GLASS CONTACT LENSES* EFFECTS OF VENTILATION

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THE earlier types of contact lenses had certain disadvantages. One of the most troublesome was the phenomenon of veiling described by Sattler (1938). If the lens is not removed once the veil has formed, epithelial bullae develop and rupture, leaving Bowman's membrane exposed. These abrasions are very painful and may take up to 48 hours to heal. It is known that this veiling is due to oedema of the corneal epithelium, but the mode of formation of the oedema is less well understood. Suggestions include:

- (1) strangulation of the limbal vascular mesh which provides the nutritional fluids for the cornea and of the small veins of the ciliary region which remove metabolites,
- (2) interference with direct exchange of gases between the corneal epithelium and the air,
- (3) stoppage of tear circulation beneath the lens, and prevention of the constant massage of the eye by the blinking movements of the lids.

Whatever the cause, much research has been directed towards the delay or prevention of this veiling, and Bier (1943, 1948) and Dallos (1946) independently reported the encouraging effects of providing the lens with a means of ventilation (fenestration, perforation, channelling).

Scope of Present Investigation

— By 1952 it was considered that sufficient time had elapsed since the introduction of the ventilated lens to permit the accurate assessment of its value as compared with that of the non-ventilated lens and the present inquiry was accordingly initiated under the auspices of the Institute of Ophthalmology.

The task was simplified by the fact that Cross (1949) had reported an analysis of the results of the use of non-ventilated glass contact lenses by over 800 patients. The present investigation was thus confined to the examination of wearers of ventilated contact lenses.

Contact lens practitioners throughout the United Kingdom were circularized and asked for details of patients fitted with ventilated lenses. From their answers it appeared that such lenses were being supplied by one organization only, the Contact Lens Centre maintained by Messrs Theodore Hamblin Ltd. Dr. J. Dallos is responsible for the work of this centre and for training the fitters working in other centres. A list of all patients fitted with this type of lens was supplied by these centres and each patient was sent a copy of a questionnaire which was made to resemble as closely as possible that used by Cross, in order to make the results comparable (*see* Figure). It differed only in the addition of questions W (a), (b), and (c), designed to elicit a direct comparison between ventilated and non-ventilated lenses from patients who had worn both types.

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GLASS CONTACT LENSES

CONTACT LENS INQUIRY

101

Please ring appropriate number e.g. (2)

A	NAME	(write in)	
B	ADDRESS	(write in)	
C (a)	MAN		1
	Occupation	(write in)	
	Mainly indoor		2
	Mainly outdoor		3
(b)	WOMAN		1
	Housewife		2
	Other occupation	(write in)	
	Mainly indoor		3
	Mainly outdoor		4
D (a)	AGE when fitted with perforated contact lens	Up to 30 yrs	1
		31-50 yrs	2
		Over 50 yrs	3
(b)	How long ago was this?	 mths yrs	
E	OCULAR CONDITION	(write in)	
F	REFERRED BY	(name of surgeon)	
G	FITTED BY	Clement Clarke Ltd.	1
		Theodore Hamblin Ltd.	2
		Davis Keeler Ltd.	3
H	FITTING TIME		
	(a) No. of sessions	(fill in)	
	(b) Period (wks) over which sessions extended	(fill in)	
I	WEAR		
	(a) Do you, at the present time, wear your perforated contact lenses?		
	Yes		1
	Occasionally		2
	One eye only		3
	No		4
	(b) If NO: For how long did you wear them?	 mths yrs	
	(c) Why did you give them up?	 (write in)	

Please answer the remaining questions with reference to the period when you were wearing the lenses

J (a)		Are they worn every day?	Yes	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">1</div>
			No.	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">2</div>
(b)		If NO: For how many days a week?	 days	
K (a)		What is the total number of hours they are worn per day?	 hrs	
(b)		For what average periods per day are they worn?	 hrs	
(c)		What is the interval between periods of wearing them each day?	 mins hrs	
		Are they worn only once a day?		<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">1</div>
L		Are they worn at work?	Yes	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">1</div>
			No	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">2</div>
M(a)		Is there any discomfort in wearing them?	Yes	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">1</div>
			No	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">2</div>
			Sometimes	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">3</div>
(b)		Do you notice blurred vision while wearing the lenses?		
			Yes, always	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">1</div>
			Yes, sometimes	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">2</div>
			No	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">3</div>
		(Ring which is applicable)	Left eye only	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">1</div>
			Left eye more	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">2</div>
			Both equally	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">3</div>
			Right eye only	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">4</div>
			Right eye more	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">5</div>
(c)		After how long wearing the lenses?		
(d)		For how long does the blur persist after removal of the lens?	 hrs	
(e)		If the lens is re-inserted immediately the blur clears, how long is it before it comes back?	 hrs	
(f)		Do any of these reasons for removal also apply?		
		(Ring all applicable)	Irritation	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">1</div>
			Smarting	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">2</div>
			General discomfort	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">3</div>
			Watering	<div style="border: 1px solid black; width: 20px; height: 20px; text-align: center; line-height: 20px;">4</div>
		Other	(write in)	

N	(a) Do you put the lens into the eye dry?	Yes	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
	(b) If NO:	Fluid used(write in)	
O	Do you feel that the period without blurring is influenced by the strength or composition of the solution used?	Yes, it is better if I use (write in)	
	No		<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
P	(a) Are you aware of air bubbles?	Yes, always	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
		Yes, sometimes	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
		Not at all	<div style="border: 1px solid black; padding: 2px; display: inline-block;">3</div>
	(b) If YES: Are they a help or a hindrance?	Help	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
		Great trouble	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
		Slight trouble	<div style="border: 1px solid black; padding: 2px; display: inline-block;">3</div>
		Don't mind	<div style="border: 1px solid black; padding: 2px; display: inline-block;">4</div>
Q	(a) Which conditions are the most favourable for wearing contact lenses?.....	 (write in)	
		All the same	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
	(b) Which conditions are the most unfavourable?	 (write in)	
		All the same	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
R	When reading with contact lenses do you have to wear spectacles also?	Yes	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
		No	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
S	(a) What benefits do you appreciate most in contact lenses?.....	 (write in)	
		None	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
	(b) In what respects have you been disappointed with them?.....	 (write in)	
		None	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
T	Were you, personally, anxious to have contact lenses, or were you persuaded into having them?	Anxious to have them	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
		Persuaded	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
		Half and half	<div style="border: 1px solid black; padding: 2px; display: inline-block;">3</div>

V	How many times have the lens been repolished?	 times
	None	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>

W (a)	Have you ever worn non-perforated contact lenses?	
	Yes	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
	No	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
(b)	If YES: How do they compare?	
	Perforated better	<div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div>
	Non-perforated better	<div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div>
	About the same	<div style="border: 1px solid black; padding: 2px; display: inline-block;">3</div>
(c)	If BETTER: In what way?	(write in)

X	Additional comments, criticisms, or suggestions:
	
	
	
	
	

Method of Fitting.—Because all the lenses reviewed in this investigation were fitted either by Dr. Dallos or by fitters trained by him, it was considered advisable to obtain a detailed account of the routine employed in this series. I am indebted to Dr. Dallos for the following account of the method used:

The lenses upon which this survey is based are made of glass and are fitted with the object of securing even contact over both cornea and sclera except at the limbal region where they are perforated in the interpalpebral area.

Their average size is 26.5 mm. (range 24–29 mm.) in their largest diameter, and their average thickness is 0.8 mm., though lenses of high refraction may measure 0.4 to 1.2 mm. in some parts of the optical area.

The criterion of even contact is rather negative; it is such that once obtained a deviation of 25 μ in the corneal region or 50 μ over the scleral conjunctiva becomes clinically noticeable through ischaemic patches, irregular air routes, rotation of the lens, and reduced tolerance.

The fitter obtains the even contact by objective fitting in systematic stages and then confirms its results both objectively and, through the patient, subjectively. First, he selects a lens out of a collection of several thousand haptic trial shells catalogued according to size, depth, and toricity for each of the more frequent clinical conditions where contact lenses are indicated. Such conditions as high myopia, hypermetropia, keratoconus, and mustard-gas scarring possess features of configuration peculiar to themselves. A correct selection from the trial shells should result in an approach within 200 μ of the haptic surface of the individual eyeball. By grinding and polishing off capillary layers over areas which appear to the fitter to be too close, partly through the prescribed manipulation of detaching the trial shell and re-attaching it in all sectors around the clock and watching the gradual and complete re-attachment, and partly by checking up on the resulting absence of previously observed unevenness and the possible emergence of new signs of misfit—

a further approach to about 50μ is obtained in the course of several fittings. At this stage, a tolerance test with the unperforated trial shell will give some relevant information about the patient's subjective and objective tolerance.

The perforation is usually made below the horizontal at the temporal limbus. Following this, the static haptic surface will require adjustment for correct functional behaviour. Disruption of adhesive contact leads to greatly increased lag of the lens during rotation of the eye, necessitating increased freedom from limbal contact for unhampered corneal movement within. This is achieved by flattening the corneal radius and grinding out a limbal ring. With the haptic surface thus receding to a thicker and more compressible peripheral zone of the bulbar conjunctiva, a further vaulting of the central area becomes necessary if even pressure is to be maintained over the area of corneal contact.

Calibration here must go to 25μ if stippled veiling is to be kept off. Should longer wear (6-8 hrs.) result in corneal turbidity, which is a change of refraction towards myopia with reduced visual acuity or "late" Sattler-type veiling, the release of a further perilimbal haptic ring with subsequent capillary corneal calibration may allow for better limbal circulation. This may be offset if the remaining haptic surface is reduced to such an extent that conjunctival strangulation occurs.

The optical properties of the actual lens centred in the physiological axis aim at emmetropic full correction. This is obtained by the proper choice of the anterior surface of the corneal portion of the contact lens except where lenticular astigmatism requires consideration as well. Refraction is checked up after the completion of the fitting, *i.e.* before, and also after, the manufacture of the final article, so that possible discrepancies are discovered and adjusted before the lens comes into use.

When full correction is obtained and confirmed, the patient is asked to wear his lenses for 4-hour periods twice a day with an interval of an hour or more in between. He should now be fully conversant with the handling and use of his lenses. He has been instructed to insert them after smearing with castor oil to prevent frothing and moistening with saline, and to wash and dry the lenses after removal so as to keep the fenestration clear. After 4 to 6 weeks, a second check is made and this may reveal a relaxation of ciliary tension, especially in hypermetropes, irregular astigmatics, and young myopes. This necessitates optical adjustment of the lens, which helps towards further guidance. Normally one of the 4-hr periods is extended to 6 hrs for the coming 2 or 3 months, after which a last visit is arranged before finally referring the patient back to his surgeon. Further extension of wear and, in fact, all further routine then largely depends on individual requirements and preferences, though most cases require further help and supervision. In order to make the best use of their contact lenses errors in handling and use which lead to smudging of the lens need to be eliminated. Unocular aphakics may need orthoptic exercises, and reading glasses may be necessary in presbyopes and in higher myopes where the effect described by Erggelet (1930) imposes an unaccustomed accommodative strain.

The ventilated lens differs from the non-ventilated type in these respects:

- (1) Suction between lens and globe is eliminated, permitting greatly increased movement of the lens upon the globe.
- (2) Air bubbles are, of course, always present, and should be away from the optical axis of the system.
- (3) The perforation is often obvious and may be a slight cosmetic disadvantage. There may also be a clicking sound as the lids open and close over the perforation.
- (4) Ventilation introduces no new factor into the optics of the system, which is the same as with non-ventilated lens.

Results of this Survey

This type of investigation has certain disadvantages, for example the difficulty of classifying some of the answers, *e.g.*:

Q.I (c) Why did you give up the lenses?

A. Without contact lenses I can see double very blurred, but with them in I can see double very plain.

Q.S (a) What benefits do you appreciate most in contact lenses?

A.1 My eyes are seen to better advantage and I have such lovely eyes.

A.2 I can wear fancy hats.

Where the question was not answered or the answer was contradicted elsewhere in the questionnaire, the reply was omitted from the analysis.

In the following Tables all figures are expressed as percentages except where otherwise stated. The figures printed in *italics* are taken from the paper by Cross (1949) so that the differences and similarities between the ventilated and non-ventilated lenses may be seen at a glance.

(1) *Response to Questionnaire* (Table I).—The later investigation produced a 15 per cent. better response, 62 as against 47 per cent. This could indicate increasing public interest in research of this nature since the introduction of the National Health Service in 1948. The information provided by the answers to the questions was transferred to punch-cards of the Findex type, so that tabulation of the results was appreciably simplified.

TABLE I
QUESTIONNAIRE

Response	Present Inquiry	Cross, 1949
No. sent out	1,283	1,850
Replies received	785	875
Percentage response	62	47

(2) *Ocular Conditions for which Contact Lenses were Ordered*.—In the present series more than double the number of aphakics have been fitted (Table II). The number of mustard gas keratitis cases has declined by over two-thirds, which indicates that fresh cases of this nature are not likely to develop at this distance of time since exposure to the irritant.

TABLE II
CONDITIONS FOR WHICH LENSES WERE SUPPLIED

Condition	Total		Men		Women	
Myopia	57	59	43.5	46	68	70
Aphakia	10.5	4	18.5	5	6	4
Keratoconus	8.5	10	3.4	3	8.5	16
Mustard gas keratitis	4	14	8.5	29	.05	0.5
Irregular astigmatism	8	0	9.5	0	6	0
Non-specific keratitis	7	0.5	8.5	0.5	4	0.5
Pemphigus	0.1	0	0	0	.05	0
Neuro-paralytic keratitis	4	0.5	6	0.5	3.4	0.5
Ophthalmia neonatorum	0.4	0	0.1	0	0.1	0
Others	1.5	5.5	2	8	0.4	3

(3) *Age of Patient when Lenses were Fitted.*—There would appear to be little difference between the two series in this respect (Table III).

TABLE III
AGE OF PATIENTS

Age (yrs)	Under 30		31-50		50+	
Total	43	38	39	34	16.5	16
Men	31	32	42	32	25	26
Women	50	44	38	34	11	8

(4) *Length of Time since Lenses were Fitted.*—Table IV, col. 6, shows that only one-third as many ventilated lenses have been worn for 5-10 years. This is only to be expected in view of their more recent development.

TABLE IV
TIME SINCE LENSES WERE FITTED

Years	0-1		1-2		2-3		3-4		4-5		5-10		10+	
Total	10	8	20	22	25	17	18	10	14	8	7	20	1	1
Men	9	6	24	20	26	16	16	9	12	9	5.5	22	1.5	0.5
Women	10	9	20	24	23	17	20	12	15	8	8	18	0	1

(5) *No. of Sessions needed for Fitting* (Table V).—Little reliance can be placed on this Table, as this question was one of the worst answered (*e.g.* “a great many”, “went on for months”, “had a baby and then had to start all over again”, etc.) The records of the Contact Lens Centre show, however, that the average number of sessions employed is about twenty for both types of lens. This represents a considerable number of both patient-hours and fitter-hours. It must therefore constitute a deterrent to busy patients as well as being a large factor in the high cost of these lenses.

TABLE V
SESSIONS EMPLOYED IN FITTING

No. of Sessions	1-5		6-10		11-15		16-20		21-30		31-40		41-50		51-60		60+	
Total	4	11	13	17	11	12	14	10	18	10	6	3	4	2	3	1	4	4

(6) *Tolerance.*—Table VI represents the crux of this investigation. Col. 2 shows that the number of patients who have given up using their contact lenses has been reduced from 1 in 3 wearers of non-ventilated lenses to 1 in 5 wearers of ventilated lenses.

TABLE VI
LENSES WORN AT PRESENT TIME

Answer	Yes		No		Sometimes or Occasionally		One eye only	
Total	37	55	20	33	25	9	18	3
Men... ..	27	49	22	38	26	9	25	4
Women	45	61	19	28	24	10	12	1

Tables VII-X show that there is a close similarity between the two series, rather than any marked differences. It must be remembered, however, that these Tables record what the patients actually do to suit their daily lives rather than what they are capable of doing under experimental conditions.

TABLE VII
LENSES WORN EVERY DAY

Answer	Yes		No		Usually	
Total	66	75	33	16	1	9
Men	69	74	31	18	0	8
Women	67	76	32	14	1	9

TABLE VIII
AVERAGE PERIODS OF WEAR (HRS)

Hours	1	2	3	4	5	6	7	8	8—	Variable
Length of time worn at a stretch	1 1	5 7	12 8	17 18	6 7	6 4	2 2	6 2	21 30	6 18
Total hours worn each day	1 1	2 2	7 2	11 7	5 3	10 4	5 1	14 11	42 47	3 18

TABLE IX
INTERVAL BETWEEN PERIODS OF WEAR

Hours	Less than 1	1	2	3	3+	Variable
Total ...	15 8	23 13	14 11	3 4	13 6	32 11

TABLE X
LENSES WORN AT WORK

Answer	Yes		No		Sometimes	
Total	69	72	28	15	3	8
Men	70	72	27	14	3	8
Women	65	73	31	16	4	7

(7) *Tolerance in certain Pathological Conditions.*—The first section (A) of Table XI (opposite) presents the most instructive analysis of the available information on this point. It shows that keratoconus and mustard gas keratitis are the two conditions best treated with contact lenses, with myopia close behind. The results with aphakia continue to be less satisfactory. It is interesting that, whereas ventilation has reduced by one-half to two-thirds the number of lenses no longer used in myopia, aphakia, and keratoconus, there has been a slight increase in the percentage of lenses given up by mustard gas keratitis cases. Possibly this is due to the increased movement upon the cornea permitted by the ventilated lens. It is becoming apparent that contact lenses are less useful as the mustard gas keratitis becomes worse.

It was not practicable to separate the myopes according to their refraction, but the impression remains that the greater the degree of myopia, particularly when associated with astigmatism, the more suited they are by contact lenses. Presumably the greater the refractive error the more the patient gains by wearing contact lenses.

There was also the impression that binocular aphakics are more successfully treated with contact lenses than unocular aphakics, due to the elimination of aniseikonia, where both eyes are aphakic.

TABLE XI
TOLERANCE IN CERTAIN PATHOLOGICAL CONDITIONS

Pathological Conditions		Myopia		Aphakia		Keratoconus		Mustard Gas Keratitis	
(A) Lenses still worn	Yes	60	51	44	46	70	74	67	77
	No	14	37	18	32.5	6	15	17	12
	Occasionally	19	11	11	15	14	5	8	5
	One eye only	7	1	27	6.5	10	6	8	6
(B) Lenses worn every day	Yes	66	73	70	62	75	83	78	74
	No	33.5	18	30	33	25	9	22	12
	Occasionally	0.5	9	0	0	0	6	0	14
(C) Length of time worn each day (hrs)	1	1	1	2	0	1	0	0	0
	2	3	2	2	5	1	0	0	3
	3	7	3	6	5	9	0	15	1.5
	4	12	7	12	9	9	4	4	1.5
	5	4	4	2	0	4	0	7	3
	6	10	4.5	12	0	10	2	7	6
	7	5	1.5	2	5	4	2	7	0
	8	12	9	19	9	12	4	15	19
	8+	42	46	40	43	50	51	45	57
	Variable	4	20	2	19	0	26	0	6
(D) Interval between periods of wear each day (hrs)	less than 1	15	12	12	5	17	8	26	18
	1	18	13	26	14	18	20	50	15
	2	14	13	14	0	13	9	8	12
	3	2	4	2	0	3	2	8	5
	3+	15	6	10	0	9	0	0	11
	Variable	36	13	36	14	40	7	8	3

(8) *Reasons for removing Lenses.*—Discomfort, veiling, and blurred vision were the usual reasons given by the patients (Table XII). Many removed their lenses because of hot, stuffy surroundings, or to remove lashes, froth, or make-up which had collected behind them. Discomfort does not appear to be any less in the ventilated lens cases.

TABLE XII
PERCENTAGE OF SUBJECTS WHO REMOVED LENSES BECAUSE OF DISCOMFORT

Discomfort Experienced				Yes		No		Sometimes	
Total	...	...	...	25	24	23	32	52	52
Men	...	...	...	30	21	22	32	48	48
Women	...	...	...	22	27	24	31	54	54

(9) *Veiling*.—Table XIII suggests that veiling is almost as common with the ventilated type of lens.

TABLE XIII
OCCURRENCE OF VEILING

Veiling Present						Yes		No	
Total	...	...	...	...	...	70	74	30	20
Men	...	...	...	...	...	75	76	25	18
Women	...	...	...	...	...	66	74	54	21

Tables XIV–XVII reveal little differences between the two series. The individual replies suggest that there was a good deal of confusion as to what constituted veiling, and that wearers failed to distinguish between true veiling (*i.e.* Sattler's veil due to oedema of the corneal epithelium) and blurred vision due to other causes (*e.g.* accumulation of froth, mucus, lashes, behind the lens, or blockage of the perforation by a plug of mucus). Ideally, "veiling" should only be admitted to be present when the condition has been confirmed by slit-lamp examination. These considerations detract from the deductions to be drawn from these Tables.

TABLE XIV
TIME BEFORE ONSET OF VEILING

No. of Hours			1		2		3		4		5		6-8		8+		Variable	
Total	...	...	17	4	15	11	10	14	15	13	9	7	7	10	9	5	18	20
Men	...	...	17	5	16	7	12	14	16	16	7	9	5	7	8	7	9	18
Women	...	...	18	3	14	15	8	14	13	10	12	15	8	11	9	4	18	22

TABLE XV
TIME OF PERSISTENCE OF BLURRED VISION AFTER REMOVAL OF LENS

No. of Minutes			None	0-15	15-30	31-45	46-60	60+	All the Time	Variable
Total	...	...	26 0	24 23	23 23	3 5	7 10	10 8	1 1	6 11
Men	...	...	23 0	23 16	24 21	4 6	6 15	12 11	2 2	6 11
Women	...	...	28 0	25 29	23 25	2 3	8 6	8 6	1 0	5 11

TABLE XVI
TIME OF RECURRENCE OF VEILING AFTER REINSERTION OF LENS

No. of Hours			0-½	½-1	1	2	3	4	5	6	6+	Variable										
Total ...	...	18	6	6	4	12	5	13	10	13	6	8	6	4	2	1	1	2	2	2	23	9
Men ...	...	21	5	3	5	11	6	13	8	15	9	9	7	6	4	1	2	2	2	2	21	11
Women ...	...	12	8	9	2	13	5	13	11	11	4	7	5	2	1	1	0	3	1	26	7	

TABLE XVII
EFFECT OF TYPE OF FLUID

Veiling Affected			Yes		No		Doubtful	
Total	...	...	24	25	36	25	40	50

(10) *Air Bubbles*.—Table XVIII illustrates the difficulties encountered in this type of investigation. Air bubbles are invariably present with ventilated lenses, and yet 34 per cent. of the wearers of ventilated lenses replied that bubbles did not form. The explanation of this discrepancy may be due to wearers having interpreted this question as meaning "air bubbles of which they were conscious".

TABLE XVIII
FORMATION OF AIR BUBBLES

Bubbles			Yes		No		Sometimes	
Total	...	...	28	44	34	19	38	36
Men	...	...	27	50	27	19	46	30
Women	...	...	29	39	40	19	31	42

Table XIX shows that only 20 per cent of wearers of ventilated lenses find bubbles a nuisance, whereas 56 per cent. of the wearers of non-ventilated lenses complain of them. The fitters of the ventilated lenses would thus appear to have been largely successful in their efforts to keep the bubbles away from the visual axes. It is interesting that 15 per cent. stated that they found the bubbles to be a help with vision but it is difficult to understand why this should be so.

TABLE XIX
EFFECT OF AIR BUBBLES

Effect					Regularly		Sometimes	
Help	...	...	...	...	16	10	15	7
No Trouble	...	...	...	...	22	9	30	17
Slight Trouble	...	...	...	...	38	23	40	23
Great Trouble	...	...	...	...	24	56	15	56

(11) *Most and Least Favourable Conditions*.—This section produced a high percentage of contradictory replies, so that a detailed analysis would have been statistically valueless. Some stated that outside conditions made no difference, but there was a general preference for cool out-door surroundings. Bright light, both natural and artificial, was unfavourable; a hot, stuffy, or smoky environment led to great inconvenience. Pregnancy, upper respiratory infections, and general fatigue, caused difficulty in wearing the lenses. A number of patients stated that their lenses were comfortable in the temperate climate of the United Kingdom, but were intolerable in certain tropical conditions, *e.g.* the hot, dusty, glaring climate of Egypt, or the humid conditions of Malaya.

(12) *Benefits of Contact Lenses*.—Here again there were a large number of irrelevant and unlikely replies, not susceptible to statistical analysis. A few samples have already been given above; there is no doubt that "vanity" is an important

element amongst men as well as women. One male patient was so anxious that his anonymity should be preserved that he obtained an undertaking to this effect before sending in his questionnaire; even members of his own household were unaware that he wore contact lenses. Professional benefits were also widely appreciated, ranging from members of the theatrical profession to the patient who replied "being able to drive a car which is something I always wanted, but until I had my contact lenses could never have done." Numerous patients could take a much more active part in athletics, notably aquatic pursuits.

(13) *Disappointments in wearing Contact Lenses.*—Unreliability was stressed by many wearers, for example, discomfort or blurring might set in unexpectedly at an inconvenient moment when the patient was on the stage, or addressing a public meeting. General discomfort was also mentioned frequently, particularly in association with hot, stuffy, smoky, or dusty surroundings. Bright light and prolonged close work also caused discomfort and disappointment to many.

(14) *Willingness to continue using Contact Lenses.*—Table XX shows that only 7 per cent. of wearers would refuse to try contact lenses again; a figure which compares with the 20 per cent. who have actually given up using their ventilated lenses. This suggests that patients are pleased to have had the opportunity of trying these lenses, even if they had to be given up later on, for one reason or another.

TABLE XX
ATTITUDE OF PATIENTS

Patient willing to persevere	Yes	Doubtful	If fittings were fewer and less troublesome	No
Total	64 88	13 5	9 0	7 3
Men... ..	58 87	14 4	11 0.5	6 2
Women	70 89	12 5	7 0	8 3

(15) *Ventilated versus Non-ventilated Lenses* (Tables XXI and XXII).—Of the 785 replies received, 144 were from patients who had worn both types of lens (56 per cent. men; 44 per cent. women), and their views on the comparative merits of the two types of lens are here analysed. Table XXI shows that an overwhelming majority of the patients who have worn both types prefer ventilated lenses.

TABLE XXI
PREFERENCE OF PATIENTS

Lenses Preferred	Ventilated	Non-Ventilated	Almost the Same
Total... ..	83	7	10
Men	76	10	14
Women	87	6.5	6.5

Table XXII shows that those patients who prefer ventilated lenses do so because in their opinion they produce less veiling and are more comfortable. It must not be forgotten, however, that a small minority (7 per cent.) prefer non-ventilated lenses; in their opinion non-ventilated lenses are more comfortable, the question of veiling being less prominent.

TABLE XXII
REASONS FOR PREFERRING ONE TYPE OF CONTACT LENS

Reason	Type of Lens					
	Ventilated			Non-Ventilated		
	Men	Women	Total	Men	Women	Total
More comfort	16	30	25	90	45	66
Less veiling	72	38	48	0	55	24
Fewer fittings	0	14	11	0	0	0
Better vision	4	6	5	10	0	10
Longer tolerance	8	2	3	0	0	0
Less diplopia	0	4	3	0	0	0
Less sensitivity to light	0	0	0	0	0	0
Easier insertion	0	2	1	0	0	0
Better in heat and stuffiness ...	0	2	1	0	0	0

Discussion

An investigation of this nature, which relies upon information given by patients at a distance, who may or may not fully understand the questions put to them, cannot presume to give results of great scientific accuracy. In this instance, where it was desired to contrast two types of lens which differed in but one respect, it was considered that this difficulty could be overcome by carrying out the investigation on parallel lines to that of Cross (1949), using his results as a control.

The present investigation falls into two parts. In sections 2-14 (Tables II-XX), the responses given by the wearers of ventilated lenses are compared with those given by wearers of non-ventilated lenses as set out by Cross (*i.e.*, an "objective" comparison). It is deduced that performance with ventilated lenses is slightly but not strikingly better than with non-ventilated lenses. Section 6 shows that 1 in 5 wearers of ventilated lenses have given up using them. This compares favourably with wearers of non-ventilated lenses, where the proportion is 1 in 3, but this failure rate is still far too high and indicates considerable wastage of time and skill, and an appreciable economic loss to the community.

In Section 15 (Tables XXI and XXII), patients who have worn both types of lens give their experiences (*i.e.* a "subjective" comparison). This comparison reveals an overwhelming preference for ventilated lenses, because they produce less veiling and are more comfortable to wear.

Duke-Elder (1949) stated:

It would thus seem that contact lenses are the perfect means of optical correction; if their haptics were commensurate with their optics and they were as readily tolerated, as easy to manipulate, and as economic as spectacles they would replace them, but unfortunately, none of these conditions holds today.

Viewing the present investigation as a whole, it is reasonable to conclude that the introduction of ventilation has led contact lenses a considerable distance along the path indicated by Duke-Elder. It is clear, however,

that they have still far to go, and that improvement is needed in certain respects, such as the number of fittings required and the discomfort experienced in hot, stuffy surroundings, or under intense illumination.

Furthermore, it is an inescapable fact that contact lenses constitute a large foreign body in the conjunctival sac, and there will always be subjects (of whom the author is one) who cannot tolerate its presence there. A strong stimulus is necessary for patients to persist in the effort to acquire toleration; the major incentives are provided by the necessity for optimum vision or by the dictates of vanity. This point is illustrated by a quotation from one of the completed questionnaires:

For persons like myself for whom glasses are no use, contact lenses are a wonderful invention. But anyone who can wear glasses I would advise them to do so, definitely. For myself I am really thankful of them, as I can now work in Road Transport, a job I always wanted from being a school-boy.

It is possible that the application of the principles involved in the use of contact lenses is approaching its zenith and that further advances wait upon the introduction of entirely new ideas.

Summary

- (1) The general principles of ventilated contact lenses are discussed.
- (2) An account of the method employed in fitting a large series of ventilated glass contact lenses is given.
- (3) A comparison is made between the results obtained with this series and a series of non-ventilated lenses previously reported by Cross (1949).
- (4) It is concluded that ventilation represents an advance in the haptics of contact lenses.
- (5) The future of contact lens therapy is briefly discussed.

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REFERENCES

- BIER, N. (1945). British Patent 592,055.
 — (1948). *Optician*, **116**, 497.
 CROSS, A. G. (1949). *British Journal of Ophthalmology*, **33**, 421.
 DALLOS, J. (1946). *Ibid.*, **30**, 607.
 DUKE-ELDER, S. (1949). "Text-book of Ophthalmology", vol. 4, p. 4584. Kimpton, London.
 ERGGELET, —. (1930). *Klin. Mbl. Augenheilk.*, **85**, 117.
 SATTler, C. H. (1938). *Ibid.*, **100**, 172.