and Guyton, 1987; Casbeer, 1995). The targets used for the centering have included a corneal light reflex of the microscope illumination filament, a corneal light reflex of the fixation light of the centering device and the center of the pupil entrance.

In photorefractive keratectomy (PRK), the optic zone involved is comparatively wider at 5~6 mm in diameter and the proper centering method has been less emphasized than in refractive keratotomy. An eccentric ablation in PRK, however, is nevertheless undesirable (Uozato and Guyton, 1987). As

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for the VISX 20/20^{TM} system, the red fixation light is placed between and inferior to the two viewing tubes (Fig. 1). The reticule for the surgeon to aim at the target with an excimer laser is attached only in one viewing tube, either left or right. Since the fixation light, the excimer laser emission beam and the viewing tube containing reticule do not coincide in-line, the center of the ablation zone can be decentered (Uozato and Guyton, 1987).

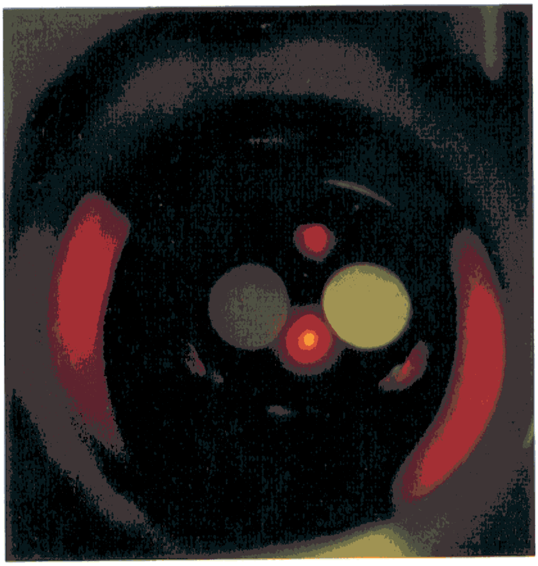

Fig. 1. The red fixation light is located in the middle and inferior to the two viewing tubes.

In the early days of PRK, the authors used the light reflex of the red fixation light as a target for the convenience of the procedure. After experiences were gained, we changed the target of centering twice in a trial of better centering. The purpose of this study was to compare the results of three different centering methods in PRK using the VISX 20/20^{TM} system through a topography analysis in order to evaluate the accuracy of each centering method.

MATERIALS AND METHODS

Ninety-seven patients with myopia were treated with PRK by a single surgeon (E. K. Kim) between Jan/1993 and Aug/1995 at Severance hospital following informed consent. All subjects had myopia

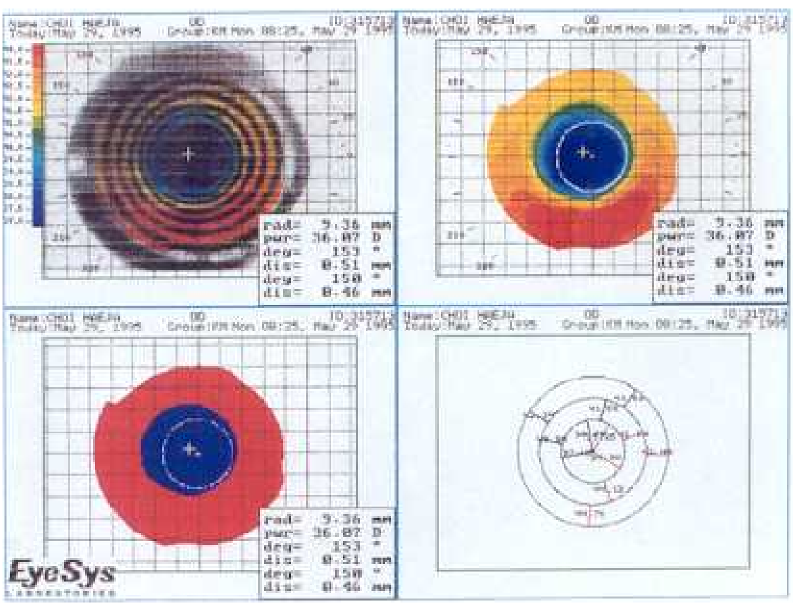

Fig. 2. The whole ablated zone was outlined and the computer "+" sign was moved to the center of the ablation zone for measuring the distance from the center of the pupil(left bottom).

of less than −15 diopters (D). The refractive surgery and topography were performed in natural, non-medicated pupils, since medications used for dilating or constricting the pupil may shift its center in some instances (Fay *et al.*, 1992). The VISX 20/20™ system (Ver. 2.7, VISX Inc., Sunnyvale, CA, U.S.A.) used in this study was set with a 6 mm diameter ablation zone. The laser beam was aligned to share the target with the center of the reticule attached in the left viewing tube. During the ablation procedure, the patients were told to observe the red fixation light, which is located between and inferior to the two viewing tubes of the microscope (Fig. 1). The eye not to be ablated was patched throughout the procedure.

PRK was performed with the laser beam focused at the surface of the cornea in three different ways as follows: In Group 1, the ablation was performed with the surgeon using both eyes to pursue the red corneal light reflex of the patient. In Group 2, the ablation was performed using the surgeon's left eye only in order to pursue the red corneal light reflex while the surgeon's right eye remained closed. In Group 3, the surgeon used his left eye only to pursue the center of the pupil while the surgeon's right eye remained closed.

Topography was performed with EyeSys Corneal Analysis System™ (EyeSys Laboratories, Houston, TX, U.S.A.) before and 2~6 months after surgery. The whole ablation zone was outlined with the software provided by the system (Fig. 2, left bottom). With the large cursor placed at the ablation center, the distances from the center of the ablation zone to the center of the pupil were recorded directly from the legend in both millimeters and meridian degrees (Fig. 2, left bottom). All measurements were performed by one of the authors (J. W. Jang.) and were repeated by a second observer. The collected data were statistically analyzed using Student's *t* tests and ANOVA. A p-value of less than 0.05 was considered statistically significant for this study.

Table 1. Characteristics of each group

	Group 1 (n=49)	Group 2 (n=27)	Group 3 (n=21)
Male	14	11	9
Female	35	16	12
Right eye	33	18	9
Left eye	16	9	12

RESULTS

The distribution of the patients in each group is outlined in Table 1. Mean age among the three groups showed no statistical difference. There was also no statistical difference in the mean attempted corrections (spherical equivalent) among the three groups ($p > 0.05$, Table 2). The mean distance from the center of the ablation to the center of the pupil in each group was; 0.69±0.45 mm for Group 1, 1.05±0.48 mm for Group 2, and 0.63±0.28 mm for Group 3. The degree of deviation from the center of the pupil in Group 2 was significantly greater than that of Group 1 and Group 3 ($P < 0.05$, respectively) (Table 3).

In a comparison between right and left eyes in the mean distance from the center of the ablation zone to the center of the pupil, the degree of deviation in right eyes was significantly greater than that of left eyes in Group 2 only ($p < 0.05$).

Table 2. Clinical data of patients

	Age (years)	S.E. (Diopters)	Ast (Diopters)
Group 1	28.3±6.4	9.01±2.83	1.34±0.80
Group 2	30.6±7.9	8.42±2.76	1.50±0.97
Group 3	28.6±7.7	8.60±2.81	1.41±1.15

S.E.: corrected spherical equivalent, Ast: corrected astigmatism

Table 3. The mean distance of the center of the ablation zone from the pupillary center in each group

	Distance(mm)
Group 1	0.69±0.45†
Group 2	1.05±0.48
Group 3	0.63±0.28†

†: $p < 0.05$ compared to Group 2

Table 4. The mean distance of the center of the ablation zone from the pupillary center in right and left eyes

	Right eye (mm)	Left eye (mm)
Group 1		0.56±0.32
Group 2†		0.76±0.17
Group 3		0.65±0.29

†: The degree of deviation was significantly greater in right eyes than in left eyes in Group 2 ($p<0.05$).
†: The degree of deviation in Group 2 was significantly greater than in Group 1 and Group 3 ($p<0.05$).

In the right eye group, the deviation was greater in Group 2 compared to Groups 1 and 3 ($p<0.05$) (Table 4). In the left eye group, no significant difference was noted among the three groups.

In all three groups, the direction of deviation of the center of the ablation zone was superior to the center of the pupil (Table 5).

Table 5. Meridian degrees of the center of the ablation zone from the pupillary center

	Right eyes °)	Left eyes (°
Group 1	120.0±110.7	123.8±73.7
Group 2	85.5±123.7	67.0±25.4
Group 3	55.6±22.7	98.3±48.9

°: degrees

DISCUSSION

In keratorefractive surgery, targets for centering of the optical zone including the light reflex from several devices and the center of the entrance pupil have been used (Steinberg and Waring, 1983; Uozato and Guyton, 1987; Casebeer, 1995). In the early days of PRK, the authors chose the light reflex as an ablation target because it was easy and the haziness of the dried and ablated corneal surface bothered the inexperienced surgeon. The authors subsequently used binocular viewing for targeting because it was relatively easy and convenient to pursue the light reflex (Group 1). Later we changed to left monocular viewing in the belief that more accuracy could be obtained by aiming the target with only the viewing tube that contains the reticule (Group 2). After much experiences with PRK, the authors introduced the concept of the pupil entrance for aiming the target (Group 3).

In similar previous studies, the mean distances from the center of the ablation zone to the center of the pupil had been reported from 0.36 to 0.78 mm (Cavanaugh *et al.*, 1993a; Cavanaugh *et al.*, 1993b; Spadea *et al.*, 1993; Amano *et al.*, 1994). The data in this study, except for the right eyes in Group 2, were similar to previous studies (Table 3, 4). The right eyes in Group 2 showed significantly greater decentration than the left eyes in the same group (Table 4).

It is generally accepted that corneal intersection of the light reflex is located more nasally than the line of sight on the corneal surface (positive angle Kappa) in most myopic eyes (Uozato and Guyton, 1987). Targeting the light reflex of the myopic cornea in the VISX 20/20™ system with the reticule in the left viewing tube-only would produce more centering error in right eyes than in left eyes (Uozato and Guyton, 1987). The data for the right eyes in Group 2 showed the effect of the positive angle Kappa combined with the misalignment of the fixation light and viewing tube containing the reticule.

Although the aiming reticule is located in the left viewing tube and the light reflex is used as the target in Group 1 and Group 2, the amount of deviation in Group 1 was less than in Group 2. This may be due to the retinal rivalry in Group 1. There was no statistically significant difference between the data of Group 1 and Group 3. The data in Group 3, however, showed less standard deviation than in Group 1, suggesting that an excessive deviation of the center of the ablation zone can be prevented by using the center of the pupil entrance for aiming.

The proceeding results suggest that pre-marking the cornea corresponding to the center of the pupil entrance and using it as the target may be effective in improving the centering in PRK. Improvements in the technology they apply to the surgical system for coaxing the fixation target, aperture of the laser beam and surgeon's viewing tube may also be required.

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