Central Islands After LASIK Detected by Corneal Topography

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A central island is defined as a localized elevated area in corneal topography after excimer laser application for myopic correction. We experienced 15 cases of central islands developed 1 week after LASIK using VISX STAR on corneal topography. The uncorrected visual acuity and best corrected visual acuity were 0.52 ± 0.22, 0.66 ± 0.25 in central islands group and 0.69 ± 0.19, 0.78 ± 0.19 in control group at 1 week after LASIK. The visual acuity in control group was more improved statistically significantly than central islands group (respectively p = 0.01, p = 0.03). There was no statistical significance between the two groups, although the uncorrected visual acuity and best corrected visual acuity were somewhat more increased in control group at 2 months and 6 months after LASIK than in central islands group (respectively p = 0.06, p = 0.24 at 2 months, p = 0.10, p = 0.17 at 6 months). On the changes of spherical equivalent after LASIK, both the central islands group and control group were in hyperopic state at 1 week after LASIK and were somewhat regressed to myopia at 2 months and 6 months after LASIK. But there was no statistical significance between the two groups at different time points (respectively p = 0.15, p = 0.64, p = 0.67). In 12 cases the central islands were disappeared spontaneously at 2 months, but in 3 cases the central islands were remained 6 months after LASIK on corneal topography. In the one case of 3 cases the best corrected visual acuity was 0.5 at 6 months after LASIK, but in the others the best corrected visual acuity was not different from the mean best corrected visual acuity. Most cases in LASIK, the central islands were dissapeared without specific treatments as in PRK. We suggest, in the case of central islands at 6 months after LASIK, that if the patient complain visual discomfort, monocular diplopia, haloes, or ghost images, central reablation with excimer laser should be considered.

Key words: central islands, LASIK

INTRODUCTION

A central island is a topographic abnormality that has been reported following excimer laser ablation of the cornea. The incidence of the central island varies with its definition,1-3 but may increase as the diameter of the ablation is increased.4 Topographic central islands are common in the early postoperative period and tend to resolve spontaneously over time. They are often associated with a loss of best corrected visual acuity and undercorrections. So some patients complain frequently the symptoms such as decreased vision, monocular diplopia,
haloes, and ghost images. Although the definite causes were not known, the central islands after laser assisted in situ keratomileusis (LASIK) were reported and corneal topographic changes after LASIK for myopia is similar to those seen after photorefractive keratectomy (PRK). This study examined the clinical characteristics of central islands after LASIK such as preoperative and postoperative refraction, postoperative uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), astigmatic changes, and subjective symptoms.

PATIENTS AND METHODS

This study comprised 109 patients (139 eyes) that had LASIK using VISX STAR by the one surgeon between March 1997 and December 1998 at the department of ophthalmology of Kangnam St. Mary’s Hospital.

All the patients were followed at 1 week, 2 months, 6 months after LASIK. Preoperative and postoperative examinations included visual acuity, manifest and cycloplegic refractions, intraocular pressure check, videokeratography, slitlamp microscopy, and central corneal thickness. All LASIK procedures were performed using the VISX STAR 193nm, argon fluoride excimer laser. VISX STAR laser pretreated the central 2.5 mm optical zone for a correction of about -1.00D to -1.50D using anti-island program.

The procedure was done using topical anesthesia of 0.5% Alcain (Alcon, USA). The cornea was marked with gentian violet using a corneal marker with 3.0 and 10.5 mm rings linked by a pararadial line. The suction ring, closed all the way, was centered around the outer marking line and the vacuum pump was turned on. Intraocular pressure was verified to be greater than 65 mmHg with Barraquer tonometer. After the nasal based corneal flap with 160 µm thickness and 8.25 mm diameter was made using the microkeratome (SCMD, U.S.A), excimer laser ablation was performed on the stromal bed using an energy fluence of 160 mJ/cm² and a repetition rate of 10Hz. The attempted correction was based on the cycloplegic refraction and the 0.5 or more diopter of astigmatism was corrected. After ablation, the flap was replaced to its original position and the interface irrigated copiously with balanced salt solution with the 23 gauge cannula to remove all particles. The flap was then centered for proper alignment according to the pararadial mark. The keratectomy incision was dried with absorptive sponges. After approximately 3 minutes, the flap was checked for adhesion. 0.3% ofloxacin and 0.1% fluorometholone eyedrops were instilled four times a day for 1 month.

We defined a central island as an elevation more than 3 D in height and more than 1.5 mm in diameter. The height of the island was determined by subtracting the K value at the steepest point of the island from the K value at the base of the island. And the diameter of the island was determined by measuring the island at its greatest dimension because the shape of the central island was not circular. The UCVA and BCVA at 1 week, 2 months, and 6 months after LASIK was analyzed after coverted as LogMAR scale. The paired t-test was used for statistical evaluation and differences were considered statistically significant when p-values were less than 0.05.

RESULTS

The mean age of the patients was 28.8 years (central islands group : 29.4 years, control group : 28.5 years). 37 cases was male and 68 cases was female (central islands group : 13, control group : 55).

There was no keratoconus suspected by corneal topography at preoperative period. Preoperative spherical equivalent was -7.55 ± 1.32D in central islands group and -7.61 ± 1.39D in control group. Preoperative central corneal thickness was 530.5 ± 38.5 µm in central islands group and 524.3 ± 31.6 µm in control group. There was no significant differences in preoperative spherical equivalent and central corneal thickness between central islands group and control group (respectively p = 0.73, p = 0.49).

The UCVA and BCVA were 0.52 ± 0.22, 0.66 ± 0.25 in central islands group and 0.69 ± 0.19, 0.78 ± 0.19 in control group at 1 week after LASIK. The visual acuity in control group was more improved statistically significantly than central islands group (respectively p = 0.01, p = 0.03). The UCVA and BCVA were 0.65 ± 0.14, 0.72 ± 0.14 in central
islands group and $0.76 \pm 0.19$, $0.84 \pm 0.14$ in control group at 2 months after LASIK, and $0.66 \pm 0.20$, $0.81 \pm 0.11$ in central islands group and $0.79 \pm 0.21$, $0.88 \pm 0.16$ in control group at 6 months after LASIK. There was no statistical significance between the two groups, although the UCVA and BCVA were somewhat more increased in control group at 2 months and 6 months after LASIK than in central islands group (respectively $p = 0.06$, $p = 0.24$ at 2 months, $p = 0.10$, $p = 0.17$ at 6 months) (Figs. 1 & 2).

On the changes of spherical equivalent after LASIK, both the central islands group and control group were in hyperopic state at 1 week after LASIK and were somewhat regressed to myopia at 2 months and 6 months after LASIK. But there was no statistical significance between the two groups at different time points (respectively $p = 0.15$, $p = 0.64$, $p = 0.67$) (Fig. 3). The astigmatic change based on the cylinder diopter was not statistically significant ($p > 0.05$) (Fig. 4). In 12 cases the central islands were disappeared spontaneously at 2 months, but in 3 cases the central islands were remained 6 months after LASIK on corneal topography. In the one case of 3 cases the BCVA was 0.5 at 6 months after LASIK, but in the others the BCVA was not different from the mean BCVA (Tables 2 & 3). All the patients with central islands did not complain subjective symptoms such as monocular diplopia.
haloes, or ghost images.

DISCUSSION

As LASIK is popular after PRK, clinically significant central islands have been reported. There are some variations in definition of central islands. Levin classified central islands as any part of the treatment zone that was surrounded by areas of lesser curvature on more than 50% of its boundary on the 3 months postoperative corneal topography. And the islands were graded according to height and diameter. Grade A was less than 3.0 D in height; grade B, more than 3.0 D but less than 3.0 mm diameter; grade C, more than 3.0 D and 3.0 mm. He reported that of the 156 who had topography at 3 months, 104 (67%) had islands in the central 3 mm; 63 (40%) had a grade A island, 21 (14%) grade B, and 20 (13%) grade C.1 Machat defined a central island as at least 1 D to 3 D in height, a diameter of at least 1 to 3 mm, measured at least 1 month postoperatively, and associated with clinical symptoms of ghosting of images, blurring, and qualitative visual changes.2 Krueger defined a central island as more than 3 D in height and a diameter of more than 1.5 mm.3 We adapted the Krueger’s definition, and 15 cases of patients after LASIK showed central islands on corneal topography 1 week after LASIK. The central islands at 2 month were dissapeared spontaneously in 12 cases, but the central island was remained at 6 months in 3 cases. It was said that the occurrence rates of central islands were increased as the severity of myopia, and Krueger reported that steep central islands were seen in 25 eyes (71%) at 1 week, 18 eyes (51%) at 1 month, 7 eyes (20%) at 3 months, and 4 eyes (11%) at 6 months.3

There are several theories about the cause and the mechanism of central islands, but the definite causes have not been proven yet. Although the definite causes were not known, the central islands after LASIK were reported less than those after PRK. The acoustic shock wave theory was postulated by
Machat, in which the central stroma might be relatively less corrected than midperiphery in the VISX subgroup due to the altered hydration pattern during the operation.6

In over 1500 cases, no central islands were seen with the Summit ExciMed, but a 17% incidence of central islands was noted with the VISX 20/20.6 As the Summit ExiMed had a gaussian energy beam profile with a higher energy density centrally, the corneal stroma in the Summit laser subgroup appeared uniformly moist intraoperatively. Whereas the stroma in the VISX subgroup became moist centrally, the occurrence rate of the central islands was lower in the Summit laser subgroup than the VISX subgroup.3

Krueger said that blowing gas was necessary to remove debris from the surface and the blowing of humidified gas during excimer laser corneal ablation produced a smoother surface than did the blowing of dry gas.7 Lin hypothesized that the presence of central islands after PRK might be due to structural and hydration differences between the more moist, deeper layers of the cornea compared with the drier, superficial layers of the cornea and the central cornea might become more moist more quickly due to its proximity to the endothelium than peripheral cornea.8 On the base of this theory, we think that there is more fluid than normal in the central cornea, resulting in central stromal underablation with a subsequent bump.

Price proposed following potential etiologies of central steep islands after automated lamellar keratoplasty: (1) ectasia of the central cornea by bulging forward of the central underlying stroma due to deep stromal resection; (2) Crimping of the central corneal disc; (3) Epithelial remodeling; (4) Irregular astigmatism leading to an anomalous topographic analysis; and (5) An aberration of the soft-

**Fig. 5.** Topographic map of case 1. A): a symmetric bowtie pattern demonstrating a 1.5D with-the-rule astigmatism before LASIK B): a central island of 2.5mm in diameter and approximately 4D in height 1 week after LASIK. C): a central island of 3mm in diameter and 4.5D in height 2 months, and D) 6 months after LASIK.
ware analyzing the topographical keratoscopic images. Also Tayler et al said that the change in the underlying stromal contour following LASIK might result in abnormal tear film distribution over the central corneal epithelium, and there was no clear correlation between the topographi maps and spectacle-corrected visual acuity or regression of the initial refractive effect. Factors increasing central islands include (1) lasers with homogeneous or flat energy beam profiles; (2) single-zone techniques; (3) large optic zones; (4) moderate or severe degrees of myopia; and (5) moist corneas intraoperatively. Though single-zone techniques utilize the greatest number of successive pulses, multizone techniques allow the stroma to dry between steps, and by starting each zone centrally, alter the stromal hydration pattern, driving fluid peripherally. Larger optic zones would be at greater risk of inducing islands owing both to the larger shock wave amplitude, and the tendency of the beam energy to drop centrally as the diameter is increased. The incidence rates of central islands in VISX STAR were lower than previous model because VISX altered its algorithm and developed a central island factor software to add additional pulses at central 2.5 mm optic zone.

Clinical symptoms of central islands are related to decreased visual acuity, monocular diplopia, haloes, glare, and ghosting, but refraction is not significantly affected in most cases. Kim reported that the occurrence of central islands was related with UCVA and postoperative changes of BCVA, but not with preoperative refractive error, corneal thickness, age, sex and correction of astigmatism. In our cases, though the visual acuity of one case with

![Fig. 6. Topographic map of case that central island was disappeared spontaneously at 2 months after LASIK](image-url)
topographic central island at 6 month was 0.5 and not corrected, the visual acuity of the others was not different from the mean visual acuity. And all the patients did not complain the symptoms such as monocular diplopia, haloes, and ghost images. In the change of refractive power, initially the central corneal epithelium is relatively thin and often is associated with hyperopia. Later, with healing and remodeling, the epithelium thickens -up to three times or more in thickness- and may be associated with myopic regression. In our cases, both the central islands group and control group were in hyperopic state at 1 week after LASIK and were somewhat regressed to myopia at 2 months and 6 months after LASIK. But there was no statistical significance between the two groups at different time points.

A conservative approach is preferred, since most patients improve with time, and the incidence of central islands at 1 year is very low — 2% in Lin’s series, and 1% at 6 months with Levin et al. It was reported that contact lens use, pharmacological treatment with corticosteroids, and mechanical debridement were not effective, and the best treatment was to use an excimer PRK to correct the island after measuring the size and height of the central island on the topographical subtraction map. For example, Manche et al reported that 6 eyes experienced an improvement in UCVA, and all eyes returned to within one line of their preoperative level of BCVA 1 month after the central reablation in 8 patients with central islands after PRK, myopic keratomileusis in situ, and LASIK. We think that if the patient with central island at 6 months complain decreased visual acuity, monocular diplopia, haloes, or ghost images, central reablation with excimer laser can be considered.

In conclusion, we think that the central islands after LASIK had no significant relationship in preoperative refraction and central corneal thickness and disappeared spontaneously in most cases. Also most central islands did not affect the surgical outcomes such as postoperative refraction, UCVA, BCVA, and clinical symptoms. But more fundamental and specific studies were required.

REFERENCES