Hyperopic Shift and Myopic Regression in a Patient 7 Years After Bilateral Refractive Keratotomy

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ABSTRACT

PURPOSE/METHODS: To report a patient who developed hyperopic progression in one eye and myopic regression in the other eye following bilateral, non-simultaneous refractive keratotomy.

RESULTS: Uncorrected visual acuity improved to 20/25 and 20/25-2 in the right and left eyes, respectively, 3 months following refractive keratotomy (one procedure in the right eye, two procedures in the left eye). The visual acuity was not stable over time and almost 8 years after surgery, uncorrected distance visual acuity was 20/40 – and 20/200. The spherical equivalent refraction of the right eye progressed from −0.50 dioptr (D) 3 months after surgery to +1.25 D several years later. The left eye regressed from a spherical equivalent refraction of −0.75 D 3 months after the second surgery to −2.50 D more than 7 years postoperatively. Slit-lamp microscopy disclosed deeper, opaque incisions in the hyperopic eye, and shallower and more transparent incisions in the myopic eye.

CONCLUSIONS: The shift toward hyperopia and myopia in an individual suggest that instability of the radial keratotomy wound may be related to local wound healing events that are, in part, related to incision depth. [J Refract Surg. 1996;12:160-162.]

One of the major drawbacks of radial keratotomy is the long-term instability of refraction. Waring and associates reported that 43% of eyes had a progression in the hyperopic direction 10 years following surgery. The cause(s) of this shift remain(s) to be elucidated. Further, whether the amount of progression is symmetric between the eyes has not been well established. Lynn reported a median difference between refractive changes of patients’ two eyes at 1 year after surgery of 0.62 diopter (D) and 71% of the patients with changes in refraction in the two eyes within 1.00 D of each other. Radial keratotomy increases the disparity of spherical equivalent refractions and induced anisometropia of 3.00 D or greater in 2.2% of patients 1 year after surgery. By 6 years after surgery, 3.6% of patients had this same amount of anisometropia. Whether this disparity was due to hyperopic progression, myopic regression, or both is not known. This histopathological finding of prolonged and variable wound healing after radial keratotomy within an individual as well as between individuals could explain the lack of predictability of refractive outcome and the continuing refractive instability in long-term follow up with the induction of anisometropia in some patients.

We report a case in which there is a myopic shift in one eye and hyperopic shift in the other eye and a difference in appearance of the incisions of the two eyes 7 years after radial keratotomy. This case suggests that the refractive changes after radial keratotomy are due to variable wound healing related in part to surgical factors such as incision depth and its effect on biomechanical stability.

CASE REPORT

A 33-year-old female underwent bilateral radial and astigmatic keratotomy for the correction of −4.50 + 1.25 × 90° D and −3.50 + 1.25 × 90° in the right and left eyes, respectively. Central keratometry readings were 42.75/44.25 D at 90° in the right eye, 42.50/43.50 D at 95° in the left eye. An eight-incision radial keratotomy (3.0-mm optical clear zone) and two transverse incisions in the 90° merid-
ian were performed in the right eye without complication. The surgery was performed with an unknown technique. Following surgery, topical gentamicin 0.3% was given four times daily for 1 week and fluoromethalone 0.1% four times daily for 4 weeks. Three months after surgery, the uncorrected visual acuity was 20/25 and the manifest refraction was $-1.50 + 2.00 \times 90^\circ$ (spherical equivalent refraction $-0.50$ D) with central keratometric values of 39.75/41.50 D at 95°. Seven months postoperatively, the uncorrected visual acuity was 20/30 with a manifest refraction of $-1.25 + 2.25 \times 90^\circ$ D (spherical equivalent refraction $-0.125$) and central keratometry readings of 39.00/41.25 at 90°. Sixteen months postoperatively, the uncorrected visual acuity was 20/20 and the manifest refraction was $-0.75 + 1.75 \times 95^\circ$ D (spherical equivalent refraction $+0.12$ D).

Seven years 8 months after radical keratotomy, the uncorrected visual acuity was 20/40, the manifest refraction was $+1.00 + 0.05 \times 85^\circ$ (spherical equivalent refraction $+1.25$) and the central keratometric values were 38.50/40.12 D at 83°.

A four-incision radial keratotomy (3-mm optical clear zone) and two transverse incisions were performed in the left eye by the same surgeon using an unknown technique 2 months after surgery in the right eye. Topical gentamicin was applied four times daily for 1 week and fluoromethalone was instilled four times daily for 1 month after each surgery. Three months after surgery, the uncorrected visual acuity was 20/30- and the manifest refraction was $-2.75 + 1.25 \times 95^\circ$ (spherical equivalent refraction $-2.12$ D) with central keratometric values of 41.75/43.25 at 90°. Due to undercorrection, an additional four incisions with a 3-mm optical clear zone were placed. One month after the second procedure, uncorrected visual acuity was 20/25+ with a refraction of $-1.00 + 50 \times 90^\circ$ (spherical equivalent refraction $-0.75$). Three months after the second procedure, the uncorrected visual acuity was 20/25-2, the manifest refraction was $-2.00 + 1.50 \times 110^\circ$ (spherical equivalent refraction $-1.25$ D) and the central keratometric values were 41.50/43.00 at 90°. Twelve months later, there was a regression of effect to $-2.00 + 0.75 \times 90^\circ$ (spherical equivalent refraction $-1.62$ D) with an uncorrected visual acuity of 20/25-. Seven years 3 months after the second surgery, the uncorrected visual acuity diminished to 20/200-. Manifest refraction was $-2.75 + 0.50 \times 95^\circ$ D (spherical equivalent refraction $-2.50$ D) and central keratometric values were 42.12/43.50 at 97°.

Slit-lamp microscopy of the right cornea disclosed incisions which extended to the limbus and which were opaque (all 8 semi-radials) of approximately 85% depth. Three nasal incisions appeared even deeper (95% to 98% depth). The incisions of the left cornea were less wide, more transparent, and shallow. Three temporal incisions were only 60% in depth. Axial lengths of the eyes were not measured.

**DISCUSSION**

Studies by independent groups have shown a continued increase in effect of 1.00 D or more between 1 and 10 years after radial keratotomy in 17% to 43% of eyes. The mechanism of this phenomenon is not well understood, although a statistically significant correlation has been found with smaller diameter clear zones, higher myopes, and deeper incisions. On the other hand, the loss of surgical effect of 1.00 D or more is less common and occurs in only 1% to 8% of eyes.

The induction of anisometropia (2.00 D or more) has not been a significant complication in 90% of patients 1 year after bilateral surgery. The median difference between an individual's two eyes was 0.62 D and 26% of patients experienced a difference in refraction of 1.00 D to 6.87 D. Six of 269 (2.2%) patients had a refractive difference of 3.00 D or greater between the two eyes. Five years later, anisometropia of 3.00 D or greater was present in 12 of 328 (3.6%) patients. Whether this increased disparity was due to myopic regression, hyperopic progression or changes in axial length is not known. Uncertainty about different results between the two eyes of the same patients in which the same procedure was performed has also been reported.

We report a case in which the direction of refractive changes after radial and astigmatic keratotomy...
varied between the two eyes. This patient exhibited a slow hyperopic shift in the right eye of 1.75 D almost 8 years after the surgery and a slow regression of effect after the second surgery of 1.75 D with a spherical equivalent refraction of -2.50 D 7 years after the second procedure. The incisions between the two eyes appeared different, suggesting that the incisions were made and healed differently. It is likely that the shallower incisions of the left eye resulted in a healing response with progressive disappearance of the epithelial plug and prolonged retraction within the fibrous scar in which the incisions became less visible. At 7 years, there was almost complete regression of refractive effect and the patient preferred the change in vision in this eye to the hyperopic eye. On the other hand, the contralateral eye showed deeper incisions which might have caused more biomechanical instability and led to a healing response characterized by persistent wound gaping or slight spreading and development of a hypertrophic scar that over time gradually increased overcorrection. Clearly, understanding the basic mechanisms involved in wound healing are of increasing concern to the refractive surgeon. Asymmetrical changes in axial length could be involved, but axial length was not measured.

As radial keratotomy is being performed by an increasing number of surgeons, the 10-year PERK results, which show a continued progression of effect, are worrisome. We feel that the ideal refractive surgery would correct distance vision in young patients but allow reading vision as patients age. It is possible that this desired effect of surgery could be achieved with shallower and narrow incisions that allow regression, as happened in the left eye of our patient. Further investigation and manipulation of the wound healing response are necessary to develop such an approach.

REFERENCES