Changes in anterior chamber depth and axial length measurements after radial keratotomy

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CLINICAL STUDY

Abstract

Purpose **To evaluate the changes that occur in anterior chamber depth and globe axial length after radial keratotomy (RK) surgery in cases with different degrees of myopia.**

Methods **One hundred and twelve eyes that underwent RK were studied. The eyes were divided into two groups: 70 eyes with a correction of myopia of 4.00 D and under after RK (group 1) and 42 eyes with a correction of myopia of more than 4.00 D (group 2). Routine examinations were done in all cases. Ultrasonic biometry and central anterior chamber depth and axial length were measured pre-operatively and on the third day, second week, third month and sixth month post-operatively.**

Results **Pre-operatively the average globe axial length was longer in group 2 than group 1. When all post-operative measurements were compared with pre-operative measurements in group 1, there was a decrease in anterior chamber depth and globe axial length, but no significant difference was found except on the third day ($t = 3.15$, $p = 0.003$). In group 2 there was an insignificant decrease in axial length but the decrease in anterior chamber depth was significant at all measurement times except for the sixth month.**

Conclusions **Refractive changes related to biometric changes after RK are not important compared with the total refractive corrections of RK. These changes should be considered, however, when planning RK procedures.**

Key words Anterior chamber depth, Axial length, Myopia, Radial keratotomy

Radial keratotomy (RK) is a commonly performed procedure for the correction of myopia. The Soviet physicians Yenaliev[1] and Fyodorov and Durnev[2] developed the modern form of the procedure. Technological advances in instrumentation, the use of corneal topography, as well as the greater understanding of corneal biomechanics, including the influences of patient age, wound morphology and wound healing, have all contributed to an improved level of safety, efficacy and predictability.[3–7] We do not yet know how to change anterior chamber depth and globe axial length after RK, and their effects on refractive correction. However, it is unknown what kind of changes occur in anterior chamber depth and axial length after RK, and how these affect the refractive correction. We could find only one published study on changes in axial length after RK, and no study on anterior chamber depth.

In this study we have evaluated changes in anterior chamber depth and globe axial length after RK.

Materials and methods

One hundred and twelve eyes of 58 myopic patients (30 women, 28 men) undergoing RK were studied. The subjects had pre-operative refractive errors ranging from −3.00 to −13.00 D. They were divided into two groups according to the degree of correction of myopia after RK: group 1 (70 eyes) consisted of patients who had 4.00 D or less of myopia; group 2 (42 eyes) consisted of those with a correction of more than 4.00 D.

Measured manifest and cycloplegic refraction, keratometry, computed video keratography, ultrasonic biometry (Biovision, A/B Scan 11 MHz, solid probe, 1550 m/s), tonometry and central-peripheral corneal pachymetry were carried out in all subjects. Calibration of the A-scan probe was checked at least once a week using a calibration block provided by the manufacturer.

Determination of optic zone (OZ) size and incision number was based on many factors, such as the degree of desired correction, age, gender, refraction and keratometric values, intraocular pressure (IOP), corneal topography, and the prior experience of the surgeon. Emmetropia was the aim in all cases.

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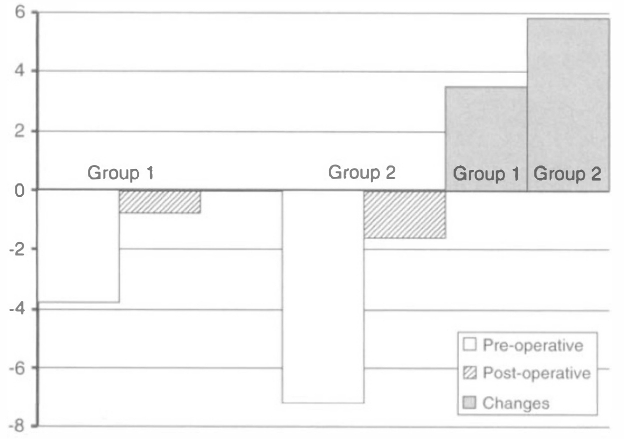

Fig. 1. *Average pre-operative and post-operative myopia and refraction changes in groups 1 and 2 (dioptres).*

We used a direct contact system with solid applanation probe for measurement of anterior chamber depth and axial length. With the patient reclining, two drops of 0.4% oxibuprocaine were instilled as a topical anaesthetic into the eye. The ultrasound probe emitted a red light on which the patient could fixate to maintain the proper alignment of the instrument with the visual axis. The hand-held probe was applied perpendicular to the corneal surface in the visual axis. To avoid indenting the cornea the examiner viewed the cornea from the side, to be certain that compression was not occurring. All measurements were done by the same surgeon. At each visit, 10 measurements were done electronically, and means and standard deviations were calculated automatically for each eye. The mean values of anterior chamber depth and axial length were recorded when the standard deviations of 10 measurements were less than 0.06 mm.

RK procedures were performed with a diamond blade using the Russian technique. All operations were performed by the same surgeon. No complications such as micro or macro perforations in the peroperative and post-operative periods were found in either group.

All subjects were informed about the procedure in detail beforehand, including the possible complications and expectations the subject should have. All subjects were healthy adults not taking any medications.

Surgery was performed under topical anaesthesia using a coaxial operating microscope. A Russian diamond blade was extended to 100% of the thinnest 3 mm paracentral corneal measurement using a calibrating scale. Russian technique incisions were initiated by plunging the blade into the stroma, and extended centripetally no closer than 1 mm to the corneoscleral limbus. The surgeon made 8, 10 or 12 radial incisions from the limbus to the OZ. Eight incisions were made on eyes with refractive errors from −3.00 to −4.50 D, 10 incisions for errors from −4.50 to −6.00 D, and 12 incisions for errors over −6.00 D, altering central corneal OZ size. The eye was then instilled with 0.3% tobramycin sulphate and covered with patch for 24 h. Post-operative medical therapy included a 5 day regimen of topical steroid (1% prednisolone acetate), prophylactic antibiotics (0.3% tobramycin sulphate) and artificial tears instilled four times daily, followed by 3 days of twice-daily instillation. When spherical equivalent cycloplegic refraction (SECR) was greater than +1.00 D within the first post-operative week, steroid was stopped.

The surgeon examined the patients on the first post-operative day, and then 3 days, 2 weeks, 3 months and 6 months later. Each post-operative visit included all the examinations performed pre-operatively.

Anterior chamber depth and axial length of 40 normal (control) eyes were measured at two different times and compared statistically before starting the study. The means and standard deviations of the measurements of anterior chamber depth for the control cases were: 3.56 ± 0.27 mm for the first measurement and 3.54 ± 0.22 mm for the second measurement. Thus there was a 0.02 mm difference between the first and second measurements of anterior chamber depth. The means and standard deviations of the measurements of axial length for the control cases were: 24.54 ± 1.14 mm for the first measurement and 24.50 ± 1.05 mm for the second measurement. Thus there was a 0.04 mm difference between the first and second measurements of axial length. No statistically significant difference was found between the values at the two different times (anterior chamber depth: $t = 0.23$, $p = 0.82$; axial length: $t = 0.35$, $p = 0.71$). These results confirm the reliability and reproducibility of our measurements.

The average post-operative follow-up times were 8.25 ± 1.14 and 9.31 ± 1.54 months in groups 1 and 2, respectively.

The results were analysed using the SPSS (Statistical Pocket Programme for Social Sciences) computer program. Comparisons were made using two-tailed Student's t-tests for paired and unpaired samples as appropriate ($p < 0.05$ significant).

Results

The average ages were 26.85 ± 4.74 and 25.19 ± 5.15 years in groups 1 and 2, respectively ($t = 0.22$, $p = 0.15$). Pre-operative average myopia was −3.78 ± 0.87 D and −7.23 ± 2.18 D in groups 1 and 2 respectively ($t = 8.35$, $p < 0.001$). Post-operative average correction values of myopia were 3.12 ± 0.73 D and 5.69 ± 0.92 D in groups 1 and 2, respectively (t −11.51, $p < 0.001$) (Fig. 1). All measurements in both groups are shown in Table 1.

In group 1, anterior chamber depth in all measurements decreased post-operatively. The difference between the pre-operative and post-operative anterior chamber depth was statistically significant on the third day ($t = 3.15$, $p = 0.003$) but not at other times. Axial length had decreased at all post-operative measurements in group 1. But no statistically significant difference was found between pre-operative and post-operative axial length at any measurement times.

In group 2, not only anterior chamber depth but also axial length was found to have decreased at all post-operative measurement times. There was a statistically significant difference between pre-operative and post-

Table 1. *Summary of data*

	Group 1			Group 1		
	Measurement	Difference	p and t values	Measurement	Difference	p and t values
Anterior chamber depth (mm)						
Pre-operative	3.60 ± 0.25	**−0.21**	$\mathbf{p = 0.003}$	3.72 ± 0.26	**−0.26**	$\mathbf{p < 0.001}$
Post-operative 3rd day	3.39 ± 0.26		$t = 3.15$	3.46 ± 0.26		$t = 4.14$
Pre-operative	3.60 ± 0.25	−0.09	$p = 0.18$	3.72 ± 0.26	**−0.21**	$\mathbf{p = 0.007}$
Post-operative 2nd week	3.51 ± 0.25		$t = 1.34$	3.51 ± 0.25		$t = 2.95$
Pre-operative	3.60 ± 0.25	−0.12	$p = 0.06$	3.72 ± 0.26	**−0.14**	$\mathbf{p = 0.041}$
Post-operative 3rd month	3.48 ± 0.22		$t = 1.95$	3.58 ± 0.27		$t = 2.18$
Pre-operative	3.60 ± 0.25	−0.09	$p = 0.18$	3.72 ± 0.26	−0.13	$p = 0.15$
Post-operative 6th month	3.51 ± 0.23		$t = 1.37$	3.59 ± 0.33		$t = 1.49$
Average axial length (mm)						
Pre-operative	24.56 ± 0.74	−0.19	$p = 0.36$	25.64 ± 1.04	−0.21	$p = 0.47$
Post-operative 3rd day	24.37 ± 0.77		$t = 0.92$	25.43 ± 1.06		$t = 0.73$
Pre-operative	24.56 ± 0.74	−0.08	$p = 0.32$	25.64 ± 1.04	−0.15	$p = 0.66$
Post-operative 2nd week	24.48 ± 0.75		$t = 0.46$	25.49 ± 1.05		$t = 0.44$
Pre-operative	24.56 ± 0.74	−0.07	$p = 0.69$	25.64 ± 1.04	−0.13	$p = 0.65$
Post-operative 3rd month	24.49 ± 0.74		$t = 0.39$	25.51 ± 1.03		$t = 0.46$
Pre-operative	24.56 ± 0.74	−0.09	$p = 0.64$	25.64 ± 1.04	−0.12	$p = 0.67$
Post-operative 6th month	24.47 ± 0.74		$t = 0.47$	25.52 ± 1.07		$t = 0.43$

Significant values are in bold type.

operative anterior chamber depths at 3 days, 2 weeks and 3 months post-operatively ($t = 4.14$, $p < 0.001$; $t = 2.95$, $p = 0.007$; $t = 2.18$, $p = 0.041$, respectively), but an insignificant difference at 6 months. No statistically significant difference was found between the pre-operative and post-operative axial length at any visit in group 2.

Discussion

Today, RK is a widely used refractive surgical procedure. There are many studies concerning refractive and keratometric changes of the eye after RK surgery, but we could find only one on the changes in axial length after RK surgery.[8] Geerts reported a 0.10 mm decrease in axial length in 49 eyes after RK, but no mention was made of anterior chamber depth.[8]

Corneal refractive surgical procedures alter the shape and structure of the tissue, possibly compromising its mechanical stability. As shown previously, corneas still have significantly decreased mechanical stability even several years after RK.[9–12]

We used a contact and hand-held method with solid tip probe for measurements. The solid tip probe, however, can more easily indent the cornea, resulting in a shortened axial length reading. Nevertheless, in most cases the experienced examiner can learn to apply the probe with minimal pressure, thereby preventing corneal compression.[13] For that reason, biometric measurements were made by an ophthalmologist experienced in such measurements and all measurements were done by the same surgeon. To avoid indenting the cornea the examiner viewed the cornea from the side, to be certain that compression was not occurring.

We found differences of 0.07 mm to 0.26 mm between pre-operative and post-operative measurements of anterior chamber depth and axial length. A difference of 0.1 mm is at the limit of accuracy of clinical biometry systems when using manual measurement. But we used an electronic measuring system, and found the reproducibility to be within 0.02 mm for anterior chamber depth and 0.04 mm for axial length. In a review of 500 axial length measurements performed by the author, the reproducibility was within 0.05 mm when measured manually and 0.01 mm when measured electronically.[14]

In our study, all measurements decreased in the post-operative period compared with the pre-operative period in both groups. There were statistically significant differences between anterior chamber depth on the third post-operative day in group 1 and on the third day, second month and third month in group 2. Anterior chamber depth may be shallow due to macro or micro corneal perforations after RK or indentation of the cornea

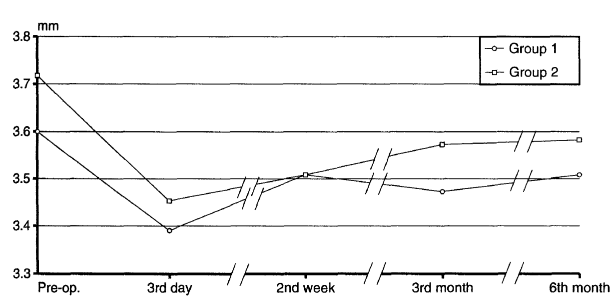

Fig. 2. *Average anterior chamber depth in the post-operative period in groups 1 and 2.*

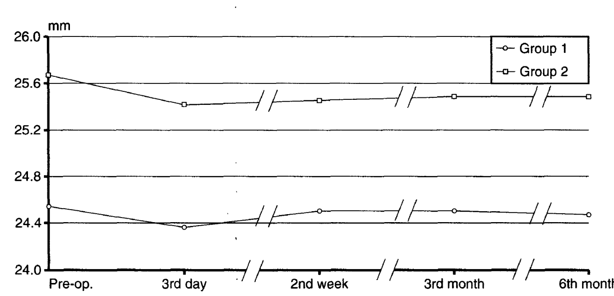

Fig. 3. *Average axial length in the post-operative period in groups 1 and 2.*

by the solid probe when measuring anterior chamber depth. But patients who had any complications were excluded from our study and we ensured that the cornea was not indented by the examiner.

Sato in the 1950s and Fyodorov in the 1970s reported that RK induced central corneal flattening and paracentral steepening. Today it is well known that gaping wounds increase the corneal surface area and weaken the cornea so that the paracentral and peripheral areas are displaced anteriorly and steepened, creating a compensatory central posterior displacement and flattening.[15] In our study we think that shortening of the anterior chamber depth after radial keratotomy may be related to central corneal flattening following the procedure.

No statistically significant difference was found between the pre-operative and post-operative axial lengths in any visit in either group.

Shortening of anterior chamber depth and axial length after RK was higher at the early post-operative visits than later, and the difference between the pre-operative and post-operative biometric measurements diminished over time. This course of biometric changes is possibly because of corneal wound healing (Figs. 2, 3). As expected, these changes were more prominent and permanent in group 2, which had greater refractive changes.

The shortening of axial length in our cases was not statistically significant, but shortening of 0.09–0.12 mm was noted at the 6 month visit, which was comparable with the results of Geerts' study.

In eyes with refractive myopia, 0.34 mm shortening of the axial length resulted in a 1.00 D refractive change. In eyes with axial myopia, 0.40 mm shortening of the axial length resulted in a 1.00 D refractive change.[16,17] According to these findings in 112 eyes, 0.11 mm shortening of axial length resulted in a 0.25 D refractive change. Such a change is not important compared with the total refractive corrections of RK. But one should consider these changes when planning RK procedures.

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