

EFFECT ON MYOPIA AND ASTIGMATISM OF KERATOCONUS BY PENETRATING KERATOPLASTY UTILIZING GRAFTS OF VARIOUS SIZES

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Keratoconus causes not only high degrees of astigmatism but high degrees of myopia. It is known that penetrating keratoplasty in keratoconus will markedly reduce high astigmatism but it has not been widely recognized that the same operation can markedly reduce the myopia of keratoconus.

It is the purpose of this paper to report the effect on the myopia and astigmatism of keratoconus by penetrating keratoplasty utilizing grafts and openings of the same size, grafts larger than the opening, and grafts smaller than the opening.

METHODS & MATERIALS

The records of 91 consecutive eyes undergoing penetrating keratoplasty for keratoconus by the senior author were reviewed. Of these, refraction and keratometry readings were not available on 11 eyes because they had hydrops, 4 eyes had a followup of less than 4 months, and 4 eyes had other ocular pathologies superimposed (cataract extraction IOL implantation).

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The surgical technique employed was fairly standard. No scleral ring was used. The cone was reduced by cautery to flatten the corneal curvature. The cornea was trephined with the guard set at 0.3 mm and the incision was completed with razor blade and scissors. The graft was taken from whole eyes in the same manner after removing the epithelium. The graft from M-K preserved corneas was punched out from the endothelial surface. All grafts were sutured with deep (90-99%) interrupted sutures of either 9-0 silk or 10-0 nylon.

It has been the practice of the senior surgeon to experiment with different sized grafts and openings in penetrating keratoplasty for keratoconus. Therefore, a number of different sized recipient beds and graft sizes have been tried.

For purpose of analysis, the 72 eyes with complete data were divided into three main groups.

Group A. Fifty-five eyes undergoing penetrating keratoplasty for keratoconus utilizing grafts and openings of the same size. This group was subdivided into five subgroups: Group A-1 (4 eyes), 6 mm graft/opening; Group A-2 (10 eyes), 6.5 mm graft/opening; Group A-3 (15 eyes), 7.0 mm graft/opening; Group A-4 (25 eyes), 7.5 mm graft/opening, and Group A-5 (1 case) 8.0 mm graft/opening.

Group B. Six eyes undergoing penetrating keratoplasty for keratoconus utilizing a graft smaller than the opening. This group was subdivided into three subgroups: Group B-1 (2 eyes), 7.5 mm graft/7.50 mm opening; Group B-2 (3 eyes), 7.50 mm graft/7.75 mm opening; and Group B-3 (1 eye), 7.75 mm graft /8.00 mm opening.

Group C. Eleven eyes undergoing penetrating keratoplasty for keratoconus utilizing a graft larger than the opening. This group was subdivided into three subgroups: Group C-1 (2 eyes), 7.50 mm graft/7.0 mm opening; Group C-2 (3 eyes), 7.75 mm graft/7.50 mm opening; and Group C-3 (6 eyes), 8.0 mm graft/7.50 mm opening.

All eyes in the study underwent cycloplegic refraction preoperatively and at least 4 months postoperatively after all sutures had been removed. Followup examinations were conducted on an average of 40.2 months (range 4-176 mo). Postoperative astigmatism was determined by cycloplegic refraction.

With excessively distorted preoperative corneas, refraction was conducted over a trial hard contact lens.

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RESULTS

Of the 72 cases reviewed, the average age was 32.7 years (range 17-64 years) and average followup was 40.2 months (range 4-176 months).

Grafts were taken from whole eyes in 29 eyes and from M-K preserved corneas and cut from the endothelial surface in 43 eyes.

Grafts were sutured with interrupted 9-0 silk in 48 eyes and with 10-0 interrupted nylon sutures in 24 eyes. The use of silk or nylon was randomized. All sutures were removed by the end of 3 months postoperatively.

Group A. The reduction in myopia produced by utilizing a graft equal to the opening size is shown in Table 1. In this subgroup (A-1), 2 eyes showed an average decrease in myopia of 10.88 diopters (range 8.62-13.13) and 2 eyes an increase of 0.63 diopters (range 0.50-0.75). When a 6.5 mm graft opening was used 10 eyes showed an average decrease in myopia of 5.58 diopters (range 1.25-17.50). With a 7 mm graft opening 13 eyes showed an average decrease in myopia of 4.69 diopters (range 0.75-13.25) and 2 eyes showed an average increase of 2.5 diopters (range 2.37-2.63). When utilizing a 7.5 graft opening 20 eyes showed an average decrease in myopia of 6.4 diopters (range 0.75-14.75) and 5 an average increase in myopia of 1.15 diopters (range 0.12-4.00). The result of an 8.0 mm graft opening was a decrease in myopia of 0.38 diopters. In the entire Group A (eyes having the same size graft and openings) 46 eyes (83.64%) revealed a decrease in myopia of 5.88 diopters (range 0.38-17.50) and 9 eyes (16.36%) an increase of 1.33 diopters (range 0.12-4.00).

Group B. The result of utilizing grafts smaller than the opening is shown in Table 2. Two eyes with a 7.25 mm graft in a 7.5 mm opening showed an average decrease in myopia of 8.44 diopters (range 6.63-10.25). With a 7.5 mm graft 7.75 mm opening, 3 eyes showed an average decrease in myopia of 16.88 diopters (range 15.00-20.00), 1 eye had a 7.75 mm graft 8.00 mm opening and showed a decrease in myopia of 15.62 diopters. In the entire Group B (eyes with grafts smaller than openings), 6 eyes (100%) showed an average decrease in myopia of 13.86 diopters (range 6.63-20.00). None of the group showed an increase in myopia.

Group C. The grafts in this group were larger than the openings (Table 3). A 7.5 mm graft 7.0 mm opening in one eye resulted in a decrease in myopia of 9.63 diopters and in one eye an increase of 0.50. A 7.75 mm graft 7.5 mm opening in 3 eyes caused an average decrease in myopia of 3.66 diopters (range 2.75-5.13).

TABLE I
Change in myopia of keratoconus after penetrating keratoplasty using
a graft equal to the opening size (Group A)

No.	age	Graf size/ opening size (mm)	fresh or preserved	suture	Cycloplegic refraction (spherical equivalent in diopters)			decrease/increase myopia (diopters)	postop. astig.	followup period months
					preoperative	postoperative	postoperative			
1	35	6.0/6.0	F	10-0 N	-8.75	-0.13	8.62	5.25	7	
2	21	6.0/6.0	P	9-0 S	-19.13	-6.00	13.13	1.00	24	
3	25	6.0/6.0	F	10-0 N	-7.25	-7.75	(0.50)*	4.62	55	
4	30	6.0/6.0	P	9-0 S	-6.75	-7.50	(0.75)*	4.75	6	
5	51	6.5/6.5	P	9-0 S	-4.25	-3.00	1.25	4.25	8	
6	18	6.5/6.5	F	9-0 S	-1.00	+0.50	1.50	0.50	108	
7	38	6.5/6.5	F	10-0 N	-6.50	-4.50	2.00	8.25	155	
8	27	6.5/6.5	P	9-0 S	-12.38	-10.00	2.38	5.00	10	
9	27	6.5/6.5	F	10-0 N	-6.25	-1.75	4.50	6.00	11	
10	35	6.5/6.5	P	9-0 S	-10.63	-9.25	1.38	-	106	
11	34	6.5/6.5	P	9-0 S	-2.50	+4.75	7.25	1.25	40	

Change in myopia of keratoconus after penetrating keratoplasty using a graft equal to the opening size (Group A)

No.	age	Graft size/ opening size (mm)	fresh or preserved	suture	Cycloplegic refraction (spherical equivalent in diopters)			decrease/increase myopia (diopters)	postop. astig.	followup period months
					preoperative	postoperative	postop. astig.			
12	34	6.5/6.5	F	9-0 S	-13.75	-5.38	8.37	1.63	27	
13	64	6.5/6.5	P	9-0 S	-11.88	-2.25	9.63	1.00	44	
14	31	6.5/6.5	F	10-0 N	-27.75	-10.25	17.50	-	153	
15	34	7.0/7.0	F	10-0 N	-3.75	-2.50	0.75	5.00	4.5	
16	28	7.0/7.0	F	9-0 S	-15.00	-14.00	1.00	-	7	
17	33	7.0/7.0	F	9-0 S	-2.50	-0.38	2.12	0.75	119	
18	36	7.0/7.0	P	9-0 S	-3.50	-0.75	2.75	4.50	84	
19	36	7.0/7.0	F	9-0 S	-10.13	-6.75	3.38	2.00	4	
20	36	7.0/7.0	F	9-0 S	-6.00	-2.25	3.75	2.80	30	
21	27	7.0/7.0	P	9-0 S	-17.50	-12.25	5.25	9.00	54	
22	18	7.0/7.0	F	9-0 S	-8.50	-3.25	5.25	2.50	87	
23	37	7.0/7.0	P	9-0 S	-7.50	-2.00	5.50	2.00	32	

TABLE 1
 Change in myopia of keratoconus after penetrating keratoplasty using
 a graft equal to the opening size (Group A)

No.	age	fresh or preserved	Graf size/ opening size (mm)	suture	Cycloplegic refraction (spherical equivalent in diopters)			decrease/increase myopia (diopters)	postop. astig.	followup period months
					preoperative	postoperative	postoperative			
24	24	7.0/7.0	F	9-0 S	-11.00	-4.75	6.25	3.50	8	
25	43	7.0/7.0	P	9-0 S	-10.75	-4.37	6.38	7.50	7	
26	40	7.0/7.0	F	9-0 S	-9.75	-0.38	9.37	0.75	28	
27	17	7.0/7.0	F	10-0 N	-13.37	-0.13	13.25	0.75	176	
28	27	7.0/7.0	F	9-0 S	-7.00	-9.37	(2.37)*	0.63	7	
29	39	7.0/7.0	F	9-0 S	-19.12	-21.75	(2.63)*	3.50	76	
30	35	7.5/7.5	F	9-0 S	-8.75	-8.00	0.75	5.63	18	
31	40	7.5/7.5	P	9-0 S	-3.25	-1.62	1.63	3.50	15	
32	29	7.5/7.5	P	10-0 N	-4.50	-2.13	2.37	1.75	11	
33	30	7.5/7.5	P	10-0 N	-4.00	-1.25	2.75	9.25	18	

Change in myopia of keratoconus after penetrating keratoplasty using
a graft equal to the opening size (Group A)

No.	age	Graft size/ opening size (mm)	fresh or preserved	suture	Cycloplegic refraction (spherical equivalent in diopters)			decrease/increase myopia (diopters)	postop. astig.	followup period months
					preoperative	postoperative	postoperative			
36	27	7.5/7.5	F	9-0 S	-4.25	+0.38	4.63	0.75	24	
37	24	7.5/7.5	P	9-0 S	-10.00	-4.75	5.25	5.50	7	
38	23	7.5/7.5	P	9-0 S	-14.25	-8.75	5.50	6.00	108	
39	39	7.5/7.5	P	10-0 N	-8.50	-2.75	5.75	2.50	5.5	
40	24	7.5/7.5	F	9-0 S	-9.25	-3.37	5.88	6.00	3.5	
41	56	7.5/7.5	P	9-0 S	-13.50	-7.25	6.25	5.00	7	
42	51	7.5/7.5	P	9-0 S	-7.63	-1.25	6.38	2.25	7	
43	28	7.5/7.5	F	9-0 S	-8.50	-	8.50	4.00	124	
44	28	7.5/7.5	P	9-0 S	-15.50	-7.00	8.50	10.00	5.5	
45	22	7.5/7.5	F	9-0 S	-14.00	-4.50	9.50	-	144	
46	24	7.5/7.5	P	9-0 S	-10.25	-0.75	9.50	0.75	19	
47	33	7.5/7.5	P	9-0 S	-14.25	-3.25	11.00	3.75	7	

TABLE I
Change in myopia of keratoconus after penetrating keratoplasty using
a graft equal to the opening size (Group A)

No.	age	Graft size/ opening size (mm)	fresh or preserved	suture	Cycloplegic refraction (spherical equivalent in diopters)			decrease/increase myopia (diopters)	postop. astig.	followup period months
					preoperative	postoperative	postoperative			
48	32	7.5/7.5	F	9-0 S	-18.00	-6.62	11.38	7.25	150	
49	38	7.5/7.5	F	9-0 S	-18.12	-3.37	14.75	2.12	18	
50	31	7.5/7.5	P	9-0 S	-7.38	-7.50	(0.12)*	7.75	5	
51	29	7.5/7.5	F	9-0 S	-3.13	-3.63	(0.50)*	4.00	148	
52	43	7.5/7.5	P	9-0 S	-4.00	-4.50	(0.50)*	2.50	30	
53	30	7.5/7.5	P	9-0 S	-6.25	-6.87	(0.63)*	2.75	5	
54	31	7.5/7.5	P	9-0 S	-6.50	-10.50	(4.00)*	7.37	91	
55	38	8.0/8.0	F	9-0 S	-22.50	-22.12	0.38	5.75	87	
Av.	32.7				-9.74	-4.87	5.88/1.33	3.93	46.6	

* Numbers in parentheses indicate postoperative increase in myopia.

F fresh donor cornea.

P preserved in M-K media.

N nylon.

S silk.

Change in myopia of keratoconus after penetrating keratoplasty using
a graft smaller than the opening size (Group B)

No.	age	Graf size/ opening size (mm)	fresh or preserved	suture	Cycloplegic refraction (spherical equivalent in diopters)			decrease/increase myopia (diopters)	postop. astig.	followup period months
					preoperative	postoperative				
1	32	7.25/7.50	P	10-0 N	-11.25	-5.13	6.63	2.25	4.5	
2	25	7.25/7.50	P	10-0 N	-12.00	-1.75	10.25	2.50	23	
3	33	7.50/7.75	P	10-0 N	-15.38	+0.25	15.63	1.00	3.5	
4	33	7.50/7.75	P	9-0 S	-18.50	+1.50	20.00	4.50	3.5	
5	41	7.50/7.75	P	10-0 N	-20.15	-5.25	15.00	4.50	9	
6	54	7.75/8.00	P	10-0 N	15.00	+0.62	15.62	2.75	4	
Av.	36.33				15.38	1.63	13.86	2.92	7.91	

F fresh donor cornea.

P preserved in M-K media.

N nylon.

S silk.

TABLE 3
 Change in myopia of keratoconus after penetrating keratoplasty using
 a graft larger than the opening size (Group C)

No.	age	Graft size/ opening size (mm)	fresh or preserved	suture	Cycloplegic refraction (spherical equivalent in diopters)			decrease/increase myopia (diopters)	postop. astig.	followup period months
					preoperative	postoperative	postoperative			
1	17	7.50/7.0	P	10-N	-12.75	-3.13	9.63	3.25	10	
2	20	7.50/7.0	P	9-0 S	-3.25	-3.75	(0.50)*	3.50	65	
3	47	7.75/7.50	P	10-0 N	-9.00	-6.25	2.75	5.50	31	
4	54	7.75/7.50	P	10-0 N	-10.87	-7.75	3.12	6.13	22	
5	34	7.75/7.50	P	10-0 N	-3.00	+2.13	5.13	2.00	110	
6	27	8.0/7.50	P	10-0 N	-4.63	-3.75	0.88	4.00	8	
7	25	8.0/7.50	P	10-0 N	-12.75	-9.50	3.25	7.12	6	
8	30	8.0/7.50	P	9-0 S	-12.00	-4.12	7.88	1.00	5	
9	43	8.0/7.50	P	10-0 N	-14.88	-3.50	11.38	1.88	16	
10	48	8.0/7.50	P	10-0 N	-9.00	-12.00	(3.00)*	1.25	7	
11	32	8.0/7.50	P	10-0 N	-4.00	-11.00	(7.00)*	8.8	4	
Av	34.3				-8.74	-5.69	5.5/3.5	4.04	25.8	

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Using an 8.0 mm graft / 7.5 mm opening in 4 eyes there was an average decrease in myopia of 5.84 diopters (range 0.88-11.38) and an increase in 2 eyes of 5 diopters (range 3.0-7.0). In the entire Group C (eyes with grafts larger than openings) 8 eyes (72.72%) revealed an average decrease in myopia of 5.50 diopters (range 0.88-11.38) and 3 eyes (27.27%) showed an average increase of 3.50 diopters (range 0.50-7.00).

Of the 72 eyes undergoing penetrating keratoplasty for keratoconus, 60 eyes (83.33%) revealed an average decrease in myopia of 6.63 diopters (range 0.38-20.00) and 12 eyes (16.67%) an average increase in myopia of 1.88 diopters (range 0.12-7.00).

Postoperative astigmatism for the three groups is shown in Table 4. Group A, showed an average postoperative astigmatism of 4.19 diopters (range 0.50-10.00), Group B, 2.82 diopters (range 1.00-4.50) and Group C, 3.98 diopters (range 1.00-8.80).

Donor material was obtained from whole eyes in 29 / 72 (40%) of the penetrating keratoplasties. Average postoperative myopia and astigmatism in this group was (decrease / increase) 6.08 / (1.5)* and 3.31 diopters respectively. Donor material was obtained from M-K preserved corneas and out from the endothelial surface in 43 / 72 (60%) eyes. Average postoperative myopia and astigmatism in this group was (decrease / increase) 7.03 / (2.06)* and 4.21 diopters respectively (Table 5).

Silk interrupted sutures were employed in 48 / 72 (66%) of the eyes (Table 6). Average postoperative myopia (decrease / increase) was 6.19 / 1.33 diopters and average postoperative astigmatism was 3.62 diopters (range 0.50-10.00). Nylon sutures were used in 24 / 72 (29%) of the eyes. Average postoperative myopia (decrease / increase) was 7.46 / 3.5 diopters; the average postoperative astigmatism was 3.62 diopters (0.75-8.80).

DISCUSSION

Troutman and Meltzer¹ reviewed the literature in 1972 and failed to find any reports of the effect of keratoplasty on the myopia of keratoconus. They reviewed 82 eyes that had undergone penetrating keratoplasty for keratoconus. The diameter of the grafts varied between 7 mm and 9 mm with 23 grafts of 7.5 mm or less all closed with interrupted silk sutures and 59 grafts of 8 mm or more all closed with nylon sutures. Apparently all grafts and openings were the same size. The authors found that grafts less than 7.5 mm sutured with silk had an average myopia of -4.2 diopters postoperatively while grafts 8-9 mm sutured with

TABLE 4
Postoperative astigmatism after penetrating
keratoplasty for keratoconus

Group A	Graft/opening, same size	Astigmatism diopters
A-1	6.0/6.0	3.91
A-2	6.5/6.5	3.49
A-3	7.0/7.0	3.23
A-4	7.5/7.5	4.58
A-5	8.0/8.0	5.75
average		4.19
Group B	graft smaller/opening	
B-1	7.25/7.50	2.38
B-2	7.50/7.75	3.33
B-3	7.50/8.0	2.75
average		2.82
Group C	graft larger/opening	
C-1	7.50/7.00	3.38
C-2	7.75/7.50	4.54
C-3	8.00/7.50	4.01
average		3.98
Total average 3.66		

TABLE 5
Comparison of fresh or preserved (M-K) donor tissue on the change
in myopia and postoperative astigmatism after
penetrating keratoplasty for keratoconus

	No.	Decrease/increase in myopia	Postoperative astigmatism
Fresh	29	6.08/(1.5)*	3.31
Preserved (M-K)	43	7.03/(2.06)*	4.21

* Numbers in parentheses indicate postoperative increase in myopia.

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TABLE 6

Comparison of interrupted silk and nylon sutures on the change in myopia and postoperative astigmatism after penetrating keratoplasty for keratoconus

	No.	Decrease/increase in myopia	Postoperative astigmatism
Nylon	24	7.46(3.5)*	4.19
Silk	48	6.19/(1.33)*	3.62

* Numbers in parentheses indicate postoperative increase in myopia.

nylon had an average of -1.4 diopters postoperatively. The authors did not state the preoperative cycloplegic refraction or whether the postoperative measurements were made after sutures were removed.

Jensen and Maumanee² reviewed 39 eyes that had undergone penetrating keratoplasty for keratoconus and found there was an average residual myopia of -4.33 diopters when interrupted sutures were used and -2.47 diopters when continuous nylon sutures were used. Apparently all grafts/openings were the same size. These authors did not state whether measurements of the residual myopia was before or after all sutures were removed.

Rubens and Colebrook³ reviewed 53 eyes undergoing penetrating keratoplasty for keratoconus which showed an increase in postoperative myopia from -1.82 diopter to -3.64 diopters after all sutures had been removed with a 5 year followup examination.

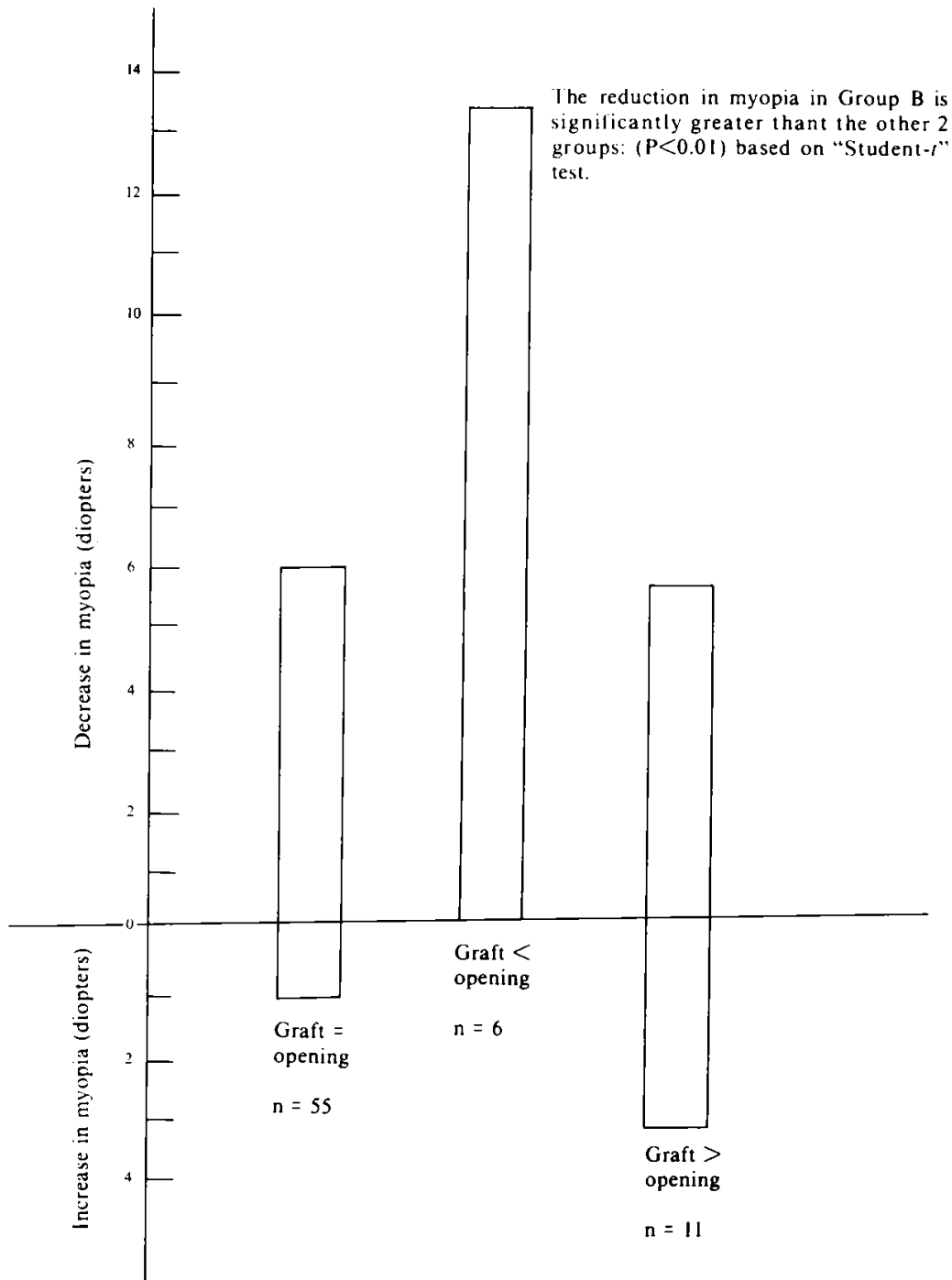
It is apparent that the final postoperative evaluation of the corneal curvatures cannot be made until all sutures have been removed.

Myopia can be axial, refractive or both. In keratoconus, the conical portion of the cornea projects anteriorly to the surrounding cornea. The myopia of keratoconus is the result of the steeper curvature of the cone and the increase in axial length. The myopia of keratoconus can be superimposed on an otherwise emmetropic eye or an eye with refractive or axial myopia.

The present study shows that replacement of the conical portion of the cornea usually reduces the myopia of keratoconus.

FIGURE 1

Effect of graft size vs. opening size in the reduction of myopia of keratoconus by penetrating keratoplasty.



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The average decrease in myopia of keratoconus after penetrating keratoplasty in 58 72 eyes was 6.63 diopters (range 0.38-20.00). Group A had an average decrease of 5.88 diopters, Group B, 13.86 diopters, and Group C, 5.50 diopters. The average increase in myopia of keratoconus after penetrating keratoplasty in 12 72 eyes was 1.88 diopters (range 0.12-7.00). Group A, had an average of 1.33 diopters Group B, zero and Group C, 3.50 diopters.

The results showed that there can be decrease in myopia with any size graft. However, the greatest average decrease in myopia (13.86 diopters) occurred in Group B, in which a graft smaller than the opening was used. Statistical analysis of the data using the "Student-t" test showed that the reduction in myopia in Group B, is significantly greater than both of the other groups at a 99% confidence level ($p < 0.01$).

Group B had the largest average preoperative myopia (15.38 diopters) as compared to Group A (9.74 diopters) and Group C (8.74 diopters). Even though Group B showed the highest average preoperative myopia, it displayed the largest average decrease in myopia and the lowest residual myopia.

There were no complications, operative or postoperative, when a smaller graft than opening was used. Apparently it is unnecessary to replace the exact amount of tissue removed from the recipient as advocated by Olson^{4, 5}. There were no incidences of increased intraocular pressure, short term or long term as reported in aphakic keratoplasty by Olson and Kaufman⁶. There were no difficulties in fitting these eyes with contact lenses. Because of their low residual myopia and astigmatism, some patients in this group prefer spectacles.

Barraquer⁷ has stated that he has tried to alter the corneal curvature by using disparate grafts and openings but without apparent success.

The second largest average decrease in myopia was found with grafts equal to the size of the opening. Grafts larger than the opening showed the lowest average decrease in myopia.

There was no correlation between the followup period and age of the patients and their change of myopia. In analyzing the eyes in which myopia increased after surgery, we noted that 7 of the 12 eyes revealed an increase of under 1.00 diopter.

The average postoperative astigmatism for the entire group was 3.66 diopters. Group A showed an average of 4.19, Group C 3.98, and Group B, the least, 2.82

diopters. The data showed Group B to have the lowest postoperative astigmatism as compared to the other two groups, however, at a very low confidence level ($p \geq 0.01$).

There was no significant difference in average postoperative myopia and astigmatism when whole eyes (6.08/(1.5)* and 3.31 respectively) or M-K preserved corneas (7.03/(2.06)* and 4.21 respectively) were used for donor material.

There was no significant difference in average postoperative myopia and astigmatism when nylon (7.46/3.5)* and 4.19 diopters respectively) or silk (6.19/1.33)* and 3.62 diopters respectively) were used for suture material.

The average postoperative astigmatism for the entire group was 4.04 diopters (range 0.50-10.00) which compares favorably with the reports of others ^{1, 2}. Group B, grafts smaller than openings showed the least postoperative astigmatism (2.82 diopters) as well as the greatest reduction in myopia (13.86 diopters) ($p < 0.01$). These results favor the use of a graft smaller than the opening in keratoconus.

SUMMARY

The records of 91 consecutive keratoconic eyes undergoing penetrating keratoplasty performed by the senior author were reviewed for changes in myopia and astigmatism. Records of 72 eyes had sufficient data for analysis postoperatively. Ages of the patients averaged 32.7 years. All sutures were removed after 3 months. Followup average was 40.2 months. Results showed an average decrease in myopia of 6.63 diopters (range 0.38-20.00) in 60/72 (82.86%) and an average increase in myopia of 1.88 diopters (range 0.12-7.00) in 12/70 eyes (17.14%). The decrease, increase in myopia and postoperative astigmatism was compared for grafts equal to the openings, grafts smaller than the openings, and grafts larger than the openings. The largest average decrease in myopia was 13.86 diopters (range 6.63-20.00) occurring when a graft smaller than the opening was used ($p < 0.01$). This group also showed the least postoperative astigmatism (2.82 diopters) ($p \geq$). There was no significant difference in average postoperative myopia and astigmatism when whole eyes or M-K preserved corneas were used for donor material. There was no significant difference in average postoperative myopia and astigmatism when nylon or silk was used for interrupted sutures after all sutures had been removed. From this study, it appears that the use of a graft 0.25 mm smaller than the trephine opening in the host (i. e. 7.50 mm graft 7.75 mm opening) for penetrating keratoplasty in keratoconus is justified. A prospective study on this subject is now in progress.

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