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CLINICAL STUDY

Comparison of the topographic ablation zone after photorefractive keratectomy for myopia using two different excimer lasers

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Abstract

Purpose To compare the topographic features of eyes treated with photorefractive keratectomy (PRK) for myopia using two different excimer lasers.
Methods A total of 65 eyes in 39 patients treated with PRK (6.0-mm optical zone) using Technolas 217C and VISX S4 excimer lasers were evaluated retrospectively to determine the size of the topographic ablation zone.
Results The zones ablated using the VISX S4 had shorter diameters in both axes (-0.89 ± 0.73, -1.59 ± 0.49 mm; both $P = 0.00$), whereas those ablated using the Technolas 217C had a longer diameter in the major axis (0.96 ± 0.63 mm; $P = 0.00$) and a shorter diameter in the minor axis (-0.39 ± 0.59 mm; $P = 0.00$). The theoretical ablated zone was a circle with a diameter of 6.0 mm. The Technolas 217C group tended to have oval cuts in comparison with the VISX S4 group, and the difference between the programmed (6.0 mm) and topographic diameters was significant in both groups.
Conclusions There was a difference between the programmed and postoperative topographic diameters of the ablation zone. The postoperative ablation zone differed in shape and size according to the type of excimer laser.
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Keywords: corneal topography; photorefractive keratectomy; excimer lasers; myopia; theoretical ablation zone; size of ablation zone

Introduction

Photorefractive keratectomy (PRK) and laser *in situ* keratomileusis (LASIK) can correct myopia and myopic astigmatism.[1–4] Despite the high success rate, decreased vision, such as glares or halos, in a dark environment can occur in patients undergoing excimer laser refractive surgery. Many studies have explained this phenomenon using the disparity between the scotopic pupil size and the optical zone,[5–7] although some studies have found no correlation between the scotopic pupil size and night vision complaints.[8,9] As the expanding transition zone may decrease night vision complaints,[8] in addition to the programmed optical zone and preoperative scotopic pupil size, the size of the transition peripheral zone should be considered previously to identify the cause of night vision problems.

The ablation zone tends to be smaller than the programmed ablation zone after refractive surgery. Recent reports suggest that the difference between the programmed and actual diameters of the optical zone also depends on the type of excimer laser system.[10,11] This difference prevents one from obtaining the best postoperative result, despite selecting an appropriate optical zone. This study evaluated the characteristics and differences of the topographic ablation zones produced using two different excimer laser systems and assessed the difference between the programmed and postoperative topographic diameters with each system.

Patients and methods

A retrospective analysis was made of 65 eyes in 39 patients who were diagnosed with myopia

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or myopic astigmatism and underwent PRK. The operations were performed using a Technolas 217C excimer laser in 34 eyes in 20 patients at Ajou University Hospital (by J Ahn) and using a VISX STAR S4 laser with an EK fixation device[12] in 31 eyes in 19 patients at Severance Hospital (by EK Kim). Eyes with previous ocular surgery, underlying ocular or systemic disease, a programmed optical zone other than 6.0 mm, significant postoperative corneal haze, or a postoperative uncorrected visual acuity (UCVA) of less than 20/25 were excluded from this study.

The programmed ablation zone was 6.0 mm. We defined the programmed ablation zone as the ablation zone diameter determined by the operator, not the ablation zone calculated by the excimer laser machines. Therefore, the programmed ablation zone was fixed at a 6.0 mm diameter, excluding the transition or blending zones.

All eyes underwent corneal topography using an Orbscan II (Bausch and Lomb) at the preoperative evaluation and at 3 months postoperatively, and a difference map between the pre- and postoperative anterior tangential maps was obtained using a program in Orbscan II (Bausch and Lomb). According to several studies that determined ablation centration based on the corneal topography,[13–15] the ablation zone on corneal topography was defined as the area including the blue central circle surrounded by the green area (Figure 1). Using the method described by Coorpender *et al*,[16] a transparent grid was placed on the difference map. Then, the lengths of the topographic ablation zone were measured at the zone of lowest curvature on the difference map (confluent blue zone). We defined the longest and shortest diameters as the major and minor axes, respectively.

We compared the two axes of the topographic ablation zone with the programmed ablation zone diameter (6.0 mm) in the Technolas 217C and VISX STAR S4 laser groups (Figure 2). In addition, we compared the two axes of the postoperative topographic ablation zone between the two different laser systems.

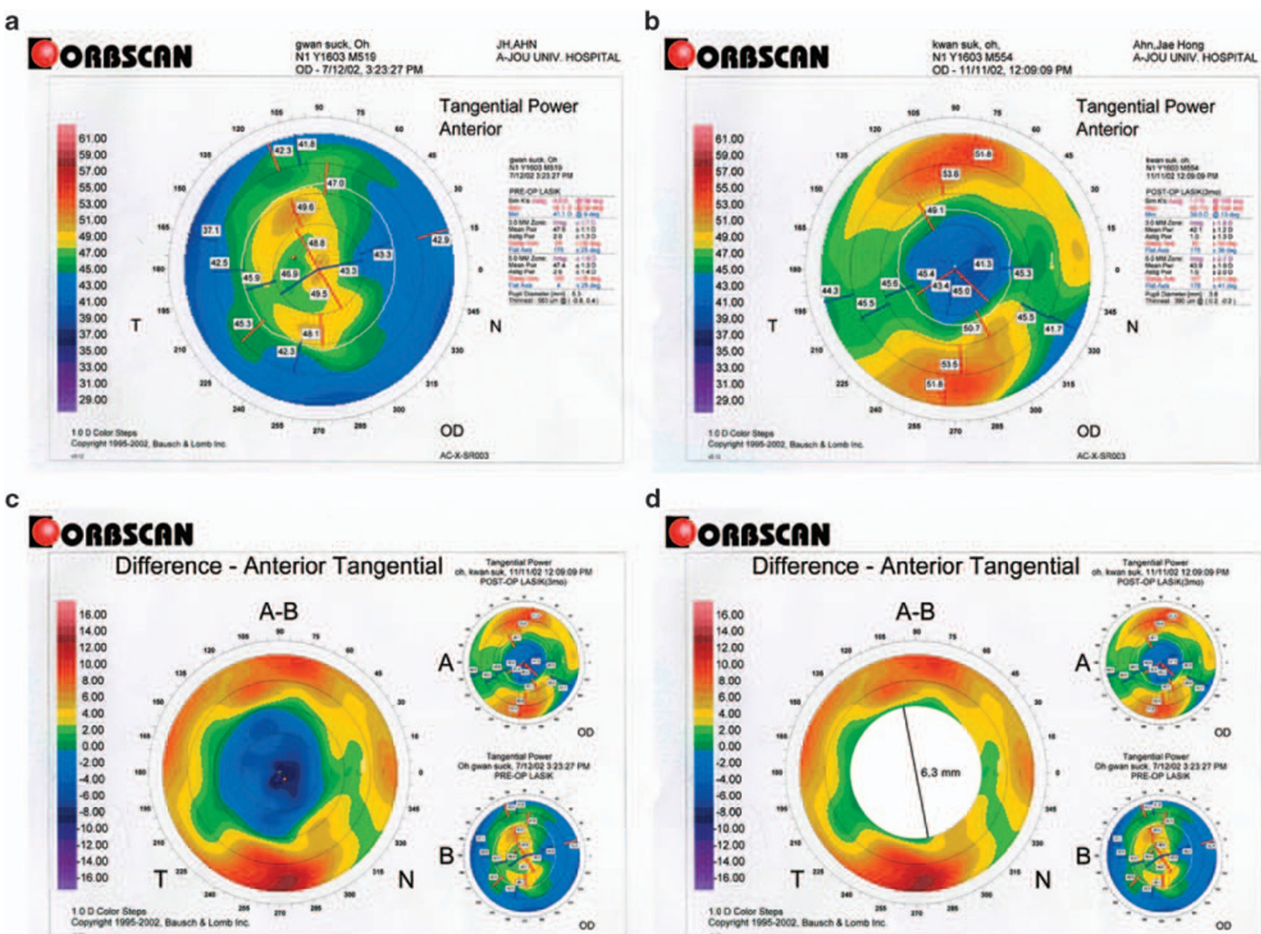

Figure 1 Maps used to calculate the postoperative topographic optical zone (1 D colour steps): (a) Preoperative anterior tangential map; (b) Postoperative anterior tangential map; (c) Map of the difference between (a) and (b); and (d) Calculating the optical zone diameter.

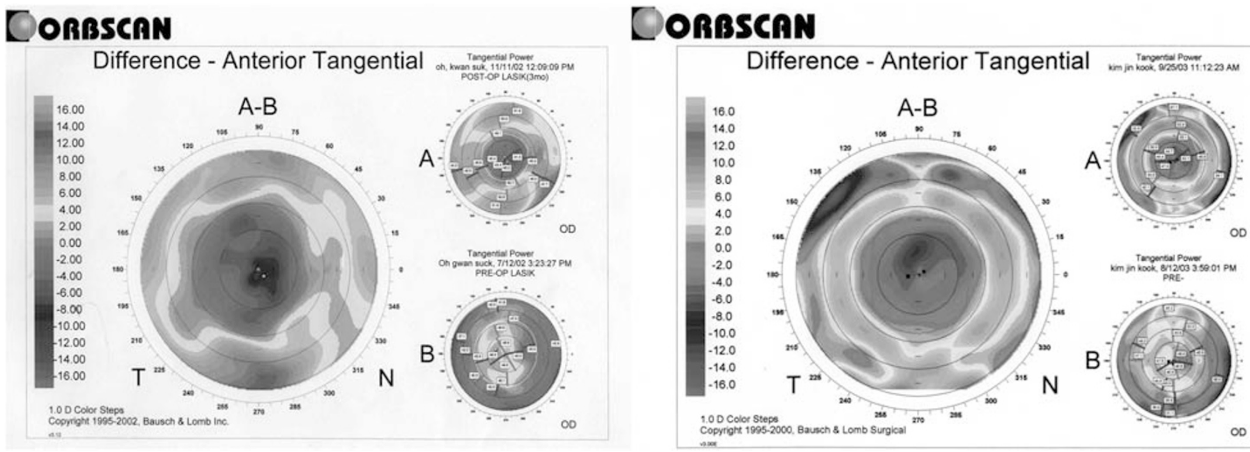

Figure 2 Difference maps for the Technolas 217C (left) and VISX STAR S4 (right) laser systems, created using Orbscan II corneal topography (1 D colour steps). The ablation zone was defined as the central confluent blue zone surrounded by the green area. In the Technolas 217C difference map (left), the long axis length was 6.4 mm, and the short axis length was 5.1 mm. In the VISX STAR S4 difference map (right), the long axis length was 4.4 mm, and the short axis length was 3.9 mm.

Table 1 Comparison of the two groups

	Technolas 217C	*VISX STAR S4*	P *value*
Age (years)	28.60 ± 4.78	27.93 ± 8.45	0.613
Preoperative spherical equivalent (D)	−4.47 ± 0.69	−4.49 ± 1.31	0.862
Postoperative uncorrected visual acuity	0.98 ± 0.07	0.98 ± 0.06	0.954

Statistical analysis was performed using SPSS 12.0, and $P < 0.05$ was considered statistically significant. An independent sample *t*-test was used to compare the programmed and topographic ablation zones in each group and between groups. The Pearson's correlation test was used to evaluate the relationship between the spherical equivalent and the topographic ablation zone diameter.

Results

The mean age of the patients was 28.6 ± 4.78 years (mean ± SD) in the Technolas group and 27.9 ± 6.45 years in the VISX S4 group. The mean preoperative spherical equivalents were −4.47 ± 0.69 (−5.88 to −3.00) and −4.49 ± 1.31 (−6.50 to −1.25) dioptres (D) in the Technolas and VISX S4 groups, respectively. The mean postoperative UCVA values were 0.98 ± 0.07 and 0.98 ± 0.06, respectively. The mean age, mean preoperative spherical equivalent, and postoperative UCVA did not differ between the two groups (Table 1).

There was a significant difference in the size of the ablation zone programmed preoperatively *vs* that measured postoperatively at the 3-month follow-up between the excimer laser systems. The major and minor diameters of the postoperative ablation zone were both shorter than the programmed ablation zone diameter in the VISX Star S4 group (−0.89 ± 0.73 and −1.59 ± 0.49 mm), whereas the major axis was longer (0.96 ± 0.63 mm) and the minor axis was shorter (−0.39 ± 0.59 mm) than those of the programmed ablation zone in the Technolas 217C group (Table 2). The major diameter of the postoperative ablation zone was longer in the Technolas 217C group than that in the VISX Star S4 group (6.96 ± 0.63 *vs* 5.11 ± 0.73 mm, $P < 0.001$). In addition, the minor diameter of the postoperative ablation zone was longer in the Technolas 217C group than that in the VISX Star S4 group (5.61 ± 0.59 *vs* 4.41 ± 0.49 mm, $P < 0.001$).

The difference between the lengths of the major and minor axes showed that the cut tended to be oval with the Technolas 217C (1.34 ± 0.47 mm) and VISX S4 (0.81 ± 0.44 mm). The effect was significantly greater in the Technolas 217C group ($P < 0.001$).

We considered the preoperative spherical equivalent to be a factor affecting the difference between the programmed ablation zone and topographic optical zone. Statistical analysis using the Pearson's correlation test revealed no significant correlation between the groups ($P > 0.05$).

Table 2 Difference between the programmed ablation zone and topographic optical zone

	Technolas 217C (P *value*)	*VISX Star S4* (P *value*)
Long axis of the ablation zone—programmed optical zone (6.0 mm)	0.96 ± 0.63 (<0.001)	−0.89 ± 0.73 (<0.001)
Short axis of the ablation zone—programmed optical zone (6.0 mm)	−0.39 ± 0.59 (<0.001)	−1.59 ± 0.49 (<0.001)

Conclusion

We evaluated the difference between the programmed ablation zone and the postoperative topographic ablation zone resulting from the use of two different excimer lasers in PRK patients.

In a study of LASIK using VISX S2, Partal *et al*[11] stated that the postoperative topographic optical zone (6.0 ± 0.2 mm, 5.5 ± 0.5 mm) was smaller than the programmed ablation zone (6.5 mm) and that this reduction seemed to be independent of the degree of myopia. Similar to Partal *et al*, we found that both the major and minor axes diameters of the postoperative topographic ablation zone were shorter than the programmed ablation zone diameter in the VISX S4 group. In the Technolas 217C group, the major axis diameter of the postoperative topographic ablation zone was longer than the programmed ablation zone diameter, whereas the minor axis diameter was shorter.

Canals *et al*[10] found large differences in the superficial dimensions and contours of the ablations produced by different excimer lasers using a polymethylmethacrylate plate covered with thin aluminium foil and a 6.0-mm programmed ablation zone. The Technolas 217C had an oval central area (5.96 × 8.73 mm), and the VISX S4 had slightly smaller, round central area (5.52 × 5.84 mm). Our postoperative values are similar to those of Canals *et al*, but the zone diameters are smaller, suggesting that wound remodelling occurred at 3 months in our human study.

The postoperative topographic ablation zone was defined as the area including the blue central circle surrounded by green area. However, this has topographic meaning only, and no clinical or real corneal meaning. Many authors have defined the optical zone using various methods.[17–19] Although it is likely that the topographic ablation zone adopted in our study is proportional to the size of the real optical zone, the effective optical zone (the zone with the attempted correction) may be by far smaller.[17] Therefore, further studies should examine the clinical correlation.

Twa *et al*[20] compared similar laser systems (VISX S3 *vs* B&L 217C) using wavefront analysis and psychophysical testing in addition to corneal topography.[20] Interestingly, they found greater spherical aberration for the VISX laser. In addition, many studies have explained night halos and glare using the disparity between the scotopic pupil size and optical zone,[5–7] so the difference between the programmed ablation zone and postoperative topographic ablation zone might explain this phenomenon. Therefore, it is necessary to study the relationship between a patient's symptoms and the disparity of the postoperative topographic ablation zone.

The ablation depth may affect the size of the postoperative ablation zone, although we found no correlation between the preoperative spherical equivalent and the postoperative topographic ablation zone. Therefore, the relatively wide range of preoperative refractive error (−1.25 to −6.50 D) may be a limitation of our study.

In conclusion, there is a difference between the programmed and postoperative topographic diameters of the ablation zone that depends on the excimer laser system, and the postoperative ablation zones differ in shape and size between the two laser systems. Therefore, the postoperative ablation zone should be considered when determining the programmed ablation zone.

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