

THREE YEAR RESULTS OF RADIAL KERATOTOMY SURGERY AT THE NATIONAL UNIVERSITY HOSPITAL, SINGAPORE

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ABSTRACT

This paper presents the three year results of radial keratotomy (RK) surgery on 51 of the first 59 consecutive eyes at the National University Hospital in Singapore. Before surgery, uncorrected visual acuity was worse than 6/24 in all eyes with 33.3% worse than 6/60. The average pre-operative spherical equivalent (SE) was -4.56 Dioptres(D). Three years after surgery the mean SE was -0.66D, a change of 3.9D; and 72.5% of eyes were within 1D of emmetropia. 70.6% had uncorrected visual acuity of at least 6/12 with no eyes having worse than 6/60 visual acuity. Analysis based on levels of pre-operative myopia showed that the best visual and refractive results were obtained in patients with SE of -6D or less. None of the patients were troubled by complications such as glare, fluctuating vision, irritation and discomfort three years after surgery. Our results indicate that RK surgery is safe and effective through the three years and more following surgery.

Keywords: radial keratotomy, refractive surgery, optics, myopia, cornea.

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INTRODUCTION

The Singapore experience with Radial Keratotomy (RK) surgery began in early 1987 at the National University Hospital (NUH). To date only a preliminary report on 18 eyes has been published⁽¹⁾. The recent acquisition of an excimer laser by the Singapore National Eye Centre has generated renewed interest in our RK results as it would provide a basis for comparing and gauging the effectiveness of the new laser. This paper will present the visual and refractive results of the first 59 consecutive eyes of 36 patients three years or more after RK surgery at the NUH Singapore. The aim of this retrospective study was to assess the effectiveness of RK surgery at the NUH.

PATIENTS AND METHODS

All 59 radial keratotomy (RK) surgeries were performed at the National University Hospital (NUH) between April 1987 and March 1989. Two eyes were operated on by Dr R Lindstrom, one by Professor G Waring (both of them visited Singapore in 1987), 18 by LCH and 30 by ASML. The other 8 eyes of 5 patients were lost to follow up and are not reported here. The data collection was done by LY and CTK. Evaluation of results in this study was carried out by LY and VB using the

PC-SAS system.

Patients' ages ranged from 23 to 44 years and pre-operative myopia ranged from -2 Dioptres(D) to -11.25D. Myopia had to be stable before surgery was undertaken. Patients with other ocular pathology eg cataract induced myopia, glaucoma, diabetic retinopathy, uveitis were excluded. The procedure and its possible side-effects were carefully explained to each patient. They were told that results were not always predictable, especially for higher degrees of myopia, and that although the ideal result aimed for was emmetropia, perfect correction was not guaranteed. It was imperative that each patient understood this and had realistic expectations. Uncorrected distance vision was 6/24 or worse in all eyes. Best corrected vision in all eyes was at least 6/12. All patients had a general pre-operative ophthalmic examination which included visual acuity, refraction, keratometry and slit-lamp examination.

Surgery was carried out under local anaesthesia with topical anaesthetic instilled into the eye to be operated on. After instructing the patient to fixate on the light of the operating microscope, the visual axis was marked on the cornea on the inferonasal aspect of the reflection of the microscope filament using a small hypodermic needle. The optical zone was then marked and ultrasonic pachymetry was performed on the four quadrants of the cornea. The diamond knife was then set to between 100%-110% of the thinnest paracentral pachymetry reading. The cornea was dried before making four to eight radial incisions depending on the degree of myopia. Two eyes had sixteen incisions because of high pre-operative myopia of -9.75D and -11.25D. LCH performed incisions from the corneal periphery inwards towards the optical axis and ASML made incisions from centre outwards to the periphery. Each incision was irrigated and topical gentamicin was instilled at the end of the operation.

Follow-up varied on a case to case basis as there had been no fixed protocol for post-operative visits. Some patients had to be recalled in order to record their latest vision and refraction. A follow-up observation taken 32 to 49 months after surgery was considered in the three-year window. Post-operative evaluation included a check on visual acuity, automated refraction followed by subjective refinement, and a slit-lamp examination. A re-operation was done by LCH on two eyes with high myopia of -9.75D and -11.25D because of undercorrection. Total number of incisions on each of these eyes was sixteen. A re-operation was treated as a complication of original surgery and not as an independent procedure. No eyes had more than two operations.

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Table I - Visual acuity (Va) before and three years after surgery

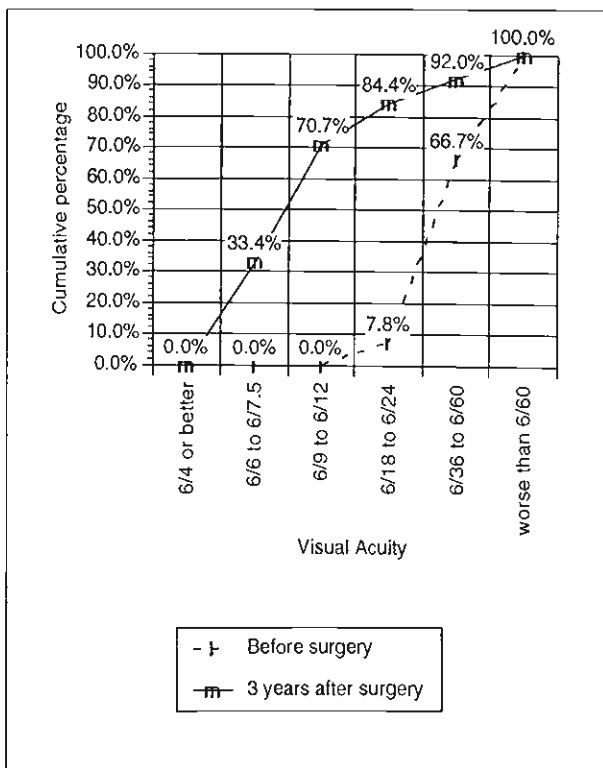
Va	Before surgery		After surgery	
	No.	%	No.	%
6/6	0	0	17	33.3
6/9 to 6/12	0	0	19	37.3
6/18 to 6/24	4	7.8	7	13.7
6/36 to 6/60	30	58.8	8	15.7
Counting fingers	17	33.3	0	0

Table II - Refractive values before and 3 years after surgery

	Pre-op SE (D)*	Post-op SE (D)
Mean	-4.56	-0.66
SD	2.06	1.06
Minimum	-2.0	-3.75
Maximum	-11.25	+2.5
Mean change		+3.9

*SE - Spherical equivalent; D-Dioptres

Fig 1 - Graph of cumulative percentage of overall visual acuity before and 3 years after surgery



RESULTS

Overall visual and refractive results

Only 4 eyes (8%) had pre-operative uncorrected vision of 6/24. None of the other eyes saw better than this before surgery. Seventeen eyes (33.3%) had only counting fingers vision. Three years after surgery, 33.3% had uncorrected vision of 6/6 and 70.6% had vision of at least 6/12. There were no eyes with worse than 6/60 vision. (See Table I) Fig 1 shows the overall

Fig 2 - Scatterplot of change in spherical equivalent against pre op spherical equivalent

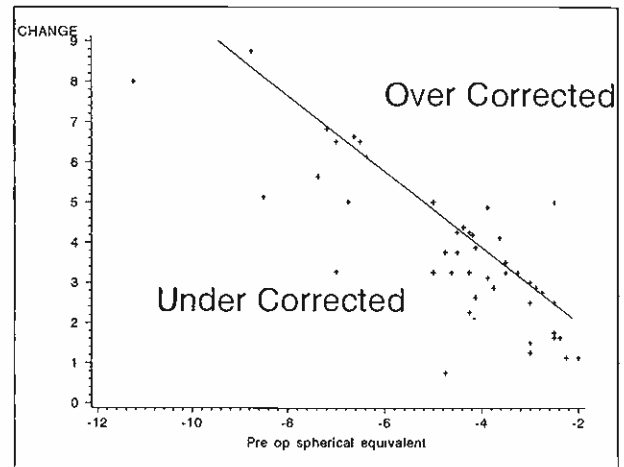
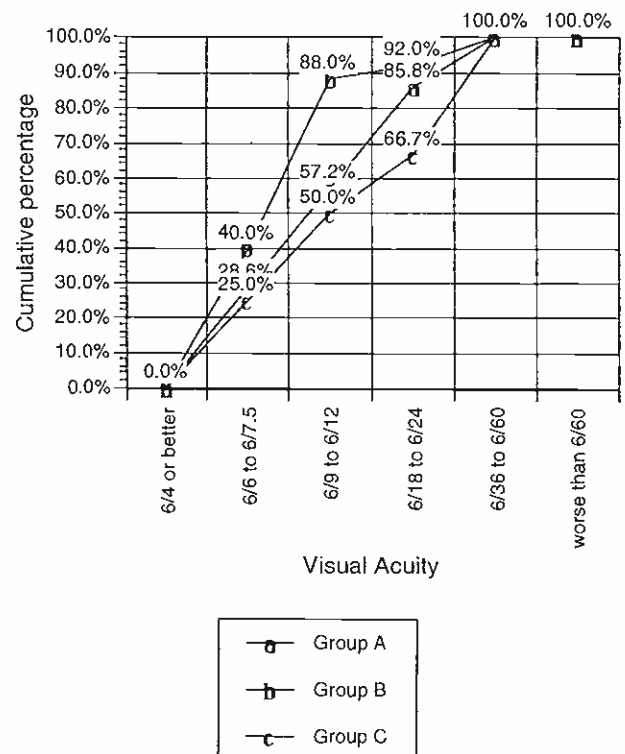


Table III - SE categories before and 3 years after surgery

Refraction	Before surgery		After surgery	
	No.	%	No.	%
Worse than -6D	12	23.5	0	0
-3.1D to -6D	25	49.0	3	5.9
-1.1D to -3D	14	27.5	10	19.6
0.0D to -1D	0	0	35	68.6
+0.1D to +1D	0	0	2	3.9
+1.1D to +3D	0	0	1	2.0

Fig 3 - Cumulative 3 year post operative uncorrected visual acuity levels by pre operative myopia groups



improvement of visual acuity three years after surgery. Best corrected vision after three years was no worse than before surgery in all eyes. Refractive results three years after surgery are shown in Table II. The mean pre-operative spherical equiv-

Table IV - Refractive results 3 years after surgery by level of pre-operative myopia

	Group A (n=14)	Group B (n=25)	Group C (n=12)
<i>Pre-operative SE in Dioptres</i>			
Mean	-2.63	-4.12	-7.76
Range	-2.0 to -3.0	-3.25 to -5.0	-6.38 to -11.25
<i>Post-op SE change (D)</i>			
Mean	+2.17	+3.68	+6.37
SD	1.01	0.71	1.42
Min	-1.75	-2.0	-3.75
Max	2.5	1.0	0
<i>% patients in each SE category post-op</i>			
worse than -6D	0	0	0
-3.1 to -6D	0	0	25% (3)
-1.1 to -3D	21.4% (3)	16% (4)	25% (3)
0.0 to -1D	71.4% (10)	76% (19)	50% (6)
+0.1 to 1D	0	8% (2)	0
+1.1 to 3D	7.1% (1)	0	0

Table V - Visual results by level of pre-operative myopia

Myopia group	6/12 or better	Within 1D of emmetropia
Worse than -6D	50%	50%
-6D and better	76.9%	79.0%

alent (SE) was -4.56 Dioptres(D). Three years after surgery the mean SE was -0.66D with a range of -3.75 to +2.5D. Table III shows the frequency of eyes in each dioptre range. 72.5% of all eyes were within 1D of emmetropia three years after surgery. A scatterplot of change in SE at three years versus pre-operative SE shown in Fig 2 further demonstrates the spread of SE values about the emmetropia line.

Visual and refractive results by degree of pre-operative myopia

Eyes were grouped by degree of pre-operative myopia. Group A: myopia of 3D or less; Group B: from -3.1D to -6D myopia; Group C: more than 6D of myopia. The post-operative uncorrected visual acuity for each group is illustrated in Fig 3. In Group A, 28.6% had uncorrected vision of 6/6 with 57.2% having uncorrected vision of 6/12 or better. In Group B, 40% had uncorrected vision of 6/6 and 88% were 6/12 or better. Group C showed 25% with uncorrected vision of 6/6 and 50% with 6/12 or better. Patients with lower pre-operative myopia ie 6D or less obtained the best visual results with a high percentage of eyes achieving 6/6 -6/12 uncorrected visual acuity. As the mean pre-operative SE increased in Groups A through C, there was a corresponding increase in the mean change in SE three years after operation. (See Table IV) In terms of reduction of refractive error to within 1D of emmetropia, Group A had 71.4% of eyes within this range; Group B, 84%, Group C, 50%. Undercorrections of more than 1D occurred most in Group C. There was a single case of overcorrection by more than 1D, which occurred to a patient with pre-operative myopia of -2.5D (Group A).

Visual and refractive results by age-group

56.9% of eyes were from patients under 35 years of age, and

Table VI - Comparison with PERK three year study

Study	No.	6/12 or better
PERK	435	76%
NUH (for eyes -8D and better)	47	74.5%

43.1% were 35 years and above. The mean SE of eyes from the under 35 group three years after surgery was -0.72D with a range from -3.75 to 2.5. In the 35 and above group, the mean SE three years after surgery was -0.59D with a range from -3.375 to 1.0D. This difference between the two age-groups was not statistically significant.

Astigmatism

There was an average of -0.49D of cylindrical refractive error before surgery, with a range from zero to -1.5D. Three years after surgery the mean cylinder measurement was -0.61D. There was an increase in astigmatism post-operatively in 33.3% of eyes. 41.2% had a reduction in astigmatism post-operatively. 25.5% showed no change. These results were not statistically significant.

Complications

Micro-perforations were the only intra-operative complications. In all instances they were self-sealing and there was no loss of anterior chamber. The most common post-operative complications such as glare, fluctuating vision, mild photophobia and mild irritation with tearing occurred in the initial few months after surgery. All these symptoms were annoying to the patients but were not incapacitating and disappeared within one year of surgery.

DISCUSSION

This paper discusses the third year and later results of 59 consecutive radial keratotomy (RK) surgeries mostly performed by two surgeons LCH and ASML at the National University Hospital, Singapore. Three eyes were operated on by two visiting surgeons. Follow up was obtained in 51 eyes. The post-operative results of LCH and ASML were not significantly different (p>0.05).

In this study, 33.3% of eyes achieved 6/6 uncorrected distance vision three years after surgery with 70.6% seeing at least 6/12. This was a vast improvement from pre-operative visual acuity levels where no eyes had 6/12 or better vision and 33.3% had worse than 6/60 vision. These results compare favourably with those from other larger studies. Sawelson and Marks⁽²⁾ reported 73% of eyes to be at least 6/12 at three years and the PERK⁽³⁾ three year study reported 76% of eyes to have at least 6/12 vision.

There was an overall decrease in refractive error three years after surgery with a mean spherical equivalent (SE) of -0.66D from a pre-operative mean SE of -4.56D. This was a mean change of +3.9D. 72.5% of all eyes and 79% of eyes initially -6D or better had a refractive error within 1D of emmetropia. These results were also in keeping with findings in the PERK study⁽³⁾ and the study by Sawelson and Marks⁽²⁾ which showed 58% and 61% respectively of eyes within 1D of emmetropia three years after surgery.

Analysis of results based on levels of pre-operative myopia showed a reduction in myopia in all three groups. The greatest change occurred in patients with the highest pre-operative myopia ie Group C. (Table IV) However, visual acuity and refractive results were best for eyes with pre-operative myopia of -6D and better. In these cases, 76.9% achieved 6/12 or better uncorrected vision three years after surgery and 35.9%

had 6/6 uncorrected vision. Seventy-nine percent of these eyes had post-operative SE within 1D of emmetropia. Similar trends were reported in the PERK⁽³⁾ three-year follow up study, the UCLA three-year study⁽⁴⁾ and others. (Table V)

When the results were adjusted to exclude those cases with pre-operative myopia above -8D (The PERK study⁽³⁾ was done on eyes with -2.0 to -8.0D refractive error) our three-year results are more similar to the PERK⁽³⁾ results with 74.5% having 6/12 or better vision and 76.6% within 1D of emmetropia. (Table VI)

An important aspect of the evaluation of radial keratotomy surgery is also patient satisfaction. The majority of patients were satisfied with the procedure and were generally pleased with their visual outcome. Most were no longer dependent on inconvenient spectacles or contact lenses. Those who had the operation on one eye because of pre-operative anisometropia were happy with their better quality of binocular vision. Even the few patients who were ambivalent about the results did not

express any regret for having undergone the operation.

CONCLUSION

On the whole, we can conclude from this study that radial keratotomy (RK) surgery has been safe and effective. We have had positive results through the three years and more following surgery. Careful selection of patients with less than 6D of myopia should ensure continuing good results after RK surgery.

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