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Ocular Changes and Other Factors Relating to Two Forms of Contact Lenses: A Comparative Study

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Summary

The work utilising a new material for contact lenses has fallen into three parts:-

1). Physiological considerations

(a) Since the cornea is devoid of blood vessels, its oxygen is derived from the atmosphere. Early hydrophilic gel contact lenses interrupted the flow of oxygen and corneal insult resulted. Three techniques of fenestration were tried to overcome this problem. High speed drilling with 0.1 mm diameter twist drills, was found to be mechanically successful, but under clinical conditions mucous blockage of the fenestrations occurred.

(b) An investigation was made into the amount of oxygen arriving at the corneal interface; related to gel lens thickness. The results indicated an improvement in corneal oxygen as lens thickness was reduced. The mechanism is thought to be a form of mechanical pump. A series of clinical studies confirmed the experimental work; the use of thin lenses removing the symptoms of corneal hypoxia.

2) Design

The parameters of lens back curvature, lens thickness and lens diameter have been isolated and related to three criteria of vision (a) Visual acuity, (b) Visual stability and (c) Induced astigmatism. From the results achieved a revised and basically successful design of lens has been developed.

3) Comparative study

The developed form of lens was compared with traditional lenses in a controlled survey. Twelve factors were assessed over a twenty week period of wear, using a total of eighty four patients.

The results of this study indicate that whilst the expected changes were noted with the traditional lens wearers, gel lens

wearers showed no discernible change in any of the factors measured, with the exception of one parameter. In addition to a description of the completed work, further investigations are suggested which, it is hoped, would further improve the optical performance of gel lenses.

Supervision

The work described in this thesis was carried out under the supervision of Mr. A.G. Sabell, M.Sc., F.B.O.A., D.C.L.P., whom the writer wishes to thank for all his help and benevolent advice.

I believe my greatest wisdom to be
the knowledge that I do not know
John Steinbeck

Dedication

This work is dedicated to my wife and parents whose help and support made this work possible.

CONTENTS

Introduction

1.1. The origin of corneal contact lenses

The earliest recorded reference to a manufactured form of corneal contact lens is probably that of Kalt[1] and Fick[2]. Working independently in the year 1888, both produced glass contact lenses which covered no more than the corneal portion of the eye. The experience of these two early lenses was unsatisfactory; the lenses were uncomfortable in wear, producing a marked adverse response by the eye. The successful haptic shell blown by Muller[3] in the previous year was to set the pattern of contact lens development over the next sixty one years, and it was not until 1947 that serious attempts were again made to produce entirely corneal lenses.

1.2 The development of modern corneal lenses

The year 1947 saw the development of two corneal contact lenses. The larger made by Tuohy [4] being 11.50 millimeters (mm) in diameter and having a bicurve posterior surface. The smaller by Wohlk[5] was 9.85 mm in diameter and single curved. The new lenses were both made of methyl methacrylate; a material first introduced for contact lens use by Mullen and Obrig[6] in 1938. The new lenses aroused interest in the potentials of purely corneal lenses and set the stage for future developments. De Carle[7] described a two curve lens in 1953 with a central optic diameter of 7.5 mm and a surrounding flange. Dunn[8] in 1959 described lenses having independent peripheral curves for the assessment of the outer portion of corneal lenses. Hung[9] in the same year described the characteristics of tri and multicurve lenses. A microlens was introduced in 1964 by Dickinson[10] having an overall

diameter of 9.0 to 9.5 mm. Whilst in the same year an even smaller lens of 8.8 mm diameter was described by Moss[11]. The increasing number of peripheral lens curves reached logical conclusion in 1966 with the description by Nissel[12] of continuous curve corneal lenses.

At the present time a large number of various designs of corneal contact lenses are available to the practitioner. The widespread use of sodium fluorescein has led to refined and accurate fitting techniques and corneal lenses as a consequence have achieved a wide usage and acceptance. The use of corneal lenses has not been without drawbacks, however, and a number of workers have reported various ocular responses to corneal lens wear.

1.3 The ocular response to corneal contact lens wear

The earliest reference to the ocular changes induced by modern corneal lenses is probably that of Berens[13] who reported 'corneal damage' to occur in 10% of patients wearing the Tuohy lens. A more precise description of the type of changes brought about by corneal lenses in guinea pigs was given by Chen and Smelser[14] in 1955. Increases were found in the thickness, hydration and optical density of the cornea of animals which had worn corneal lenses. An increase was also found in the concentration of lactic acid present in tear fluid. Shape changes in human corneas were reported by Black[15] in 1960 who also described changes in the carbohydrate and ribonucleic acid metabolisms of the cornea brought about by the "more nearly anaerobic" conditions in corneal lens wear. The question of shape changes was also raised by Dixon[16] in 1963 who reported this effect to be associated with changes in refractive state of corneal

lens wearers. Dixon also reported a sensory loss to occur over a prolonged period of corneal lens wear. The refractive changes reported by Dickinson were exhaustively investigated by Rengstorff in two papers[17,18]. In the earlier, Rengstorff dealt with visual acuity reductions among United States army entrants of whom fifty per cent showed a reduced acuity after a twenty one day period of non lens wear. Among those entrants of long standing lens wear, a small proportion showed permanently reduced visual acuity, which could only be improved by a return to corneal lens wear. In the later paper Rengstorff investigated the question of vertical and horizontal astigmatic changes. He reported a mean decrease of 0.98 diopters after cessation of lens wear in the horizontal meridian. With the rule astigmatism was found to increase over the first three days of non lens wear; a variation which was much less marked at a second examination after sixty days. With the production of these two papers Rengstorff established corneal shape and visual acuity changes as a "normal" response to prolonged period of corneal lens wear. The sensory loss earlier reported by Dixon has also become widely accepted as a normal clinical phenomenon and is so widespread that a state of no change is a cause for clinical comment.

In addition to the changes in the sensory and anatomical state of the cornea of corneal lens wearers, it has become widely recognized that corneal lenses disrupt the integrity of the corneal epithelium. Cochet and Bonnet[19] first attempted to classify epithelial disruptions in 1959 with three basic categories:- 1) small 'dots' resulting from pressure 2) lines formed as the result of a corneal lens abrading the eye and 3) microvesicles formed as a result of insufficient aspiration. Shulman attempted a wider classification in

1966[20], dividing the corneal 'abrasions' brought about by corneal lenses into seven categories:- 1) Arcuate 'abrasions' 2) Punctate 'abrasions' 3) Superficial 'abrasions 4) Deep epithelial 'abrasions' 5) Linear 'abrasions' 6) limbal 'abrasions' and 7) Superficial conjunctival 'abrasions'. Although neither of these papers lead to a widely accepted classification of epithelial disturbance patterns, the phenomenon of differing types of epithelial disruptions induced by corneal lenses has become widely recognized.

The phenomenon of epithelial disruption combined with corneal shape and sensitivity changes have become regarded as a 'normal' response to prolonged wear of corneal lenses. It was these factors together with the associated changes in spectacle refraction and visual acuity which form the basis of a comparative study, later described in this thesis.

The ocular response syndrome which is associated with corneal lens wear is a substantial reason for the search for new materials from which to manufacture corneal lenses. The increasing sophistication of corneal lens design and technique of fitting has undoubtedly led to a reduced degree of corneal insult. Despite this, the ocular changes already mentioned still appear as an integral part of the wearing of corneal lenses. In a consideration of new materials for corneal lenses it may be argued that a flexible material which conformed readily to the ocular contours would reduce and possibly eliminate the ocular response in its present form. In this respect the so called hydrophilic gel developed by Professor Otto Wichlerle of the Institute of Macromolecular Chemistry in Prague has aroused interest in the contact lens field.

1.4 The development of hydrophilic gel contact lenses

The development of hydrophilic gel contact lenses arose out of work undertaken to produce a material for utilisation in general body prosthetics. The requirement for this material was that it should be as nearly homogenous with the type of body tissue in which it was likely to be placed as possible. In this respect a flexible, stable gel would have certain obvious physical attributes. The development of such a material took place during the middle years of the last decade at the Institute of Macromolecular Chemistry in Prague. The result of a number of years of research was a hydrogel formed by a polymer of the esters of acrylic and methacrylic acid with alcohols having hydrophilic groups which after polymerisation imparted hydrophilic properties to the polymer obtained. Patents were filed in 1956 for the group of compounds to which the mentioned polymer is a member, and were granted on March 28th, 1961[21,22]. The new material known as hydrophilic gel or later in the contact lens field simply as 'gel' had unusual and interesting properties. The material was optically clear and consisted of some sixty per cent by weight of water. The water content was retained through hydrogen bonding giving a hydrophilic nature to the whole matrix. The material was mechanically strong whilst being at the same time flexible.

Within a short time of the successful polymerisation of hydrophilic gel, the possibility of its use in the field of contact lenses was being considered. Upon completion of successful toxicological trials[23], clinical work was undertaken with human volunteers by Dr. M. Driefus, a consultant eye surgeon at Prague General Hospital. Driefus showed the lenses

to produce "no primary intolerance" when fitted to large numbers of human eyes[24].

1.5 The manufacture of hydrophilic gel contact lenses

The apparent success of the new form of contact lens promoted work into the large scale manufacture of such items. A revolutionary manufacturing technique was developed by Wichlerle: a graduated amount of monomer and alcohol were placed in a hemispherical mould which was rotated. As polymerisation took place, the centrifugal force caused the liquid to form a revolution meniscus, which as it solidified formed the posterior surface of the contact lens. The anterior surface was derived from the shape of the mould, and the thickness and overall size were products of the quantity of monomer and the speed of rotation. The apparatus was refined and sophisticated by the addition of multiple sensors which coupled to a computer provided a self regulatory mechanism. Gel lenses manufactured in this manner could be produced with most forms of aspheric back and front surfaces, and had particularly thin edges. The automated nature of this new form of contact lens manufacture provided a practical basis for the potential of mass fitting to which it was felt that gel lenses were ideally suited.

1.6 Clinical techniques of gel contact lenses

The mass production of gel contact lenses suggested possibilities in their clinical utilisation. Driefus showed that the probability of any one patient achieving a visual acuity of 6/6 or more, with any one gel contact lens was about eighty per cent[25]. A method of fitting was therefore evolved which depended entirely upon the visual acuity achieved in early lens wear. If a particular lens proved unsatisfactory

when initially fitted the lens was replaced by a second, and if necessary, by a third until a satisfactory level of vision was achieved. A fitting technique built upon these lines proved very much more rapid than the techniques applied to traditional corneal contact lenses, and the possibility of mass contact lens manufacture and supply had been opened up.

1.7 The evolution of the design of gel contact lenses

A search of the available literature has failed to find a reference to scientific design studies being applied to gel contact lenses. The first lenses were thick (0.6 to 0.8mm) and large (12 to 14 mm) when compared to most forms of traditional corneal lenses. As successive clinical trials were carried out the lenses used became smaller and thinner: apparently as the result of individual practitioner's experience rather than through controlled scientific analysis. At the time of writing gel contact lenses are some 0.2 to 0.33 mm thick and eleven to twelve mm in diameter. The central back optic radius having increased from approximately six mm to eight mm over the same period. The rather surprising lack of controlled scientific design work gave an opportunity to undertake such studies, and these form the second section of the present work.

The lack of scientific design work has influenced the optical performance of gel lenses. As the new lenses became generally available outside Czechoslovakia criticism of the visual acuity obtainable with gel lenses was made by Hart[26] and others[27]. Hart also showed gel lenses to be subject to a form of lens induced astigmatism not formerly met with in contact lens practice. These findings together with a comprehensive paper by Morrison [28] and an initial undergraduate survey by this writer,[29] form the basis of the initial work described in the first two sections of this thesis.

Section 2

The problem of corneal oedema

2.1 Introduction

Gel lenses received from Czechoslovakia in the summer of 1964 were shown to have two main defects:-

1) The clinical symptoms of corneal oedema were invariably present after a few hours of wear.

2) Gel lens wear resulted in a form of lens distortion which approximated to randomly induced astigmatism.

These effects which were also reported by Hart[30] and Blackstone[31], were felt to be the major shortcomings of this new form of contact lens.

The classical remedy for the appearance of the symptoms of corneal oedema has been fenestration after the method of Bier[32]. It was this avenue of approach which was first employed in the present case. The difficulty of gel lens induced astigmatism and the more general question of gel lens design are dealt with in section 3.

2.2 Methods

The volume of tears enclosed between a gel lens and the cornea is minimal[33]. For this reason it was felt that the sideways diffusion of gasses from the base of any fenestration formed in gel lenses would be slow, and effective only over a limited area. This suggested the need for a number of non central fenestrations to cover as wide an area of the cornea as possible. Following a search of the literature, it was apparent that the proposed fenestrations should be no more than 0.1 mm in diameter. Sellers[34] has shown patients to become optically aware of fenestrations larger than this diameter.

Discussion with Dr. Rogers[35] of the Department of Physics suggested at least three approaches to the problem:-

1) Fenestration by electric arc.
2) Fenestration by the passage of a fine needle through the hydrated material.
3) Fenestration by high speed drilling of dehydrated material.

2.3 Fenestration by electric arc

A laboratory induction coil capable of maintaining a maximum spark of fifty mm was set up, with needle electrodes in the same horizontal and vertical plane, and separated by a small air gap.

A sheet of gel lens material 1 mm thick and 1 centimeter (cm) in diameter, which had been maintained in 0.9% saline solution, was introduced between the electrodes. The electrodes were separated by a gap of:- (a) 0.5 cm (b) 1.5 cm and (c) 3.0 cm. Sparking took place for periods of (1) 2 seconds, (2) 5 seconds and (3) 15 seconds. Three samples of material were exposed to a discharge for each combination of electrode separation and time.

At the conclusion of each discharge the sample was removed and placed vertically on the stage of a rotary freezing microtome. After complete freezing, sections ten microns thick were taken from the sample. Every hundredth section was mounted and examined under a Beckman photographic microscope. Photographs were taken of any areas which showed evidence of fenestration or material damage.

The technique was repeated using dehydrated samples of material which had been exposed to a dry heat of 60°C for twenty minutes. Control samples of unsparked material were also examined for both wet and dry sheet.

Results and discussion

Fig. 1 is a representative sample of the photographs taken. None of the slides showed microscopic evidence of fenestration. However considerable material damage was found. Fig. 2 shows a single localised area of disturbance, showing a series of concentric 'waves' around the central area. Considering Maxwell's law and the work of Conn[36] on exploding wires, it may be possible that this type of disturbance is brought about by rotation of an area through which a spark has passed.

Photographic records of sections of dehydrated material (Fig. 3 and Fig. 4) show a similar situation to the results from the hydrated gel. The damage caused is apparently similar, being spread in localised areas throughout each section.

The lack of microscopic evidence of fenestration does not necessarily preclude its presence. Holes as small as 50 A^{o} have been found in some sparked dielectric materials.[37]

The appearance of material damage, however, even for short discharge times, does indicate a flaw in this technique. Since other possibilities of fenestration remained, it was decided to carry out further exploratory experiments before undertaking further possible arc discharge investigations.

2.4 Needle fenestration

A small vertical hand press manufactured by W.T. Rees was set up in the manner shown (Fig. 5). Initially a semicomplete circular electrode A, was introduced around the heat hardened tungsten wire B. N.10 potassium hydroxide solution was pipetted onto the electrode until a single droplet had formed around the wire. Current was allowed to flow through the completed circuit until separation of the wire occurred,

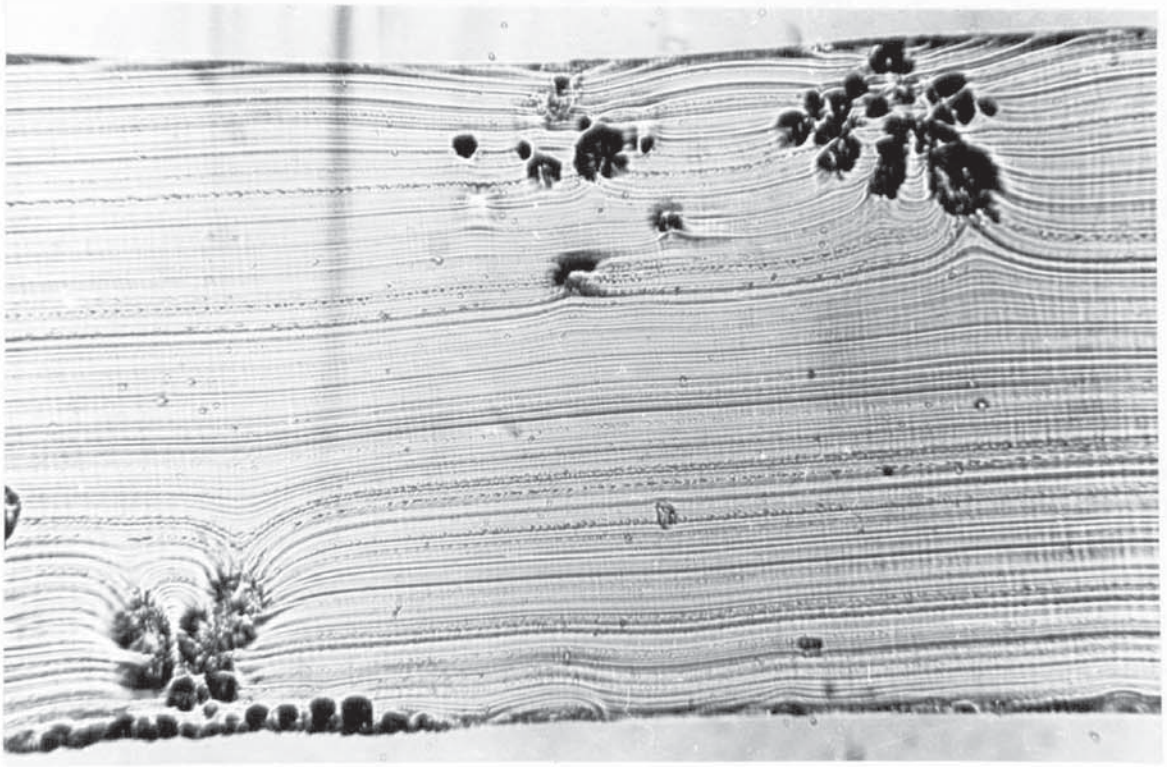


Fig. 1. Damage to hydrated gel sample, caused by an arc discharge of 5 seconds, with an electrode gap of 1.5 cm(x 90)

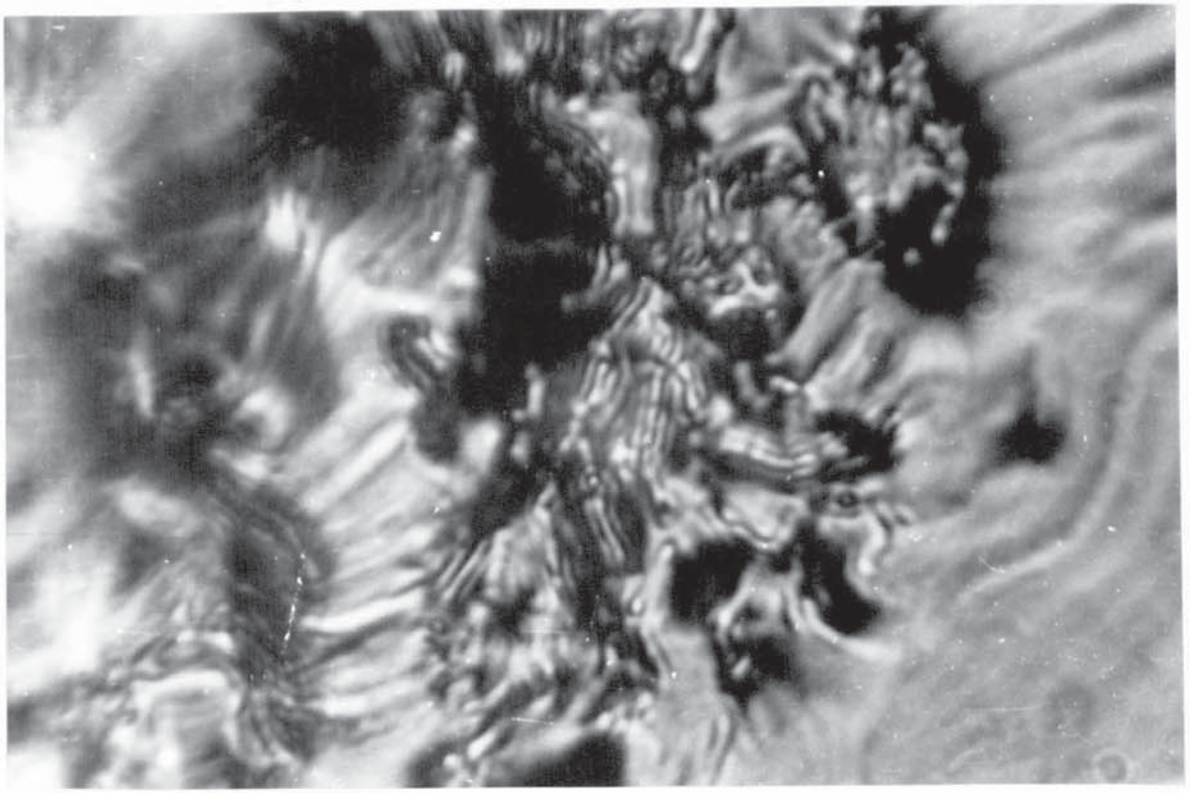


Fig. 2. Localised area of arc discharge damage in a hydrated sample of gel. Electrode separation 1.5 cm for 5 seconds(x 1000.)

Fig. 3. Damage in a dehydrated sample of gel, due to an arc discharge of 5 seconds with an electrode gap of 1.5 cm(x 90.)

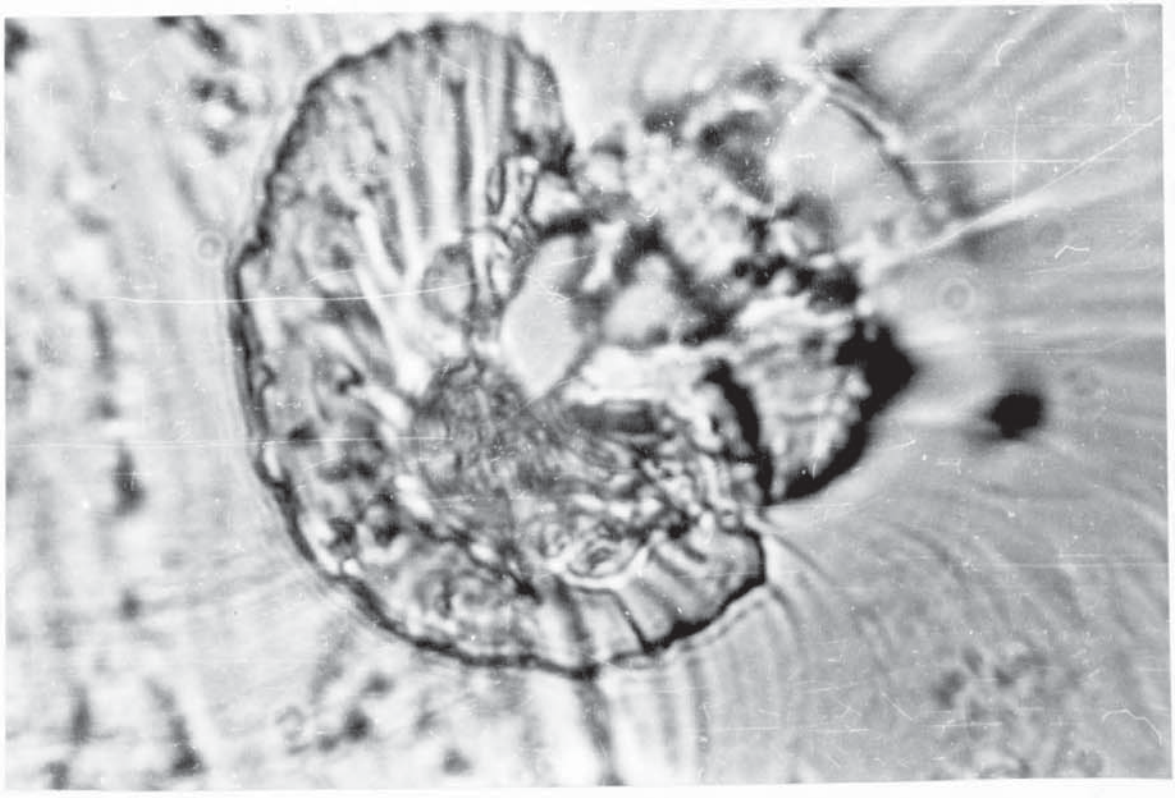


Fig. 4. Localised damage area in a sample of dehydrated material due to an arc discharge of 5 seconds with an electrode separation of 1.5 cm(x 1000.)

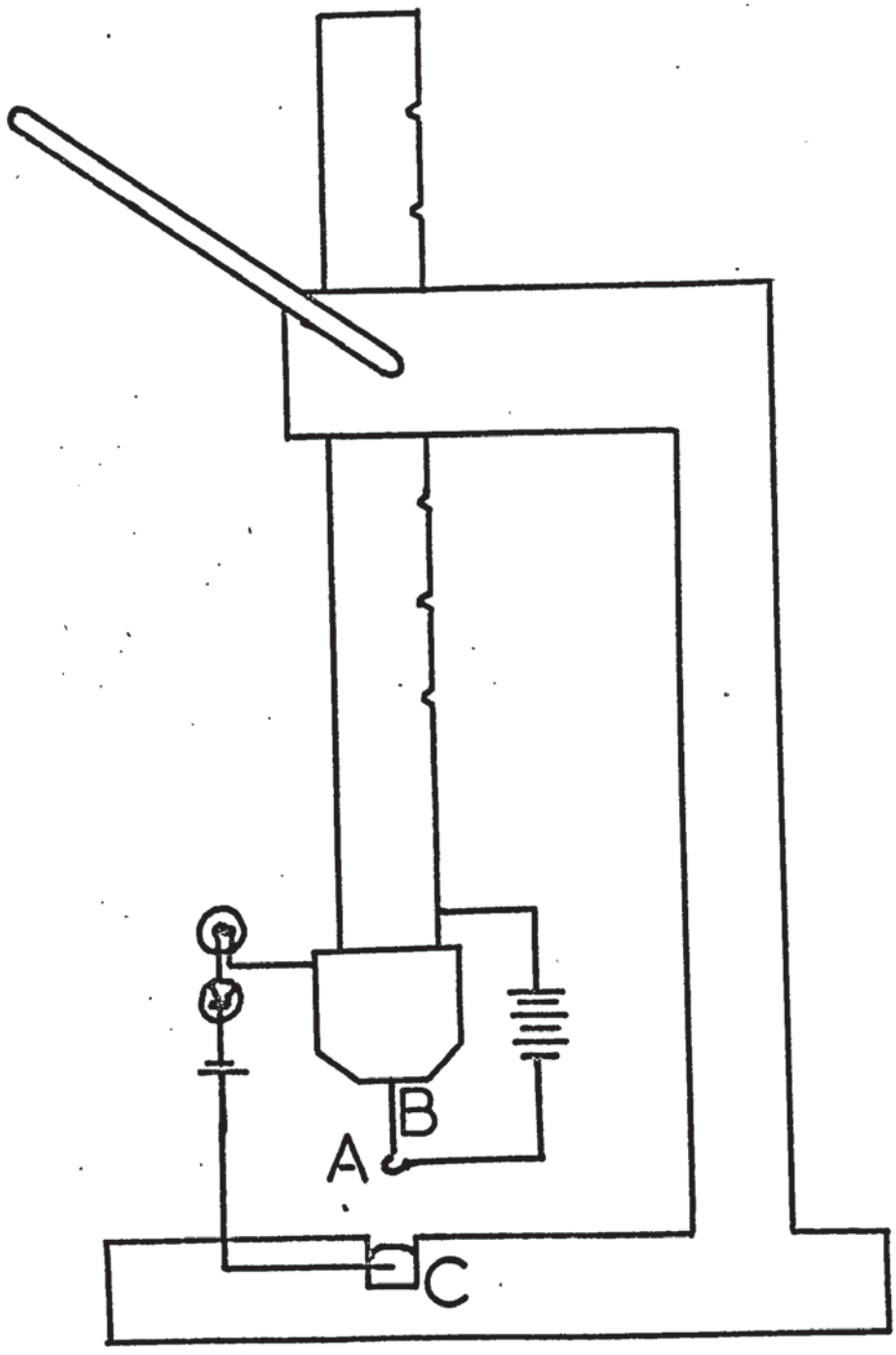


Fig. 5. Hand press manufactured by W.T. Rees.

leaving a fine needle formed by electrochemical etching. The electrode A, was then carefully removed and the needle washed from above with distilled water.

A sheet of gel lens material 1 mm thick was clamped above the mercury reservoir C. The needle was lowered until the pilot light indicated complete needle penetration. The needle was then withdrawn.

The gel sample was mounted vertically on the stage of the freezing microtone and 0.001 mm sections taken. Serial sections showing evidence of needle fenestration were examined and photographed.

Results and discussion

Examination of fenestrations formed in the above manner showed evidence of wall damage (Fig. 6). It is felt that this damage probably arises through uneven slippage of the needle point giving rise to compression tearing.

The presence of wall damage of the order found, would not prove an optical inconvenience. Microscopic graticule examination showed the diameter of the most extensive damaged areas to be less than 0.1 mm. However, it is possible that the tears formed would act as the focus for more generalised tearing during the compression and movement of normal wear. For this reason, the technique was not felt to be potentially practical and the method was abandoned.

2.5 Fenestration by drilling

A sample of hydrophilic gel 1 mm thick and 1 cm in diameter was dehydrated by dry heating at 60°C for twenty minutes. The sample, now of thickness 0.75 mm, was mounted in wax on a small face plate, and secured in the chuck of a Boley and Leiner instrument lathe. A Spirex twist drill of diameter 0.1 mm was

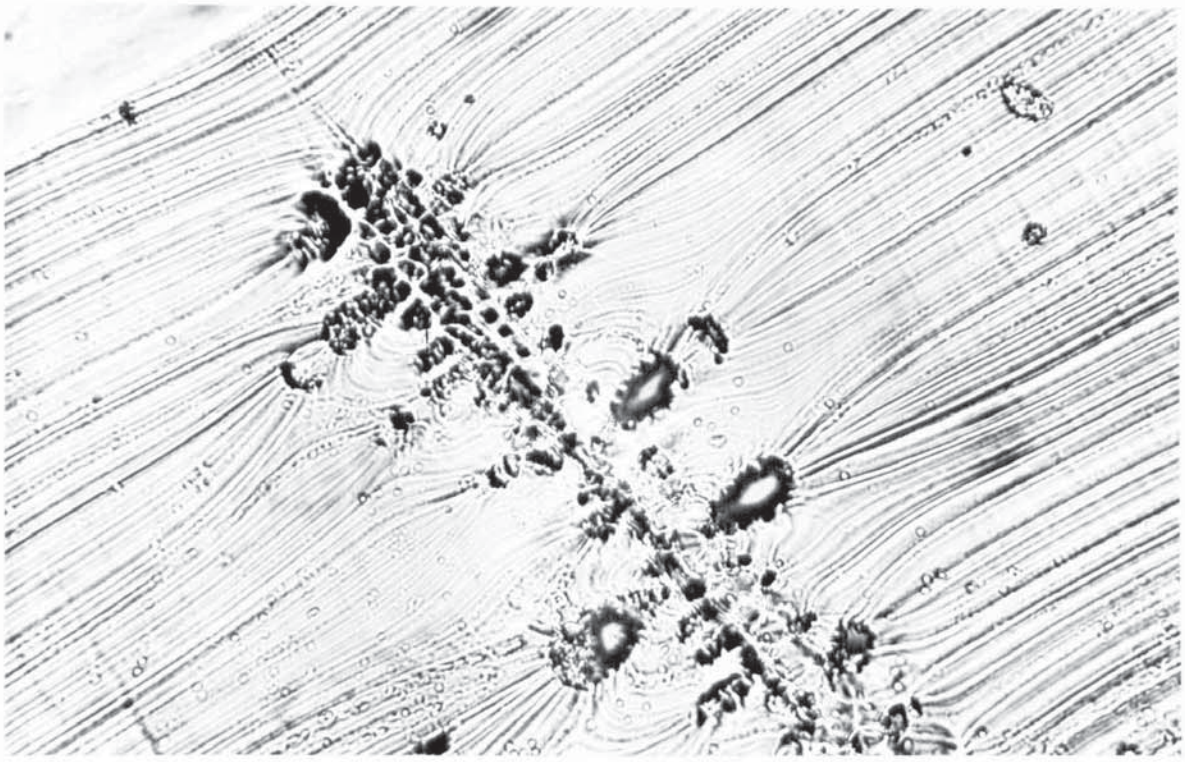


Fig. 6. Wall damage caused by needle fenestrations(x 200.)

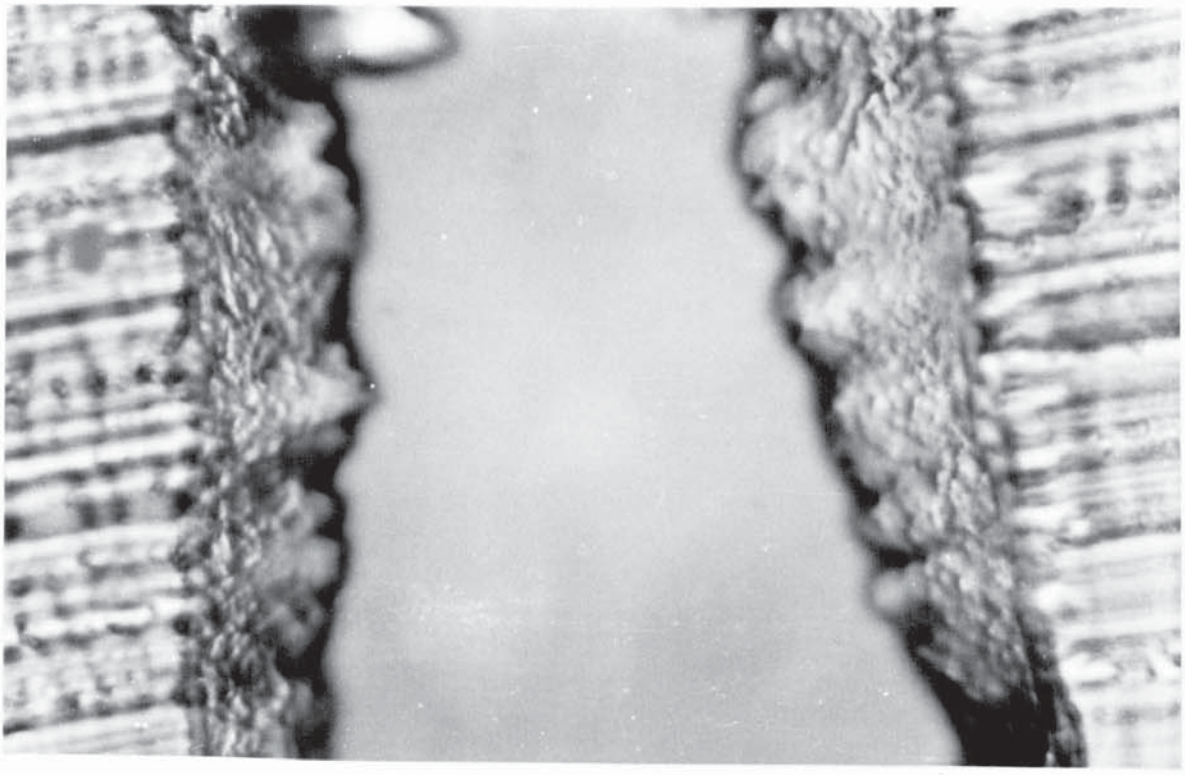


Fig. 7. Section of fenestration wall formed by drilling (x 1000.)

mounted in a pin chuck and secured in the moving stage of the lathe. Using a mechanical probe against the drill tip, centration was achieved such that less than 0.001 mm deviation was noted for a complete rotation of the drill. The probe was removed and the chuck and drill rotated at 12,000 r.p.m. The drill was then brought up to the face of the sample and using a 10 x magnifier, a hole was drilled through the sample. Upon withdrawal of the drill the sample was removed and hydrated. After hydration it was mounted on the stage of the microtone and sections ten microns thick taken.

Examination of serial sections show complete sample penetration. Microscopic examination of the fenestration walls (Fig. 7) shows no evidence of damage, although 'swarf' was occasionally encountered.

It was felt that of the three techniques of fenestration this far described, drilling of dehydrated sheet was the most successful. It was therefore decided to attempt to assess the effect of fenestrations formed by drilling, upon the symptoms of oedema previously mentioned.

2.6 Fenestration and corneal oedema

The clinical symptoms of corneal oedema are held to be the appearance of "rainbow rings round lights" and a blue mistiness of vision[38,39]. Both of these symptoms had been reported by patients during preliminary work with Czech hydrophilic lenses.

Following work into gel lens design (section 3) it was decided to fit five patients; three female and two male with gel lenses of specification:-

Lens thickness 0.39 mm

Lens diameter - 11.00 mm

Lens power To patient's prescription

Patient's Prescription

	Sphere	Cylinder	Axis
1	- 5.00	- 0.05	95
2	- 2.50	- 0.75	145
3	- 3.00	- 0.25	10
4	- 4.25	0.00	
5	- 1.75	- 1.00	95

Lenses single curve and knife edge.

Lenses were fitted 0.4 mm steep on the mean keratometric value. The patients concerned showed no discernible pathological or congenital anomaly prior to fitting. Upon being fitted, each patient was asked to record the daily time of onset of oedema for each eye. The lenses were not worn for more than one hour after 'veiling', and patients were asked to boil their lenses for five minutes after each period of wear. The lenses being stored in physiological saline when not being worn.

After two weeks of wear the fitted subjects reported the onset of oedema to have increased from an initial mean of 1.1 hours to a mean of 3.2 hours (tabulated results, p.19). Following a further two week period, no increase was noted in this average time, and it was considered that the adaptive phase of oedema had ceased. At this point the gel lens from one eye, randomly selected, of each patient, was removed and fenestrated. The fenestrations were arranged in a triangular

pattern of three, each being midway between the centre and periphery of the lens. Each fenestrated lens was surface polished with a paraffin based suspension of stannic oxide, and returned to the patient. Slit lamp examination showed all fenestrations to be complete and free from 'swarf'. Patients were again asked to record the daily time of onset of oedema for each eye.

Results and discussion

The results of the non fenestrated lens show no significant difference in the oedema times, at the end of each four week period of wear.

Student t testing of the time of onset of the symptoms of oedema following fenestration, compared to the times prior to fenestration show a significant increase (for a probability of 0.1) of 1.07 hours (page 23). Although this increase is significant when the entire period of wear is considered, there are only two individual days (40 and 56, page 23) when the increased time is significant at the same level of probability. In addition to an increase in the mean times of the onset of oedema the distribution of results as indicated by the first standard deviation has also increased from 0.14 to 0.66 (pages 21 and 22).

It would seem reasonable from the results to suggest that the increased times before oedema, following fenestration, were due to an increased flow of oxygen to the cornea. However, the wider distribution of results would suggest that this improvement was not uniform. Among the possible explanations exists the question of whether the holes became blocked at various times. Slit lamp examination of the eighteen fenestrations, twenty eight days after drilling showed nine to be blocked by, what was considered to be, mucous secretion.

Tabulated Results

Time of onset of oedema symptoms

Patient	Day No. (Initial four week period of wear)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2	2	2½	2	2½	2½	3	2½	2½	3	3	2½	3	3
2	1	1½	1	2	2½	2½	2	3	3¼	3¼	3	3½	3½	4
3	¾	1	1½	1½	2	1¾	2	2¼	2	1¾	2	2½	2¼	2½
4	1	1½	2	2½	2½	2¾	3	3	3¼	2¾	3¾	4	3¾	4½
5	1	1¼	1	1½	2	2¼	1¾	2	2½	2½	2¾	3	3½	3½

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	3	3	2¾	3	2¾	3	3	3	2¾	3	3	3	3	3
2	3¾	4	4	4½	3¾	4	4	4½	3¾	4	4	4½	3¾	4
3	2½	2½	2	2½	2½	2½	2	2¼	2¼	2½	2½	2	2½	2½
4	4	4½	4¾	4½	4½	4	4½	5	4	4¼	4½	4½	4¼	4¾
5	3¼	3¾	2¾	3	3½	3¾	4	3½	3½	4	3¼	3¼	3½	3¾

Patient	Day No. (Second four week period of wear of non fenestrated lens)													
	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1	3	3½	2¾	3	3¼	3½	3	3¼	2¾	3	3	3	2¾	3
2	4	3½	4	4½	4	4	3½	4½	4	4½	4½	4	4	3½
3	2½	2¼	2¾	3	2½	2¼	2½	2½	2¼	2	2¼	2¾	2½	2½
4	4½	4½	4½	3¾	4½	5	4½	4¼	4¼	4½	4¾	4½	5	4¾
5	3¾	3½	3½	3¾	3¾	4	3¾	3¼	3¼	3½	2¾	3½	3½	3

	43	44	45	46	47	48	49	50	51	52	53	54	55	56
1	3¼	3	3¼	3½	2¾	2¾	3	3	2¾	3½	3	3¼	3	2¾
2	4	4	4¼	4¼	4	3½	3¾	4	4	4½	3¾	4	4	3½
3	3	2½	2¾	2¾	2½	2½	2¾	2¾	2½	2½	2¼	2¼	2½	2½
4	4½	4¾	4¾	4½	4½	4¼	4¾	4½	4½	4¾	4½	3¾	4½	4½
5	3¼	3¾	3½	3½	3¾	3¼	3½	3¾	3¾	4	3½	3¼	3½	3½

Time of onset of oedema symptoms

Patient	Day No. (Second four week period of wear of fenestrated lens)													
	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1	3	4	3	6	3½	3½	6¼	5½	3	2¾	2¾	7	7½	2¾
2	5	4	4	4	5	4	4½	4	4½	5	4	5	5	4
3	2½	5	3	2½	4	6	2	5½	2½	5	7	2½	2¼	2¼
4	3¾	6	3¾	5	4½	7	4½	8½	7¾	4½	8¾	4½	4½	5¼
5	3¾	3½	5	6	5½	5½	6¼	3¾	3½	3¾	7	7¼	5½	6¼

	43	44	45	46	47	48	49	50	51	52	53	54	55	56
1	8½	4½	3	3	2½	4½	7½	6	6	5½	2¾	7	6½	5½
2	5	4½	5½	4	5	5	3½	4	5	4	5½	4	5½	5½
3	3	6	2½	2¾	2½	2¼	2¼	3	8	6	2½	4½	3½	4½
4	4¾	4½	4¾	4½	4½	4¼	4¾	4½	4¾	4¾	4½	3¾	4½	4½
5	7½	6¾	4½	4¼	3¼	3½	4½	4½	4	4¼	3¼	3½	3½	3½

Tabulated Results

Table of means and standard deviation of the times of the onset of oedema

1) Initial four week period of wear

	Day No.						
	1	2	3	4	5	6	7
Mean	1.15	1.45	1.60	1.90	2.30	2.35	2.35
Standard deviation	0.48	0.37	0.15	0.41	0.27	0.37	0.60
	8	9	10	11	12	13	14
Mean	2.55	2.70	2.60	2.90	3.10	3.20	3.50
Standard deviation	0.44	0.54	0.60	0.62	0.65	0.59	0.79
	15	16	17	18	19	20	21
Mean	3.30	3.55	3.25	3.50	3.40	3.45	3.50
Standard deviation	0.59	0.79	1.10	0.93	0.80	0.67	1.0
	22	23	24	25	26	27	28
Mean	3.65	3.25	3.55	3.45	3.45	3.40	3.60
Standard deviation	1.12	0.72	0.75	0.79	1.06	0.67	0.87

2) Subsequent four week period: non fenestrated lens

	Day No.						
	29	30	31	32	33	34	35
Mean	3.55	3.45	3.50	3.60	3.60	3.70	3.45
Standard deviation	0.79	0.75	0.77	0.62	0.76	1.02	0.75
	36	37	38	39	40	41	42
Mean	3.55	3.50	3.35	3.45	3.55	3.55	3.35
Standard deviation	0.82	0.79	1.20	1.10	0.71	1.0	0.85
	43	44	45	46	47	48	49
Mean	3.60	3.60	3.70	3.70	3.50	3.25	3.55
Standard deviation	0.62	0.87	0.80	0.69	0.85	0.68	0.77
	50	51	52	53	54	55	56	Overall
Mean	3.60	3.50	3.85	3.40	3.30	3.50	3.30	3.51
Standard deviation	0.72	0.84	0.89	0.84	0.67	0.79	0.85	0.14

Table of means and standard deviation

of the times of the onset of oedema

3) Subsequent four week period: fenestrated lens

	Day No.							
	29	30	31	32	33	34	35	
Mean	3.60	4.50	3.75	4.70	4.50	5.20	4.70	
Standard deviation	0.94	1.0	0.82	1.48	0.79	1.44	1.74	
	36	37	38	39	40	41	42	
Mean	5.45	4.25	4.20	5.90	5.25	4.95	4.10	
Standard deviation	1.89	2.09	0.95	2.45	1.95	1.89	1.67	
	43	44	45	46	47	48	49	
Mean	5.75	5.25	4.05	3.70	3.55	3.90	4.50	
Standard deviation	2.22	1.06	1.25	0.77	1.15	1.06	1.94	
	50	51	52	53	54	55	56	Overall
Mean	4.40	5.55	4.90	3.70	4.55	4.70	4.70	4.58
Standard deviation	1.08	1.54	0.84	1.26	1.41	1.30	0.83	0.66

Tabulated Results

1) 't' test of mean time of the onset of oedema times for the fenestrated and unfenestrated lens

Day No.	29	30	31	32	33	34	35
Variance of sample	3.60	3.70	4.50	3.75	4.70	4.50	5.20
Standard deviation	0.89	0.92	1.00	0.68	2.20	0.62	2.07
't'	0.87	0.90	0.90	0.80	1.13	0.77	1.24

Day No.	36	37	38	39	40	41	42
Variance of sample	4.70	5.45	4.15	4.20	5.90	5.25	4.95
Standard deviation	3.04	3.57	3.55	0.91	6.01	3.81	3.57
't'	1.34	1.39	1.45	1.01	1.90	1.47	1.51

Day No.	43	44	45	46	47	48	49
Variance of sample	4.10	5.25	4.05	3.70	3.55	3.90	4.45
Standard deviation	2.80	1.12	1.57	0.60	1.32	1.14	3.79
't'	1.32	0.97	1.05	0.73	1.01	0.89	1.48

Day No.	50	51	52	53	54	55	56
Variance of sample	4.40	5.55	4.90	3.70	4.55	4.70	0.70
Standard deviation	1.17	2.38	0.70	1.60	2.01	1.70	0.81
't'	0.92	1.24	0.86	1.07	1.10	1.07	2.63

Value of 't' from tables (p = 0.1) = 1.86

2) 't' test of mean time of the onset of the symptoms of corneal oedema for the total fenestrated and total unfenestrated groups

Mean of unfenestrated group	3.52 Hrs
Mean of fenestrated group	4.57 Hrs
't'	7.51
Value of 't' from tables	2.62 (p=0.01)

The problem of fenestration blockage was one which could only be solved by larger diameter apertures, and for optical reasons this was undesirable.

During the period that the fenestration experiments were taking place, personal communication with Professor Wichlerle[40] had suggested an adequate corneal respiration in very thin gel lenses. Before further investigations with fenestration were carried out it was decided to investigate this possibility.

2.7 Corneal respiration with thin gel lenses

The requirements for oxygen by the cornea are small - about 8.6 ml of oxygen hour^{-1} cm^{-2}. [41,42] but the cornea will show insult if this quantity is not met.

Wichterle and Dreifus acting independently of one another, but using a common form of standard gas diffusion apparatus claim an oxygen diffusion constant (D) for hydrophilic gel of 3.3 x 10-7 cm. 2 sec^{-1}. [43]. In practical terms this would mean that a lens 0.1 mm thick would over-subscribe the corneal oxygen requirement by about six times.

The figures of the two Czech workers have been challenged by Fatt, I., Hill, R. and Takahashi[44], and on a later occasion, by Hill alone[45]. Utilising a Clerk type of membrane oxygen electrode, in physical, and later, clinical experiments, they have claimed an insufficiency in corneal oxygen during hydrophilic lens wear.

The essential difference between the two techniques of physical experimentation would seem to be the media in which the gel was contained. In the work of Wichterle and Dreifus the sheet of gel material remained fully hydrated throughout the investigation. In the work carried out by Fatt et al., however, nitrogen gas was passed over the anterior lens surface for a

period of twenty minutes, during which time it is possible that this interface became dehydrated. Since the water content inherent in a gel lens provides the transport media for oxygen, and since Fatt later showed a negligible water transmission rate for this material, it may be possible that the low figure arrived at was the result of an imperfect technique.

It is not possible, however, to argue an error in the later clinical experiments of Hill. The use of a micro-oxygen electrode to measure pre-corneal fluid tension very shortly after contact lens wear would seem perfectly valid, and a modified form of this technique was adopted in the present work.

Method

A polargraphic micro-oxygen electrode manufactured by Electronic Instruments Ltd., was attached to a high impedance amplifier manufactured by the same company. The apparatus was contained in a temperature and humidity controlled room at 20°C (∓ 1°) and 70% (∓ 10) humidity, and the apparatus calibrated in terms of percentage oxygen saturation of physiological saline (0.9%). Volunteer patients were asked to wear gel contact lenses of varying thickness for a timed period of ten minutes. Five seconds after removal, the posterior surface of the lens was applanated against the face of the probe. After a timed period of 120 seconds the oxygen tension was recorded.

Eight volunteer patients took part in the experiment, each patient wearing lenses from set C (p.34) in a random sequence. Twenty four hours were allowed to elapse between the wearing of each lens, but the time of day for each wearing period was kept constant.

A control to the experiment was constructed by placing a

sheet of microcellular latex foam 1 mm thick over a composite plaster/brass surface of 7.8 mm radius of curvature. The latex was soaked in physiological saline and the whole maintained at 34°C. The lenses were placed in a random sequence on the foam surface and covered with a single layer of Kleenex tissue, soaked with 0.2 ml saline. After ten minutes the lenses were removed and the oxygen tension recorded in the manner previously described. As a check on the control, the oxygen tensions of the foam surface was recorded for five ten minute periods, selected at random times throughout the day. No discernible change in O_2 tension was noted during any of the periods.

Results

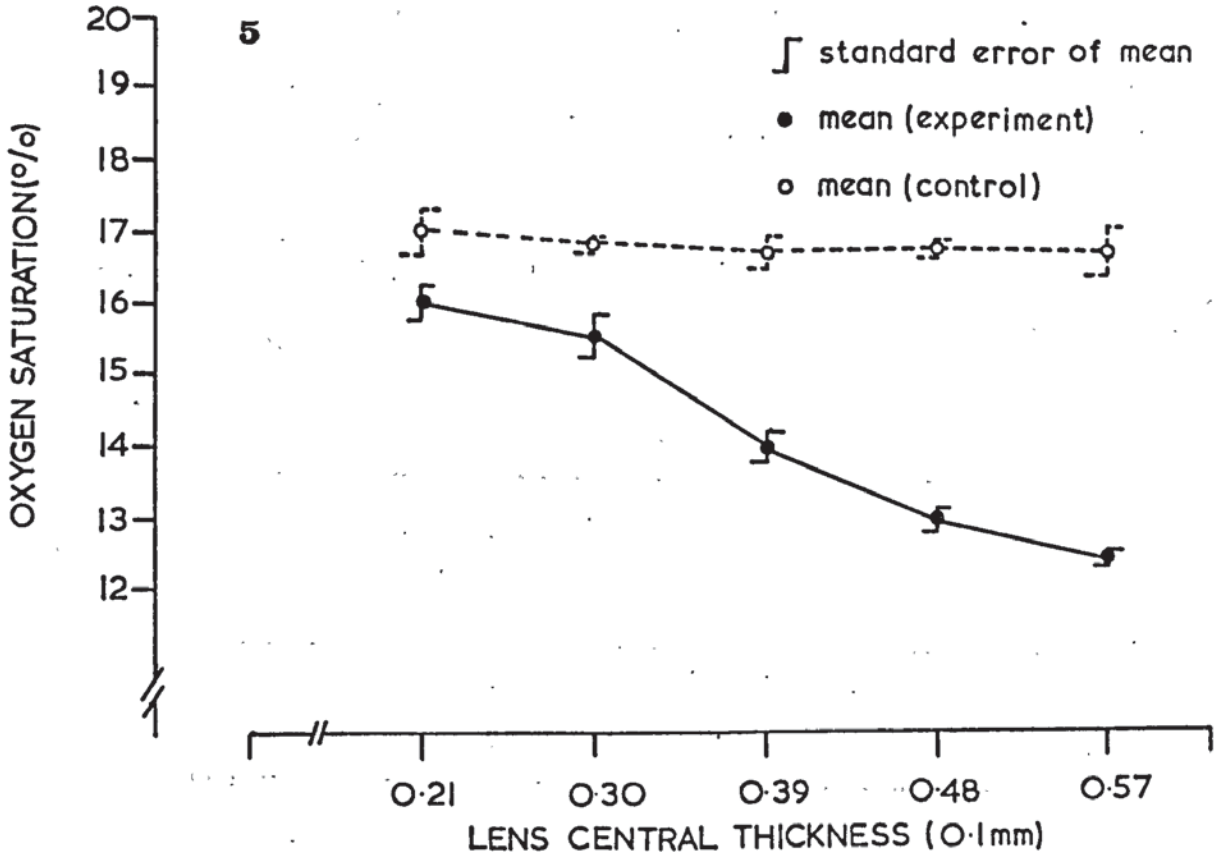
Student t testing of the pairs of points on graph 5 show that all the points differ significantly from one another for a probability (p) of at least 0.1 with the exception of the experimental means at 0.21 and 0.29 mm which are statistically insignificant at this level of testing (page 29).

Discussion

Graph 5 shows an increase in oxygen available to the cornea for a reduction in gel lens central thickness. Extrapolation of the graph apparently shows that the posterior lens surface would show no depletion of oxygen for a lens thickness of 0.10 to 0.15 mm. These results would appear to agree with the basic tenet of Wichterle's work; that an adequate amount of corneal oxygen would be derived from a lens of 0.1 mm central thickness. However, manufacture and oxygen measurement of such a lens would be required for confirmation of this hypothesis.

In relating the results obtained to those of Hill, it is apparent that for a lens 0.2 mm thick there will be insufficient

Corneal Oxygen Related to Gel Lens Thickness



Tabulated Results

Oxygen tension and gel lens thickness

Patient	Lens thickness				
	0.21 mm	0.29 mm	0.38 mm	0.47 mm	0.56 mm
1	15	15	14	13	12½
2	16½	16	15	13	12½
3	15	14	12½	12½	12½
4	16	16	14	12½	12
5	16	16	14	13	12½
6	16½	15	14	12½	13
7	16	16	15	13	13
8	16	16	14	14	12½
Mean	15.9	15.5	14.0	12.9	12.5
Standard error of mean	0.55	0.62	0.44	0.38	0.19

Control

Replicate	Lens thickness				
	0.21 mm	0.29 mm	0.38 mm	0.47 mm	0.56 mm
1	17	16½	17	16½	17
2	19	17	17	17	17
3	17	18	18	17	17
4	17	17	17	17	17
5	16½	17	16½	17	17
6	17	17	18	17	17
7	17	17	17	18	20
8	15	17	17	17	15
Mean	17.0	17.1	17.2	17.0	17.1
Standard error of mean	0.69	0.26	0.41	0.19	0.70

Tabulated Results

Oxygen tension and gel lens thickness

't' test

(Value of 't' from tables (p = 0.1) = 1.76)

Comparison of means of experimental results

	0.21 and 0.29	0.29 and 0.38	0.38 and 0.47	0.47 and 0.56
Variance of sample	0.57	0.60	0.26	0.10
Standard deviation	0.67	0.76	0.65	0.42
't'	1.11	3.75	3.46	1.80

Comparison of means of experiment and control

	0.21	0.29	0.38	0.47
Variance of sample	0.17	0.28	0.17	1.84
Standard deviation	0.61	0.66	0.46	0.98
't'	5.12	9.40	18.01	9.26

quantities of oxygen to meet corneal requirements. Since Hill's technique was to measure the rate of consumption of oxygen following lens wear, it is not possible to give a quantitative assessment of the degree of agreement between the results obtained.

It is possible, however, to speculate on the mechanism of the oxygen supply in view of Hill's latest paper[46]. In it Hill has shown that if normal eye movements are prevented during gel lens wear a rapid and marked insufficiency of corneal oxygen occurs. In the present work only a slight insufficiency in corneal oxygen was found during normal eye movements. It may therefore be possible that eye movements contribute towards the supply of oxygen, suggesting the mechanism of a mechanical pump. Should such a pump exist, it would be necessary, in view of the results found, to speculate that its efficiency would increase with a decrease in lens thickness. This is perhaps the reversal of what would be expected were the pump to be related to lid pressure, where an increasing lens thickness would evoke an increased force from the lids. In this respect the nature of a pump is uncertain, and it remains for future work to establish its precise function.

It is of interest to note that in the next experiment described, although the cornea's requirement for oxygen was not met by a lens 0.2 mm thick, this did not result in the clinical symptoms of corneal oedema, for periods of up to sixteen hours a day wear. This would appear to suggest that for a limited period of time the cornea is capable of adapting to some degree of reduced oxygen supply without showing corneal insult.

2.8 Corneal oxygen and oedema

In relating gel lens central thickness to the clinical phenomenon of corneal oedema, the following procedure was adopted:-

Method

Five volunteer patients of no discernible pathological or congenital anomaly were fitted 0.4 mm steep on mean 'K' with gel lenses of specification:-

Overall diameter	11.00 mm
Central thickness	0.39 mm
Power	To patient's prescription

The time of daily onset of oedema was then recorded for a four week period. Patients were asked to record the onset of haloes (rainbow rings) round lights and a blue mistiness of vision. At the completion of this period, one eye of each patient was randomly selected, to be refitted with a lens of specification:-

Overall diameter	11.00 mm
Central thickness	0.21 mm
Power	To patient's prescription

Oedema times for both eyes of each patient were again recorded for a four week period.

Results and discussion

The initial two weeks of the four week period of wear of gel lenses of central thickness 0.39 mm showed an increase in the mean oedema onset time from $1\frac{1}{2}$ hours to $3\frac{1}{2}$ hours. The latter two weeks of wear showed a stable onset of oedema at $3\frac{1}{2}$ hours.

On randomly refitting one eye of each patient with a lens of 0.21 mm thickness, it was found that no oedema symptoms were reported by any of the patients for this eye. The other eye, however, remained constant and gave an oedema time with a mean

of $3\frac{1}{2}$ hours.

Since a number of workers have shown an association between an insufficiency in corneal oxygen and an oedematous state in the corneal epithelium[47,48], it is probable that this present work is a further demonstration of this effect.

In later work in which twenty eight patients wore lenses of central thickness 0.21 mm, for a period of twenty weeks, only one instance of persistent oedema symptoms was recorded. In this case the history was complicated by an attack of conjunctivitis during the fourth week of wear, and this patient was felt to be unrepresentative for this reason.

Section 3

The design of hydrophilic gel contact lenses

3.1 Introduction

The form of gel lens distortion previously mentioned (page 8) necessitated an investigation of this phenomenon and if possible its complete or partial elimination. The possibility that this phenomenon could be related to one or more of the parameters of gel lenses, gave an opportunity to investigate the basic design criteria of these lenses.

A search of the literature showed that with the exception of theoretical papers by Kaplan[49] and Wichterle[50] no formal work had been carried out on the basic design structure of gel lenses. As an initial step in design work, three parameters were isolated:- 1) Lens thickness 2) Overall lens diameter and 3) Lens back curvature. To facilitate investigation three sets of gel lenses were ordered in which these factors were isolated and varied over a given range.

A preliminary study was made in which each isolated parameter was related to various criteria of vision. As a result of these experiments it was predicted that changes in the visual performance of gel lenses would result from changing each of the isolated parameters. The degree of change was predicted in each case and the minimum number of patients required to show each change was calculated. Arrangements for the necessary number of patients were made and a series of formal experiments were carried out.

3.2 Materials

The lenses used in this study were manufactured by a well known laboratory from dehydrated blocks of material mounted on

a normally centred contact lens lathe, the material being supplied from Czechoslovakia. After manufacture, the lenses were soaked in water for 24 hours. Upon receipt the lenses were surface dried, checked and each placed in 100 ml. physiological saline (0.9%), which was then autoclaved for a period of 20 minutes at 15 lb in^{-2}. The following were the lenses received for this work:-

Set (A)

Overall diameter	11 mm
Central thickness	0.30 mm
Power	-2.00 dioptres
Back radius*	(1) 6.8 mm. (2) 7.0 mm. (3) 7.2 mm. (4) 7.4 mm. (5) 7.6 mm. (6) 7.8 mm. (7) 8.0 mm. (8) 8.2 mm. (9) 8.4 mm.

All lenses single curved and knife edged.

Set (B)

Overall diameter	(1) 8.5 mm. (2) 9.0 mm. (3) 9.5 mm. (4) 10.0 mm. (5) 10.5 mm. (6) 11.0 mm. (7) 11.5 mm. (8) 12.0 mm.
Central thickness	0.30 mm.
Power	-2.00 dioptres
Back radius*	7.8 mm

All lenses single curve and knife edge.

Set (C)

Overall diameter	11.0 mm.
Central thickness	(1) 0.21 mm. (2) 0.30 mm (3) 0.39 mm. (4) 0.48 mm. (5) 0.57 mm.
Power	-2.00 D.
Back radius*	7.8 mm.

* Lenses were cut in the dehydrated state 1.0 mm. steeper than the figures given, to allow for predictible flattening upon hydration.

The specification given refer to the lenses in the hydrated state, and with the exception of back curvature for which no known checking procedure is available, and in the absence of British Standards, an acceptance limit of $\pm 5\%$ was applied.

3.3 Subjects

University students between the ages of 18 and 24 acted as volunteer patients. The accepted subjects showed no discernible pathological or congenital anomaly and had less than 1D. of corneal astigmatism.

In investigating possible associations between lens back curvature and criteria of vision, one eye each of 24 patients (12 male and 12 female) were used.

The results of 9 volunteers (5 male and 4 female) were used in relating central lens thickness to visual considerations.

Ten patients (5 male and 5 female) were utilised in the investigation of the visual effects of altering the overall lens diameter.

Upon completion of this part of the work, it was possible to produce a revised design of lens. Fifteen patients (8 male and 7 female) were used to investigate possible changes in the fitting relationship as a result of design modifications.

3.4 Methods

The parameters investigated were:-

(1) Central lens thickness

(2) Lens back curvature

(3) Overall lens diameter

In investigating the contribution of each parameter to the overall optical performance of the lens, three criteria of vision were selected:-

(1) Visual acuity

(2) Visual stability*

(3) Gel lens induced astigmatism

Lenses from each of the sets A, B and C were fitted to the subjects in a random sequence. Initially a lens was applied to the temporal inferior bulbar conjunctiva. Following a time lapse of one minute, the lens was moved on to the corneal surface by manipulation of the lids. After examination for centration and trapped air bubbles, measurements were taken.

3.5 Measurements

(1) Visual acuity was measured on an internally illuminated letter chart under conditions of constant external illumination.

(2) A subjective ranking system at 4 levels were utilised for visual stability. 1, represented the highest visual acuity which was obtained, for each lens, for an estimate of $\frac{1}{4}$ or less of a five minute period. 2, represented a period of $\frac{1}{4}$ - $\frac{1}{2}$ of the five minutes, 3, a period of $\frac{1}{2}$ - $\frac{3}{4}$ of the five minute period, and 4, a period of $\frac{3}{4}$ to continuously visible of the five minute period.

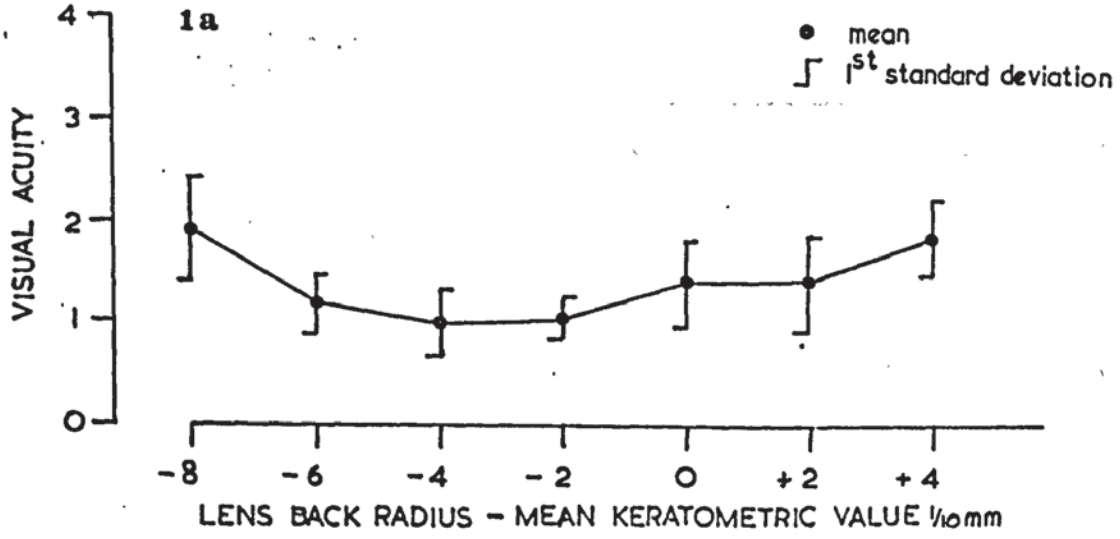
(3) Gel lens induced astigmatism was measured using a normal cross cylinder technique whilst the patient viewed two concentric circles under conditions of constant illumination.

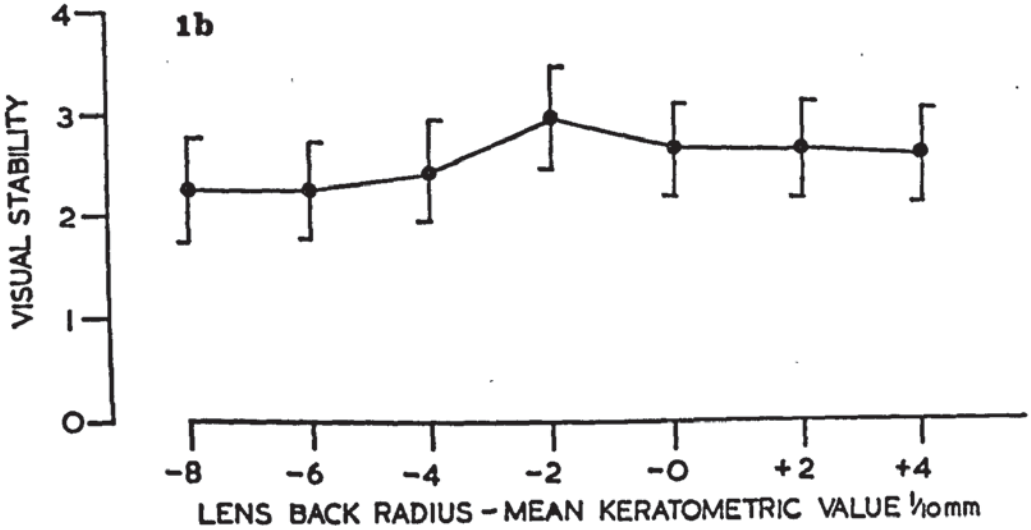
3.6 Results and analysis of three factors associated with gel lens back curvature

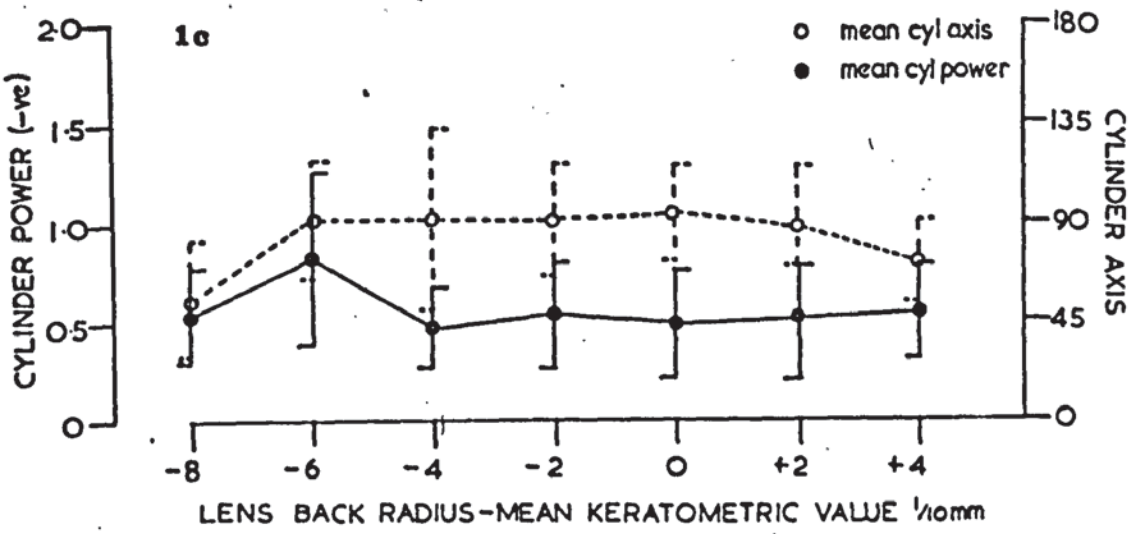
The results shown in diagramatic form on graphs 1a, 1b and 1c, show the relationship found between gel lens back curvature and the three criteria of vision.

* A pilot study indicated the presence of monocular diplopia in relation with lens diameter and is therefore considered in terms of this factor only.

Visual Factors Associated with Gel Lens Back Curvature







Tabulated Results

Lens back radius and visual acuity

Patient No.	Lens back radius - mean keratometric value $^{1}/_{10}$ mm						
	-0.8	-0.6	-0.4	-0.2	0	+0.2	+0.4
1	2.0	1.0	1.0	0.8	0.8	1.5	1.5
2	1.0	1.5	1.0	1.0	1.0	1.0	1.5
3	1.0	0.8	0.8	1.5	1.5	1.5	2.0
4	4.0	2.0	1.0	1.0	1.5	1.0	1.5
5	3.0	3.0	1.5	0.8	0.8	1.5	2.0
6	3.0	1.0	1.0	1.5	3.0	1.0	2.0
7	4.0	1.0	1.0	1.5	3.0	2.0	1.5
8	1.5	1.5	3.0	1.5	1.5	3.0	2.0
9	2.0	1.5	3.0	1.5	1.5	1.5	3.0
10	0.8	1.5	1.0	1.5	0.8	1.5	3.0
11	3.0	0.7	0.8	1.0	1.0	1.5	2.0
12	1.5	0.8	1.0	1.0	1.5	1.5	1.5
13	1.0	1.5	1.0	1.5	1.0	1.0	2.0
14	1.0	0.8	0.8	0.8	1.5	1.5	1.5
15	1.5	1.5	1.0	1.0	3.0	1.5	2.0
16	1.0	1.0	1.0	1.0	1.5	2.0	3.0
17	2.0	1.5	1.0	1.0	1.5	1.5	1.0
18	1.0	1.0	1.0	1.5	1.5	1.0	2.0
19	1.0	1.0	1.0	1.5	1.5	1.0	1.0
20	1.0	1.0	1.0	1.5	1.5	1.5	1.5
21	3.0	0.8	1.0	0.8	1.0	2.0	3.0
22	3.0	2.0	1.0	0.8	1.0	0.8	1.5
23	0.7	1.0	0.7	1.5	1.0	0.7	2.0
24	1.0	1.5	1.0	0.8	1.5	1.5	1.0
Mean	1.91	1.22	1.09	1.17	1.46	1.41	1.83
Standard deviation	1.05	0.49	0.58	0.35	0.64	0.64	0.58

Control

The patients visual acuity with spectacles was also recorded

Tabulated Results

Lens back radius and visual stability

Patient No.	Lens back radius - mean keratometric value 1/10 mm						
	-0.8	-0.6	-0.4	-0.2	0	+0.2	+0.4
1	4	1	3	3	3	3	3
2	2	3	4	2	2	3	4
3	1	3	2	3	4	2	2
4	3	1	4	2	2	1	2
5	4	2	1	3	2	3	2
6	3	1	2	2	2	3	3
7	2	3	3	3	2	3	4
8	3	2	2	4	3	2	4
9	2	2	2	3	3	3	2
10	4	2	3	4	2	4	2
11	2	3	1	1	1	2	2
12	3	2	4	3	4	4	3
13	1	2	2	3	4	4	3
14	1	2	2	3	3	2	2
15	3	4	3	1	2	3	4
16	2	3	3	4	4	3	2
17	2	3	4	3	2	2	3
18	4	3	4	4	4	4	4
19	1	3	1	2	3	2	2
20	2	3	2	2	3	2	4
21	1	1	3	2	2	3	4
22	1	1	2	4	2	2	2
23	2	2	3	2	4	3	2
24	3	2	1	3	2	4	1
Mean	2.3	2.3	2.5	3.0	2.8	2.8	2.7
Standard deviation	1.03	0.88	0.93	0.93	0.83	0.84	0.91

Tabulated results

Lens back radius and induced astigmatism

Patient No.	Lens back radius - mean keratometric value 1/10 millimeters													
	-0.8		-0.6		-0.4		-0.2		0.0		+0.2		+0.4	
	Power	Axis	Power	Axis	Power	Axis	Power	Axis	Power	Axis	Power	Axis	Power	Axi
1	0.50	45	0.50	130	1.00	165	0.00	-	0.50	115	0.50	180	0.00	-
2	0.50	110	1.00	110	0.75	50	0.50	5	0.00	-	0.00	-	1.00	90
3	0.25	135	4.00	145	0.50	70	0.25	130	0.75	110	0.25	120	0.50	25
4	0.75	30	1.00	165	0.25	180	0.50	50	0.00	-	0.50	40	0.50	45
5	0.00	-	1.00	25	1.00	5	0.75	70	0.75	25	0.00	-	1.00	125
6	0.00	-	0.00	-	0.50	140	0.50	140	0.25	75	0.50	105	0.75	125
7	0.50	15	0.25	180	0.00	-	0.00	-	0.00	-	0.50	20	0.00	-
8	0.00	-	0.50	120	1.50	160	2.00	130	0.50	130	0.50	150	0.75	35
9	0.50	40	0.00	-	0.00	-	0.50	85	0.50	170	0.50	170	1.50	15
10	3.00	130	0.00	-	0.50	45	0.50	150	0.00	-	0.00	-	0.75	120
11	0.00	-	1.25	20	0.50	140	1.25	30	0.50	105	0.50	70	0.50	15
12	0.00	-	0.25	125	0.00	-	0.25	70	0.00	-	0.25	60	0.00	-
13	0.25	25	0.50	35	0.50	80	0.50	155	0.00	-	0.75	115	0.50	120
14	1.50	30	0.00	-	0.50	35	0.50	20	0.00	-	0.50	10	1.00	170
15	0.00	-	0.50	50	0.50	125	0.50	50	0.75	80	0.50	50	0.50	30
16	0.50	40	1.00	170	0.50	30	0.50	90	0.00	-	0.50	90	0.50	70
17	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-
18	0.75	40	0.50	70	0.25	70	0.25	100	0.25	110	0.00	-	0.25	70
19	0.25	30	0.75	80	0.25	45	0.50	60	0.50	60	0.50	90	0.25	30
20	1.50	50	0.75	100	0.75	100	2.75	105	1.00	100	0.00	-	0.75	60
21	0.50	120	0.25	60	0.75	105	0.75	140	1.75	30	1.00	95	0.50	30
22	0.50	100	3.50	105	0.75	125	0.50	45	0.50	140	2.50	90	1.00	90
23	0.75	70	1.00	163	0.50	100	0.50	135	0.50	10	1.25	40	0.50	30
24	0.75	115	1.00	100	0.50	90	0.25	90	2.50	160	1.00	130	0.75	65
Mean	0.55	66	0.81	103	0.46	93	0.60	93	0.47	96	0.52	86	0.57	69
Standard deviation	0.53	50	0.88	52	0.30	49	0.55	42	0.56	39	0.50	47	0.36	35

Analysis of variance (two way factorial)

Visual acuity related to gel lens back curvature

Cell totals

Group	Curvature difference (radius of curvature in mm.) -0.8	-0.6	-0.4	-0.2	0.0	+0.2	+0.4
Gel lenses	44.00	30.90	27.60	28.30	35.40	34.50	45.00
Control	18.00	18.00	18.00	18.00	18.00	18.00	18.00

Variance

Source	Degrees of freedom	Sum of squares	Mean square	F ratio
Between curvatures	6	7.5413	1.2568	6.22
Between lenses and control	1	43.0919	43.0919	213.53
Interaction	6	5.7685	0.9614	4.76
Residual	322	65.0055	0.2018	

Value of F from tables

Between curvatures (probability p = 0.01) = 2.80
Between group (probability p = 0.01) = 6.63
Interaction term (probability p = 0.01) = 2.80

Confidence Limits

Variance of the average of one group

$$= \frac{\text{residual mean square}}{2} = 0.1054$$

therefore standard error = 0.3924

therefore 90% confidence limits = value of t for 322 degrees of freedom x 0.3924

= 1.64 x 0.3924

= 0.64

Confidence Limits

	Curvature difference	-0.8	-0.6	-0.4	-0.2	0.0	+0.2	+0.4
Visual Acuity	Upper limit	2.55	1.86	1.73	1.81	2.10	2.05	2.47
	Lower limit	1.27	0.58	0.45	0.53	0.82	0.75	1.19

Analysis of Variance (Multiple One Way)

Visual Stability Related to Gel Lens Back Curvature

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between curvatures	6	6.9522	1.1587	1.33
Residual	166	139.7086	0.8677	

Value of F from tables

F (for a probability p = 0.1) = 1.77

Analysis of Variance (Multiple One Way)

Lens Induced Astigmatism Related to Gel Lens Back Curvature

a) Cylinder power

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between curvatures	6	1.7733	0.2955	0.75
Residual	161	62.9928	0.3912	

Value of F from tables

F (for a probability p = 0.1) = 1.77

b) Cylinder axis

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between curvatures	6	16272.3807	2712.3807	1.07
Residual	98	246746.6670	2517.8231	

Value of F from tables

F (for a probability p = 0.1) = 1.85

The results displayed on graph 1c and tabulated on page 38 were analysed using two way factorial analysis of variance or F test (page 101) in order to compare the changes in visual acuity associated with curvature changes and to compare the vision obtained with gel lenses to that obtained by the same patients wearing spectacles.

The analysis on page 41 shows that the changes in visual acuity between curvatures, and the difference between the gel lenses and the control, are significantly different; the appropriate calculated values of F exceeding the value of F from tables by 3.42 and 206.90 respectively. In addition, a significant relationship exists between the curvatures and groups as shown by the interaction term.

The application of confidence limits to the means of visual acuity (page 41) shows a considerable overlap to occur between all the curvatures. The overlap is however least for the results at -0.6, -0.4 and -0.2 mm.

Multiple one way analysis of the results displayed on graphs 1b and 1c and tabulated on pages 39 and 40 show no discernible relationship to exist between the factor of visual stability and induced astigmatism and the three criteria of vision; the value of F from tables exceeding the calculated values of F by 0.44, 1.02, and 0.78 respectively (pages 42 and 43

Conclusion

The analysed results show that only one significant relationship was established; that between visual acuity and lens back curvature. Although the application of confidence limits is not successful in completely separating the varying curvatures, it is apparent from inspection of these limits that the results at -0.6, -0.4 and -0.2 mm show very little change

from one another and are the best acuities obtained. This region was therefore adopted as the fitting range in the later experiments.

The significant difference between the gel and control groups shows that although some improvement in visual acuity could be achieved by varying the lens curvature the level of vision was not as high as that which could be achieved with spectacles.

3.7 Results and analysis of three factors associated with gel lens thickness

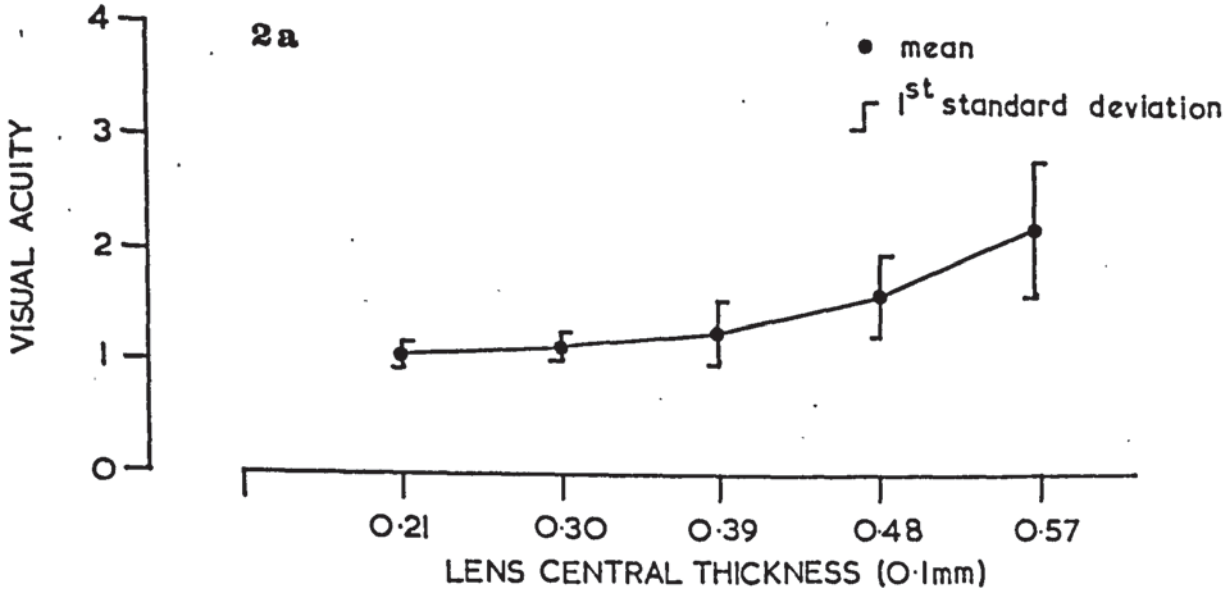
The results shown on the graphs 2a, 2b and 2c illustrate the relationship found to exist between the three criteria of vision and gel lens thickness.

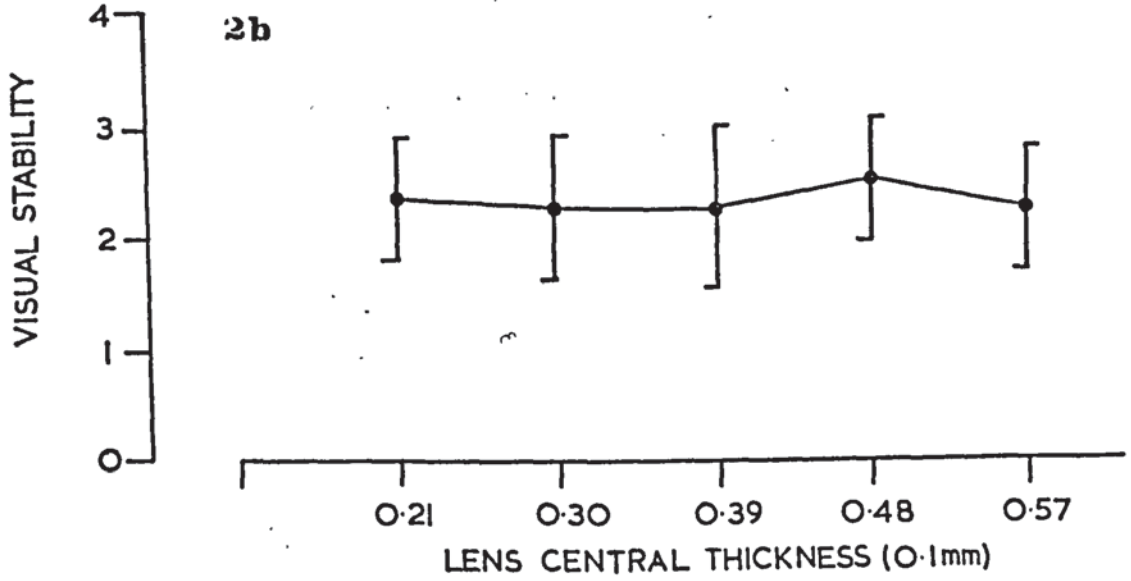
Two way analysis of variance (F test) of the tabulated results for visual acuity (page 50) show that significance has been established for the between groups and interaction term but not for the between thicknesses expression. These results are somewhat at odds with one another since no change is present in the control cell totals. This would suggest that the between thicknesses term may in fact be significant if the variance estimate were not a composite one for the two groups. The application of 90% confidence limits unfortunately just fails to confirm this prospect completely, since the lower limit of the 0.57 mm results overlaps the upper limit of the 0.21 mm result by 0.21. However, the fact that the interaction term is significant for a probability p of 0.01, the value from tables is exceeded by 0.52, whilst the between thicknesses term falls short of significance by only 0.43 would suggest that these results are different.

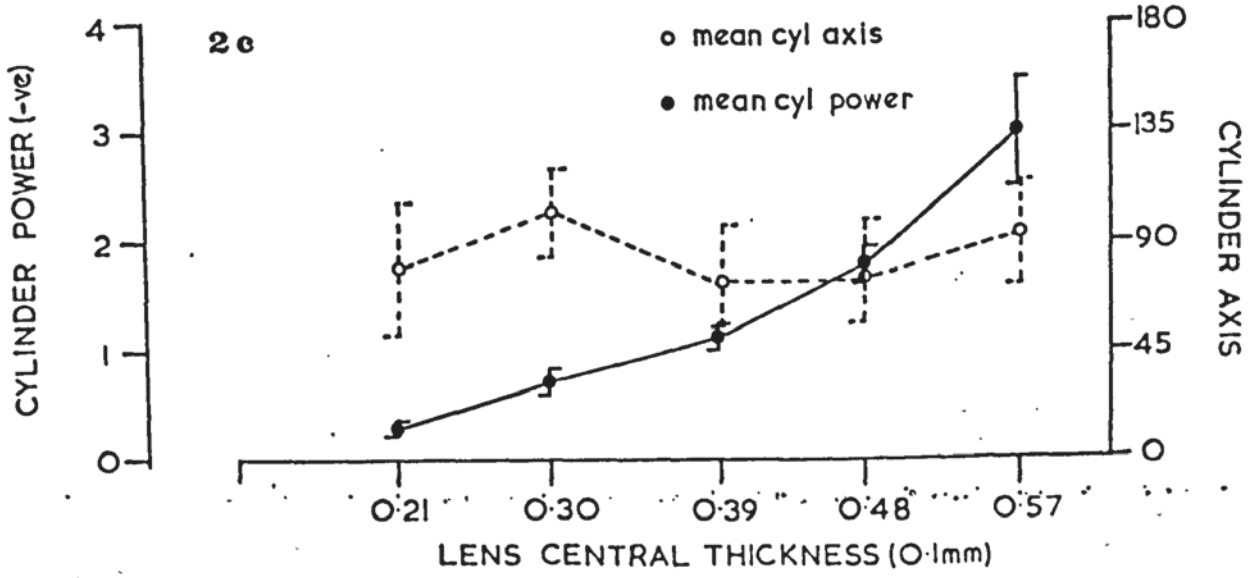
One way analysis of variance for the results of visual stability (tabulated page 51) shows an insignificant F ratio: the value of F from tables exceeding the calculated value by 1.95.

The tabulated results of cylinder power (page 49) are significantly different, as shown by one way multiple analysis of variance on page 52. The application of confidence limits shows the results at 0.57 mm differ from the results at 0.48 mm.

Visual Factors Associated with Gel Lens Thickness







Tabulated Results

Gel Lens Thickness and Three Criteria of Vision

1) Visual acuity

Patient No.	Lens thickness 0.21	0.30	0.39	0.48	0.57
1	1.0	1.0	1.0	1.5	1.0
2	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.5	1.0	1.5
4	1.5	1.5	0.8	1.5	4.0
5	1.0	1.0	1.0	2.0	1.5
6	0.8	1.0	1.0	2.00	4.0
7	1.0	1.0	3.0	4.0	4.0
8	0.8	0.8	1.0	2.0	1.5
9	1.5	1.0	1.5	1.0	1.5
Mean	1.0	1.11	1.32	1.78	2.23
Standard deviation	0.24	0.20	0.63	0.88	1.30

2) Visual Stability

Patient No.	Lens thickness 0.21	0.30	0.39	0.48	0.57
1	2	2	3	1	4
2	2	4	1	4	2
3	3	2	2	2	2
4	3	1	4	3	2
5	4	3	4	3	4
6	1	1	1	3	2
7	1	1	1	2	1
8	3	4	4	2	2
9	3	3	1	4	2
Mean	2.4	2.3	2.3	2.7	2.3
Standard deviation	0.98	1.1	1.4	0.9	0.9

Tabulated Results

Gel Lens Thickness and Three Criteria of Vision

3) Gels lens induced astigmatism

Patient No.	Lens thickness 0.21		0.30		0.39		0.48		0.57	
	power	axis	power	axis	power	axis	power	axis	power	axis
1	0.50	80	0.50	165	1.25	110	2.25	125	3.50	120
2	0.25	40	1.00	85	1.50	105	2.00	80	2.00	90
3	0.25	180	0.50	75	1.50	110	2.00	30	3.00	170
4	0.25	90	0.50	100	1.25	110	1.25	30	3.25	70
5	0.25	125	0.75	85	1.00	50	2.00	30	3.00	95
6	0.50	15	0.75	70	0.75	15	1.25	75	2.75	85
7		-	0.75	90	1.00	30	2.00	180	2.25	30
8	0.25	45	0.50	80	1.00	65	1.25	60	3.25	120
9	0.25	130	1.00	150	1.00	140	1.50	100	4.00	75
Mean	0.27	78	0.69	100	1.41	81	1.72	79	3.00	95
Standard deviation	0.10	52	0.17	32	0.20	40	0.28	41	0.57	37

Analysis of Variance (Two Way Factorial)

Visual Acuity and Gel Lens Thickness

Cell Totals (sum of nine values)

Group	Lens thickness 0.21	0.30	0.39	0.48	0.57
Gel	9.6	9.3	11.8	16.0	20.0
Control	6.8	6.8	6.8	6.8	6.8

Analysis

Source of Variance	Degrees of freedom	Sum of squares	Variance estimate	F ratio
Between thicknesses	4	2.1703	0.5425	1.56
Between groups	1	11.8042	11.8042	33.94
Interaction	4	5.5728	1.3932	4.00
Residual	80	27.8167	0.3477	

Value of F from tables

Between thicknesses (probability p = 0.1) = 1.99
Between group (probability p = 0.01)= 2.79
Interaction term (probability p = 0.1) = 1.99
(probability p = 0.01)= 3.48

Confidence limits

Variance of the average of one group $= \frac{\text{residual mean square}}{2} = 0.1738$

therefore standard error = 0.3477

therefore 90% confidence limits = Value of t for 80 degrees of freedom x 0.3477

= 1.67 x 0.4341

= 0.72

Analysis of Variance (Multiple One Way)

Visual Stability and Gel Lens Thickness

Source of Variance	Degrees of freedom	Sum of Squares	Variance Estimate	F Ratio
Between thicknesses	4	0.7555	0.1878	0.14
Residual	40	52.2223	1.3055	

Value of F from tables

F (for a probability p = 0.1) = 2.09

Analysis of Variance (Multiple One Way)

Lens Induced Astigmatism and Gel Lens Thickness

a) Cylinder power

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between thicknesses	4	40.6027	10.1506	65.4033
Residual	40	6.2085	0.1552	

Value of F from tables

F (for a probability p = 0.1) = 3.83

Confidence Limits

Standard error = 2 x 0.1552 = 0.314

therefore 99% confidence limits = Value of t for 40 degrees of freedom x 0.3104

= 1.66 x 0.3104 = 0.51

Confidence limits

Cylinder power	Thickness	0.21 mm	0.30 mm	0.39 mm	0.48 mm	0.57 mm
	Upper level	0.78	1.10	1.92	2.23	3.51
	Lower level	0.00	0.18	0.90	1.21	2.49

b) Cylinder axis

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between thicknesses	4	2796.2500	699.0625	0.34
Residual	35	70193.7500	20055.5357	

Value of F from tables

F (for a probability p = 0.1) = 2.14

The results and 0.48 mm in turn is significantly greater than the results at 0.39 mm. The confidence limits of the remaining groups overlap, although the means continue to fall.

The analysis of the results for cylinder axis (page 52) is statistically indifferent; the value of F from tables exceeding the calculated value of F by 1.80.

Conclusion

The analysis of the tabulated results show that a decrease in the power of the lens induced astigmatism took place as the lens thickness was reduced. The phenomenon of lens induced astigmatism was not however completely eradicated, but extrapolation of the graph shows that this may occur for a lens 0.1 mm to 0.15 mm thick. The reduction in lens induced astigmatism was accompanied by an improvement in visual acuity. Since lens induced astigmatism in traditional corneal lenses is frequently associated with reduced visual acuity,[51] it would seem reasonable that the two factors are also related in gel lenses.

3.8 Results and analysis of three factors associated with gel lens diameter

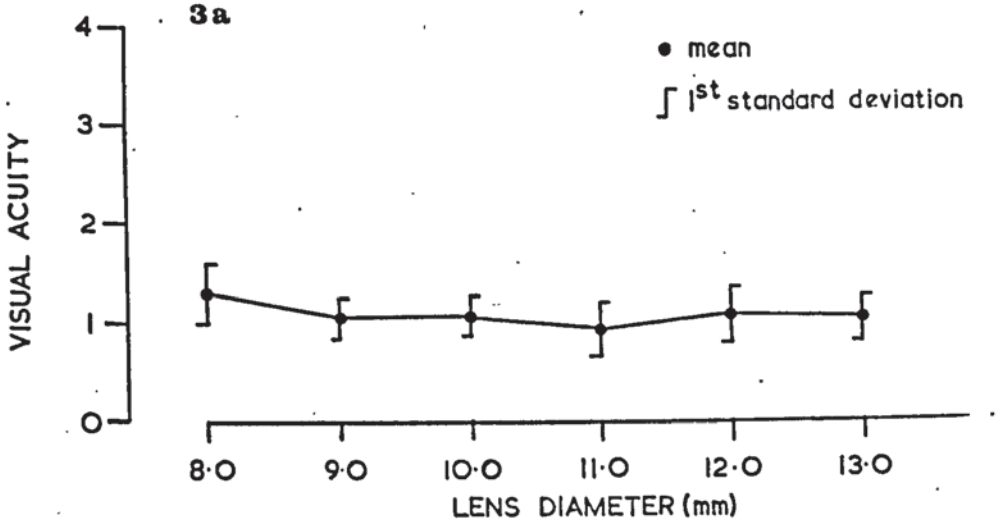
Two way analysis of variance of the tabulated results of visual acuity for differing lens diameter, shows only the between groups term to be significant (page 58). The between diameters and interaction terms being exceeded by the appropriate values of F, by 1.20 and 1.21 respectively.

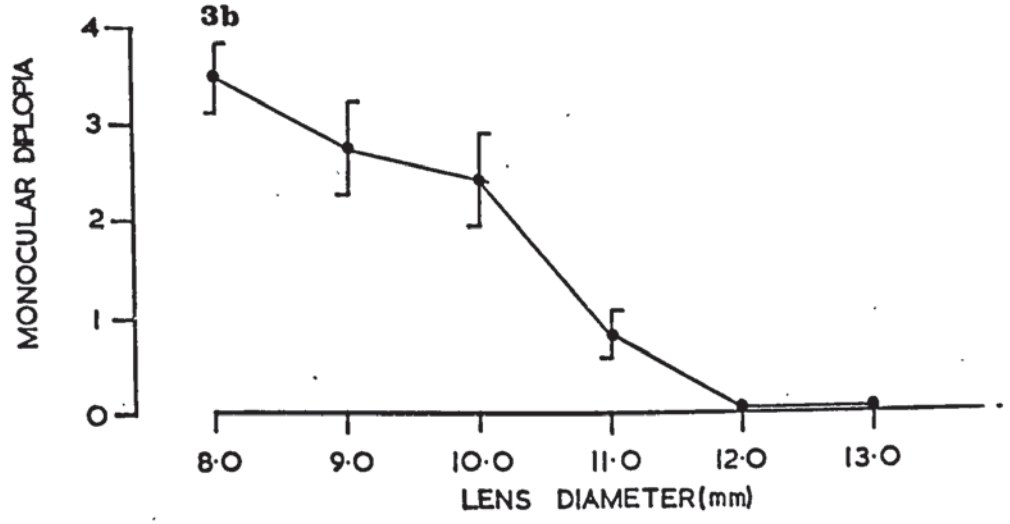
One way analysis of variance of the results for monocular diplopia illustrated in graph 3b show a significant difference to exist between lens diameters. Examinations of the means for monocular diplopia (page 56) shows a reduction and complete elimination of this phenomenon for lenses of eleven and twelve millimeters diameter. The analysis of variance for the results of lens induced astigmatism related to diameter (page 59) is statistically insignificant for a probability (p) of 0.1, the value of F from tables exceeding the calculated value by 1.29 for cylinder power and 1.86 for cylinder axis.

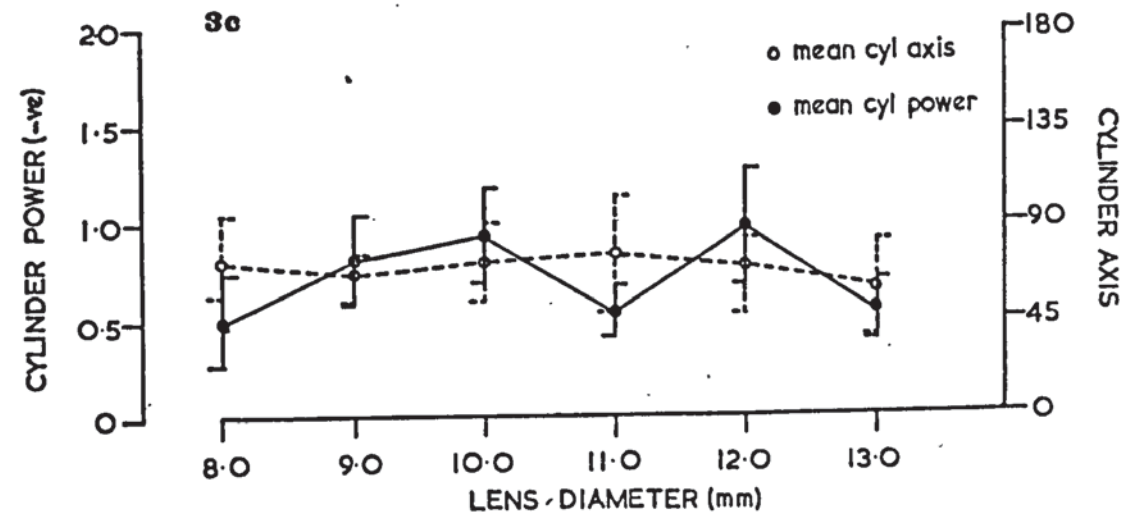
Discussion

The only criteria of vision found to significantly change as a consequence of changes in gel lens diameter is the incidence of monocular diplopia. The removal of this impediment of vision is complete at this level of replication for lenses in excess of eleven millimeters diameter, a factor which has a strong bearing on the design of these lenses.

Visual Factors Associated with Gel Lens Diameter







Tabulated Results

Gel Lens Diameter and Three Criteria of Vision

1) Visual Acuity

Patient No.	Lens Diameter (millimeters) 8.0	9.0	10.0	11.0	12.0	13.0
1	1.0	1.5	1.0	1.0	1.5	1.5
2	1.0	1.0	1.5	1.5	1.0	1.5
3	1.0	1.0	1.0	1.0	1.5	1.0
4	2.0	1.5	1.0	1.0	1.5	1.0
5	0.8	1.5	1.5	0.8	1.0	2.0
6	1.0	1.0	0.7	1.0	1.0	0.8
7	1.5	1.0	1.0	1.5	1.0	1.5
8	0.7	1.0	1.5	0.7	1.0	1.0
9	2.0	1.0	1.0	0.8	1.0	1.5
10	2.0	1.0	1.5	1.0	2.0	1.0
Mean	1.30	1.15	1.17	0.96	1.15	1.08
Standard deviation	0.45	0.22	0.28	0.24	0.44	0.39

2) Visual Stability (Monocular Diplopia)

Patient No.	Lens Diameter (millimeters) 8.0	9.0	10.0	11.0	12.0	13.0
1	2	2	2	1	0	0
2	3	2	1	1	0	0
3	3	1	2	1	0	0
4	4	3	4	0	0	0
5	4	4	4	0	0	0
6	4	3	2	1	0	0
7	3	4	2	2	0	0
8	4	4	3	1	0	0
9	4	3	2	0	0	0
10	4	2	2	0	0	0
Mean	3.50	2.80	2.40	0.70	0.0	0.0
Standard deviation	0.67	0.97	0.90	0.46	0.40	0.46

Tabulated results

Gel lens diameter and three criteria of vision

3) Gel lens induced astigmatism

Patient No.	Lens Diameter 8.0		9.0		10.0		11.0		12.0		13.0	
	Power	Axis	Power	Axis	Power	Axis	Power	Axis	Power	Axis	Power	Axis
1	1.00	180	0.50	135	0.75	40	1.25	90	0.50	60	0.75	125
2	2.00	180	1.00	125	0.75	50	1.50	90	0.00	-	1.25	40
3	0.00	-	0.75	90	0.50	130	1.75	160	0.75	110	1.00	155
4	1.00	20	2.00	110	3.50	105	0.50	25	3.00	95	2.00	25
5	0.50	90	1.00	10	1.00	55	1.00	10	4.50	20	1.00	90
6	1.50	35	3.00	55	1.00	90	0.50	75	0.00	-	0.75	75
7	0.75	20	1.00	55	0.50	70	0.75	125	0.75	90	1.25	30
8	0.50	80	0.00	-	3.00	90	0.50	115	2.00	100	1.50	40
9	3.00	120	2.00	75	1.50	70	1.75	70	2.00	170	2.00	20
10	0.50	70	2.00	65	2.00	20	1.00	55	3.00	45	0.00	-
Mean	1.00	79	1.30	72	1.40	72	1.05	81	1.50	69	1.15	60
Standard deviation	0.83	40	0.81	35	1.01	29	0.53	54	1.41	40	0.56	45

Analysis of Variance

Visual Acuity Related to Gel Lens Diameter

Cell totals (sum of ten values)

Group	Lens Diameter 8.0	9.0	10.0	11.0	12.0	13.0
Gel	13.0	11.5	11.7	10.3	12.5	12.8
Control	7.4	7.4	7.4	7.4	7.4	7.4

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
Between diameters	5	0.2596	0.0519	0.70
Between groups	1	6.2554	6.2554	84.53
Interaction	5	0.2566	0.0513	0.69
Residual	108	7.9920	0.0740	

Values of F from tables

Between diameters	(probability p = 0.1)	= 1.90
Between groups	(probability p = 0.01)	= 6.85
Interaction term	(probability p = 0.1)	= 1.90

Analysis of Variance (Multiple One Way)

Visual Stability Relating to Lenses of the Revised Design

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between curvatures	5	7.5463	1.5120	1.30
Residual	84	96.9346	1.1539	

Value of F from tables

F (for a probability p = 0.1) = 1.95

Lens Induced Astigmatism Relating to Lenses of the Revised Design

a) Cylinder power

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between curvatures	5	0.0672	0.0134	0.22
Residual	84	5.0873	0.0605	

Value of F from tables

F (for a probability p = 0.1) = 1.95

b) Cylinder axis

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between curvatures	5	7970.8321	1594.1675	0.43
Residual	48	174266.6671	3630.5456	

Value of F from tables

F (for a probability p = 0.1) = 1.95

Conclusion

The analysed results of the relationship existing between the three parameters under investigation and three criteria of vision suggest three general conclusions:-

1) A relationship, in terms of visual acuity exists between the ocular contours and gel lens back curvature.
2) A reduction in gel lens induced astigmatism, coupled with an improvement in visual acuity can be achieved by reducing gel lens central thickness.
3) The phenomenon of monocular diplopia which is present for lenses of small diameter, may be removed by increasing the lens diameter to at least eleven millimeters.

These conclusions would suggest a large thin design of lens with a specific fitting relationship to corneal curvature. In order to investigate the visual properties of such lenses a set was obtained of the following specification:-

Central thickness	0.21 mm
Overall diameter	11.50 mm
Back curvature	7.2 to 8.6 mm at 0.1 intervals
Power	- 2 diopters.

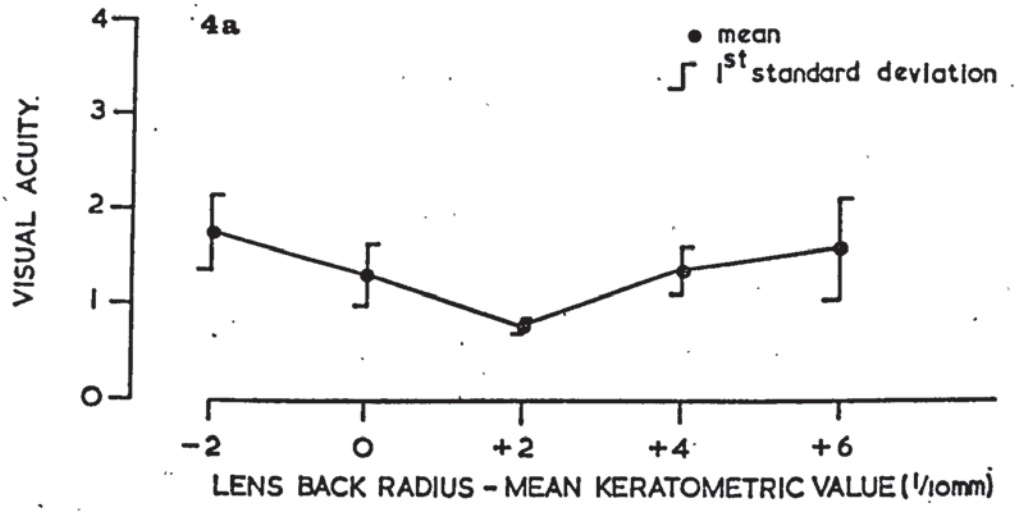
The fourteen lenses from this set were fitted to fourteen eyes in the manner previously described (page 17).

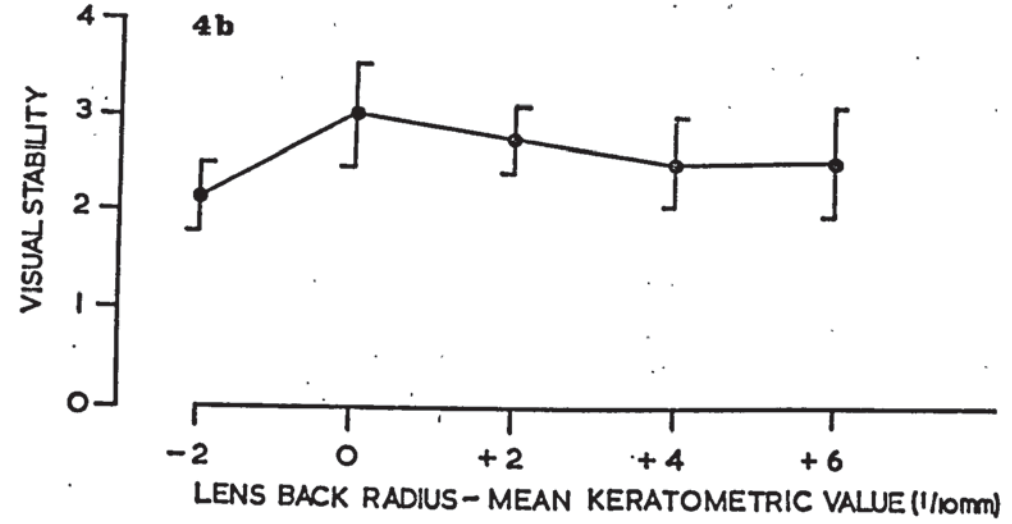
3.9 Results and analysis of three visual properties of gel lenses of a revised design

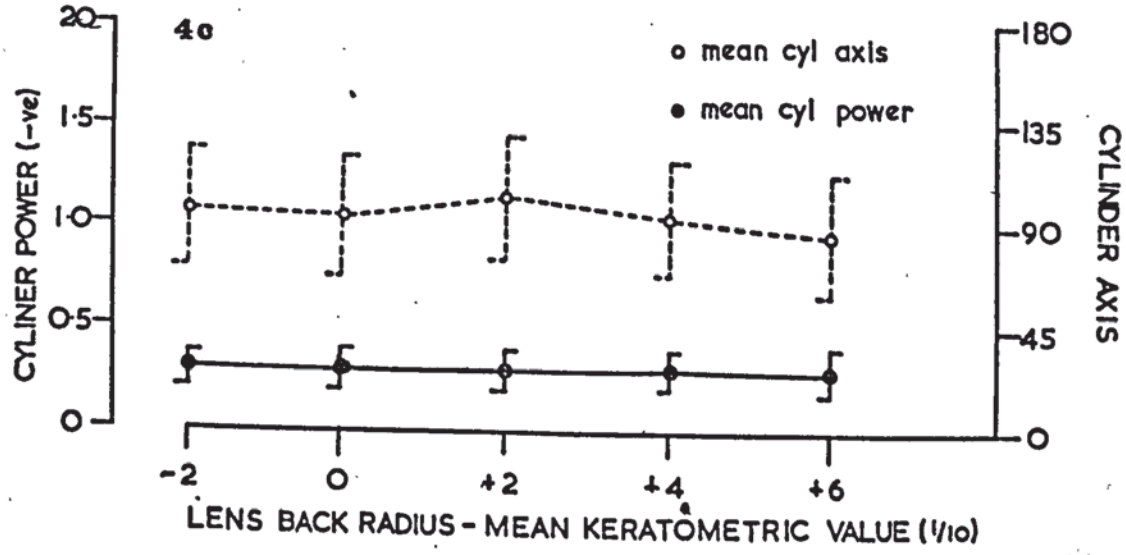
The visual properties of the revised design of lens are illustrated in graphs 4a, b and c (page 61).

Two way analysis of variance of the results of visual acuity (page 66) shows the between curvatures and between groups term to be significant at this level of testing. The

Visual Factors Relating to Lenses of Revised Design







application of 90% confidence limits shows some overlap of the upper and lower limits for all the results. However, inspection of the first standard deviation shows that the distribution of results is less for the value of visual acuity at plus 0.2 mm flat on the mean keratometric value, than for the other four values. Since the mean visual acuity at 0.2 mm is the highest achieved it is considered that this represents an optimum value for this criteria of vision.

One way multiple analysis of the results for visual stability and lens induced astigmatism (page 67) are statistically insignificant at this level of testing; the appropriate values of F from tables exceeding the calculated values by 0.65, 1.73 and 1.57 respectively.

Discussion

The mean visual acuity achieved for a fit of 0.2 mm flat on mean 'K' provides a reasonable level of visual acuity at 6/6. This apparently acceptable level of acuity is marred by the visual instability, to which the lenses are still subject as shown by graph 4b.

The level of induced astigmatism shown graphically in 4c confirms the conclusion reached earlier (page 52) in respect to this factor.

In adopting a fitting technique from the results obtained, it was found useful to fit an initial lens 0.2 mm flat on mean 'K' and two subsequent lenses 0.1 mm and 0.3 mm flat on 'K'. Should either of these subsequent lenses achieve a higher visual acuity than the initial lenses, it was attempted to 'bracket' this result by moving 0.1 mm flatter or steeper. This procedure was repeated until the highest acuity was established.

In view of the apparent improvements in visual performance achieved through modifications in gel lens design, the next investigation was an attempt to assess the general lens behaviour against that of traditional corneal lenses.

Tabulated Results

Some Properties of Gel Lenses of the Revised Design

1) Visual acuity

Patient No.	Difference in curvature -4	-2	0	+2	+4	+6
1	1.5	4.0	1.5	0.8	3.0	0.8
2	2.0	1.5	2.0	0.7	1.0	2.0
3	4.0	1.5	2.0	0.7	1.0	2.0
4	2.0	1.5	3.0	1.0	1.5	1.5
5	1.5	1.5	1.5	1.0	1.5	1.5
6	0.8	1.0	0.8	0.8	2.0	1.5
7	0.7	1.0	1.5	0.8	1.5	2.0
8	1.5	1.0	1.0	0.7	1.5	3.0
9	1.5	1.5	1.5	0.8	1.5	1.5
10	1.5	1.5	1.0	1.0	0.7	3.0
11	1.0	1.5	1.0	1.0	0.7	1.5
12	1.5	1.0	1.0	1.5	1.5	4.0
13	3.0	3.0	0.8	0.8	1.5	1.5
14	3.0	3.0	0.8	1.0	1.0	0.8
15	2.0	2.0	1.0	0.8	1.0	1.0
Mean	1.83	1.76	1.36	0.89	1.34	1.84
Standard deviation	0.88	0.86	0.72	0.02	0.55	1.03

2) Visual stability

Patient No.	Difference in curvature -4	-2	0	+2	+4	+6
1	2	4	2	3	3	2
2	2	3	3	1	2	1
3	1	1	3	4	1	2
4	1	2	1	2	3	1
5	1	4	4	3	4	1
6	3	4	4	3	2	4
7	2	4	2	1	3	1
8	2	1	2	1	2	2
9	2	2	3	1	2	1
10	3	4	4	4	4	3
11	3	4	1	4	2	4
12	3	2	3	1	4	3
13	3	4	3	4	2	4
14	2	2	3	3	3	1
15	2	4	2	2	1	3
Mean	2.13	3.00	2.86	2.46	2.46	2.20
Standard deviation	0.72	1.14	0.83	1.20	0.97	1.16

Tabulated results

Some properties of gel lenses of the revised design

3) Gel lens induced astigmatism

Pat. No.	Difference in Curvature -4		-2		0		+2		+4		+6	
	Power	Axis°	Power	Axis°	Power	Axis°	Power	Axis°	Power	Axis°	Power	Axis°
1	0.50	160	0.00	-	0.50	150	0.50	140	0.00	-	0.50	180
2	0.25	100	0.00	-	0.00	-	0.00	-	0.50	155	0.00	-
3	0.00	-	0.00	-	0.50	90	0.25	130	0.25	80	0.00	-
4	0.50	90	0.25	80	0.25	135	0.75	45	0.75	70	0.25	135
5	0.25	20	0.50	125	0.50	145	0.00	-	0.50	20	0.25	135
6	0.75	175	0.50	175	0.25	50	0.25	155	0.25	30	0.75	120
7	0.50	180	0.25	10	0.00	-	0.50	20	0.75	150	0.00	-
8	0.00	-	0.00	-	0.50	175	0.50	170	0.25	165	0.25	45
9	0.75	15	0.25	90	0.50	15	0.50	20	0.25	40	0.50	15
10	0.50	75	0.25	130	0.00	-	0.50	15	0.25	15	0.50	20
11	0.00	-	0.50	30	0.25	100	0.00	-	0.50	80	0.00	-
12	0.00	-	0.25	120	0.00	-	0.00	-	0.00	-	0.00	-
13	0.00	-	0.00	-	0.50	140	0.00	-	0.00	-	0.50	10
14	0.25	90	0.25	90	0.50	110	0.25	150	0.50	160	0.50	10
15	0.25	120	0.50	120	0.25	90	0.00	-	0.00	-	0.00	-
Mean	0.29	98°	0.23	97°	0.30	109°	0.26	93°	0.31	87°	0.26	74°
Standard Deviation	0.17	53°	0.20	55°	0.20	48°	0.22	54°	0.24	57°	0.22	58°

Analysis of Variance

Visual acuity related to gel lens back curvature for lenses of the revised design

Cell totals

Group	Curvature difference -4	-2	0	+2	+4	+6
Gel lens	27.5	26.5	20.4	13.4	20.9	27.6
Control	11.3	11.3	11.3	11.3	11.3	11.3

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
Between curvatures	5	16.6415	3.3283	7.72
Between groups	1	26.0779	26.0779	60.50
Interaction	5	1.5829	0.3165	0.73
Residual	168	72.4080	0.4310	

Value of F from tables

Between curvatures (probability p = 0.01) = 6.63
Between groups (probability p = 0.01) = 3.02
Interaction term (probability p = 0.1) = 1.85

Analysis of Variance (Multiple One Way)

Visual Stability (Monocular Diplopia) Related to Gel Lens Diameter

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between diameters	5	116.1334	23.2266	47.16
Residual	54	26.6000	0.4925	

Value of F from tables

F (for a probability p = 0.1) = 3.51

Lens Induced Astigmatism Related to Gel Lens Diameter

a) Cylinder power

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between thicknesses	5	3.3458	0.6691	0.71
Residual	54	50.7626	0.9400	

Value of F from tables

F (for a proability p = 0.1) = 2.00

b) Cylinder axis

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
Between thicknesses	5	1666.6667	333.3333	0.14
Residual	42	96931.2500	2307.8869	

Value of F from tables

F (for a probability p = 0.1) = 2.00

Section 4

The factors involved in a comparative study of contact lens performance

4.1 Introduction

During the period that the experiments concerned with gel lens design took place, it was noted that the normal changes as induced by hard contact lenses were apparently absent. This impression was supported during a visit to Czechoslovakia where a number of clinicians were of the same opinion. It was therefore decided to investigate this question.

The apparent improvement in gel lens performance which had resulted from design modifications gave an opportunity to compare gel lenses with traditional corneal contact lenses on an equal basis. It was hoped that wearing times of up to sixteen hours a day could be obtained with a tolerable level of vision by gel lens wearing patients.

A total of twelve factors were considered:-

1) Lens riding position:- During a visit to Prague it was noted by the author that the gel lenses then in use in Czechoslovakia tended to ride low on the cornea. In traditional corneal lenses this writer was of the opinion that corneal lenses tended to ride high on the cornea. It was therefore attempted to assess this factor.

2) Visual acuity:- One of the properties found for the revised design of gel contact lenses (section 3 page 62) was an improved visual acuity at 0.2 mm flat on the mean keratometric value. It had not been established, however, how closely this acuity approached that of corneal and spectacle lens wearing subjects. In addition it was also hoped to assess any changes

in gel lens visual acuity which took place over a period of time.

3) Oedema (subjectively):- The absence of the symptoms of corneal oedema which had apparently resulted from the work described in section 2, had only been established for a short period of time. It was hoped that an examination over twenty weeks would give an indication of any return of the symptoms of corneal oedema during gel lens wear.

4) Visual acuity (with spectacle lenses after contact lens wear):- As reported in the introduction (page 3), corneal contact lenses have been shown to produce reductions in visual acuity with spectacle lenses. The author was told during the visit to Prague that this effect did not occur with gel lenses. However no recorded clinical trials had been carried out to substantiate this clinical opinion, and this factor is therefore included in the present work.

5) Corneal epithelial disturbances:- As with the question of visual acuity, the clinical opinion of Czechoslovakian ophthalmologists was that gel contact lenses did not disturb the corneal epithelium. Again this factor is included in the present work, due to the absence of controlled trials elsewhere.

6) Corneal sensitivity:- Corneal sensitivity is considered in the present survey for identical reasons to visual acuity and corneal epithelial disturbance. Sensitivity is known to

reduce in corneal lens wear, and although it is claimed not to reduce in gel lens wear this had not been substantiated in a controlled study.

7) Corneal topography:- Corneal topography is included for the reasons expounded in (4), (5) and (6) above.

8) Refractive changes:- Refractive changes are included for the reasons in (7).

9) Patients' general symptoms:- It was hoped to assess patients' symptoms for the differing types of contact lens in a controlled manner by the use of questionnaires. The results of the questionnaires would be presented as supporting evidence to those factors already mentioned and would not be recorded separately.

10) Oedema (objectively):- Towards the completion of the experiment, personal communication with a member of the academic staff[53] suggested the need to confirm the subjective symptoms of corneal oedema by objective means. This was carried out on the last occasion on which the patients were seen.

11) Stability of vision with contact lenses:- As reported in section 3 gel lenses are subject to a form of visual instability. It had not been established at the time the work described in section 3 was carried out, if this instability were an adaptive phase of gel lens wear. It was therefore decided to assess the instability in vision after twenty weeks of wear and to compare it to that found among corneal lens wearing patients.

12) Additional patients' symptoms:- As work on the survey progressed patients reported subjective changes in the stability of vision and the appearance of the symptoms of corneal oedema. Since these factors were not exhaustively covered in the general questionnaire, a supplementary questionnaire was prepared, which covered these factors.

It was hoped that consideration of these factors would give a general picture of gel lens performance and indicate those aspects which had not yet reached parity with traditional contact lenses.

4.2 Experimental design

A number of experimental designs were initially considered for the proposed survey:-

1) Paired organ study

2) Individual studies of each factor

3) General comparative study of all factors

1) Paired organ study

The basis of a study of two paired organs within the same animal, is that they are sufficiently alike to remove considerations of individual peculiarities from the experiment. That this concept is true of the eyes, has been established for some time. Indeed differences in the power of the two eyes of quite a small magnitude are rare enough to warrant a special clinical definition of anisometropia.[54] In considering the eyes as paired organs, however, some special factors arise. Unlike other pairs of organs in the body the eyes are required to act together in a harmonious relationship. This state of harmony is advanced to such a level as to make possible certain sympathetic reactions between the two eyes. One of these reactions is of particular interest in the present case; that of sympathetic corneal disturbance. If the corneal epithelium of one eye becomes disturbed to any marked extent, the epithelium of the second unaffected eye will show a similar disturbance pattern. This phenomenon has been demonstrated in the past by the use of geometrically shaped probes and sodium fluorescein dye.[55] As far as the present work is concerned the incidence of uncontrolled sympathetic staining patterns would introduce a random variable into the experiment. For this reason it would be impractical to examine the staining induced in the epithelium by individual contact lenses. Since the comparative

description of epithelial stained areas was to form an important part of the proposed survey it was decided to reject a paired organ experimental design for this project.

2) Individual studies of each variable

The advantage of studying each reaction to contact lens wear individually would lie in the small number of patients required for each experiment. A number of factors to be investigated showed a marked difference to one another during preliminary work. It would be reasonable to propose that in the case of corneal sensitivity, where gel lenses appeared to cause no reduction and where traditional lenses are known to increase the threshold by at least three times[56]; no more than two groups of five or six subjects each would be required to establish statistically different group means. The disadvantage of taking a single factor or a small number of related factors in isolation, lies in the large number of factors that were envisaged. Taking subjective symptoms as a single issue there are thirteen factors which need to be assessed. In all, the preliminary work indicated the need for a total of at least forty-six patients in each of three groups. This was considerably more than would be required if all factors were taken together and this type of design was therefore dropped.

General comparative study of all factors

The attraction of a comparative study of all factors lies in the relatively small number of patients required. The most subtle changes to be determined were those of corneal shape. The results of a preliminary survey indicated the need for eighteen patients to determine a difference in group means of 0.1 mm (at a probability p of 0.01) in the radius

of curvature. Consideration of the factors, it was proposed to study, indicated that they should all show significant differences with the use of this number of patients.

Having accepted that a general comparative study appeared the most efficient way of carrying out the survey, the number of groups and the frequency of sampling was determined. In addition to the two groups of traditional, and gel lens wearing patients, it was essential that a control group should also be included. The control patients would be selected in an identical manner to the experimental patients, but would wear glasses instead of contact lenses.

The frequency of sampling after fitting with contact lenses presented certain problems. The purpose of the survey was to establish the overall comparative performance of the two types of lens. It was therefore not considered relevant to investigate the early transient changes lasting perhaps three or four weeks[57]. In any case the large number of patients and the wide spectrum of factors would make this task virtually impossible. However, for general clinical reasons it was necessary to see the patients as soon after fitting as possible, for safety. It was therefore decided to make the first examination at four weeks, it being hoped that the early transient adaptive symptoms would have begun to subside by this time. Since it was hoped to study the general effects of the two types of lens the experiment was to run for some months. In practical terms it was not possible to run the survey for more than twenty weeks without becoming involved in one of the longer University vacations, when the patients would be generally unavailable. It was considered that in the period between the fourth and twentieth week two further examinations could be undertaken.

These were at the twelfth and twentieth weeks. The three proposed after care appointments together with the patients' initial examination would give four definitive points for each parameter under investigation. In statistical terms this would be just enough to determine general trends, although some irregular effects would not be noted.

Having arranged the general outline of the survey, the type of patient to be used was considered. It was felt that the most important factor in the proposed investigation was uniformity. In order to achieve this a profile within which each accepted patient would fall was constructed. The patient profile was was constructed on two basic premises:-
1) the patient should show no discernible pathological or congenital ocular anomalies, particularly in respect of the cornea; 2) the patients should fall inside the third standard deviation in those factors which were to be investigated. Having constructed a profile, each patient was screened to determine if they lay inside the requirements. In addition to establishing a criterion for the accepted patients, the principle of randomisation was applied in constructing groups, in a further attempt to achieve a balanced and uniform experiment.

Appointment schedules

In order to achieve meaningful results it was important that the examination times were distributed evenly in all three groups of patients. To this end the patients were asked to begin contact lens wear as near to 9,00 a.m. as practicable. The times of examination were then arranged on a basis similar to that of a latin square. It should be made clear

that this is not a latin square experimental design, but a way of achieving uniform examination times which resembles a latin square. The appointment times were arranged as shown in table No. 1

Table No. 1

	10.00 -10.50	11.00 -11.50	11.50 -12.40	2.00 -2.50	3.20 -4.10	4.10 -5.00
Monday	T	C	H	T	H	C
Tuesday	C	H	T	C	T	H
Wednesday	h	t	c			
Thursday	H	T	C	H	C	T
Friday						

T = Examination of traditional lens wearing patient

C = Control patient

H = Examination of hydrophilic lens wearing patient

The figures in ordinary type refer to the same category of patient as those in bold type, but these patients were arranged on a latin square which covered all three visits:-

	Visit No. 1 4 weeks	Visit No. 2 12 weeks	Visit No. 3 20 weeks
10.00-10.50	h	c	t
11.00-11.50	t	h	c
11.50-12.40	c	t	h

The aim of the appointments schedule was two fold. Firstly to ensure that the average time (at the time of examination) would be the same for all groups of patients; and secondly to ensure that the distribution of examination times

within each group would be similar. In this way it was hoped to avoid the type of false result that might have arisen if one group of patients were seen after an average of four hours and the second after an average of six hours wear.

4.3 Selection of patients

Undergraduate students from the universities of Aston and Birmingham acted as volunteer patients. Initially two articles describing the proposed work appeared in the newspapers of each university. The students were invited to apply to be fitted with contact lenses, or to act as paid control patients. Eighty-three applications were received for contact lenses, forty-two as controls. All the applicants were then subjected to mass screening.

Screening factors

The results of screening were recorded on punched cards which were later broken down for analysis in the normal way. In all thirty-five factors were assessed and the information was recorded as follows:-

Hole No.

(A) History	Condition
1	Patient younger than 18 or older than 24
2	Patient male
3	Patient received eye injury or operation
4	Patient had some recent (within the last six months) ocular medication
5	Patient is at present receiving any form of drug for ocular use
6	Patient is at present receiving any form of drug for systemic use
7	Patient has had some form of orthoptic treatment (principally strabismus leading to abnormal eye positions).

8	Patient suffers from 'hay fever'
9	Patient suffers from asthma, allergic dermatitis or other allergic conditions
10	Patient is subject to recurrent or persistent red eyes, repeated styes, intolerance to light, watery eyes, scaly eye lids, repeated colds
11	Patient is at present receiving psychiatric care
12	Patient not of European extraction
13	Palpebral aperture greater than 12 mm in depth or less than 8 mm (right eye)
14	Palpebral aperture greater than 32 mm long or less than 28 mm (right eye)
15	Palpebral aperture greater than 12 mm in height or less than 8 mm (left eye)
16	Palpebral aperture longer than 32 mm or shorter than 28 mm (left eye)
17	Myopia of -4 dioptres to -8 dioptres (right eye)
18	Myopia of 0 to -3.75 dioptres (right eye)
19	Hypermetropia to 0 to +3.75 dioptres (right eye)
20	Hypermetropia of +4 to +8 dioptres (right eye)
21	Myopia of -4 to -8 dioptres (left eye)
22	Myopia of 0 to -3.75 dioptres (left eye)
23	Hypermetropia of +0 to +3.75 dioptres (left eye)
24	Hypermetropia of 7 to 8 dioptres (left eye)
25	More than one dioptre of astigmatism in either eye
26	Visual acuity less than $^{6}/_{6}$ either eye

27	Thickness of cornea less than 0.47 mm or greater than 0.63 mm (right eye)
28	Thickness of cornea less than 0.47 mm or greater than 0.63 mm (left eye)
29	Keratometric value greater than 8.54 mm or less than 7.13 mm for either meridian of the right eye
30	Keratometric value greater than 8.54 mm or less than 7.13 mm for either meridian of the left eye
31	Pathological or congenital anomaly of the cornea shown by slit lamp examination
32	Fluorescein staining of the cornea as shown by slit lamp examination
33	Central corneal sensitivity threshold greater than 0.96
34	Pathological or congenital anomaly of the eye shown by ophthalmoscopic examination.

History

Failure to comply with factors 1, 3, 4, 5, 6, 10, 11 and 12 excluded a patient from the experiment. Factor 7 did not exclude a patient, providing orthoptic treatment had been successful. Patients were excluded from the experiments if more than one of the conditions referred to in 8 and 9 were present. They were not excluded on the basis of a single condition.

Palpebral aperture

The acceptable limits for the palpabral aperture were determined on the basis of the third standard deviation established in preliminary work.

Astigmatism

As previously stated, gel lenses correct little or no corneal astigmatism. For this reason patients having in excess

of one dioptre of astigmatism were excluded from all the groups.

Corneal thickness and shape

The acceptable limits of corneal thickness and shape were established on the basis of the third standard deviation established in preliminary work

Corneal staining

In cases of corneal staining found during screening the patient concerned was asked to return in twenty four hours. If it was then established that the staining pattern was repeated, the patient was excluded from the survey. In the case of transient staining the patient was accepted for the work.

Group composition

As a result of screening 84 patients were accepted for the survey. The rejection rates for each factor are as follows:-

Factor	Contact Lenses	Control
Age	3	1
Eye injury	4	2
Non European	1	
Palpebral aperture		
Palpebral aperture		
More than 1 D astigmatism	8	5
V.A. less than $^{6}/_{9}$	3	1
Corneal staining	2	2
Corneal sensitivity	1	1
Pathological or congenital anomaly	1	1

After rejection of unsuitable subjects those remaining patients who applied to wear contact lenses were divided into two groups. The division was made on the basis of random numbers. Each patient was given a random number from zero to fifty six. Those patients numbered zero to twenty seven were fitted with traditional lenses, whilst those numbered twenty eight to fifty six were given gel lenses. The number of control patients was initially twenty nine and one patient was randomly rejected to provide balanced groups. After assembly of the groups the methods of assessment for each factor to be investigated was considered.

4.4 Methods of investigation

1) Lens riding position:- This was assessed on a qualitative basis by the author. Whilst the patient viewed a point light source in the horizontal plane, the lens was judged to ride high, central or low. The patient was allowed to blink normally and a standard period of sixty seconds observation was made for each subject.

2) Vision:- The vision achieved with the contact lens, was recorded after the correction of any spherical residual error. Induced or uncorrected astigmatic errors were uncorrected and later related to the level of vision achieved. The vision was recorded on an internally illuminated letter chart under conditions of standard external illumination.

3) Oedema (subjectively):- Each patient was asked to view a point source of light in a darkened room; they then stated if a large coloured rainbow, which frequently denotes the presence of corneal oedema,[58,59], could be seen around the light. With the room illuminated each subject was questioned about

another common symptom of corneal oedema; a light blue mist. The factors of haloes and mistiness were recorded separately.

4) Refractive changes:- A normal objective and subjective refraction was carried out with the contact lenses removed. The retinoscopic results were modified, where necessary, on the basis of duochrome findings, and particular attention was paid to achieving a binocular balance on this unit in an attempt to control accommodation.

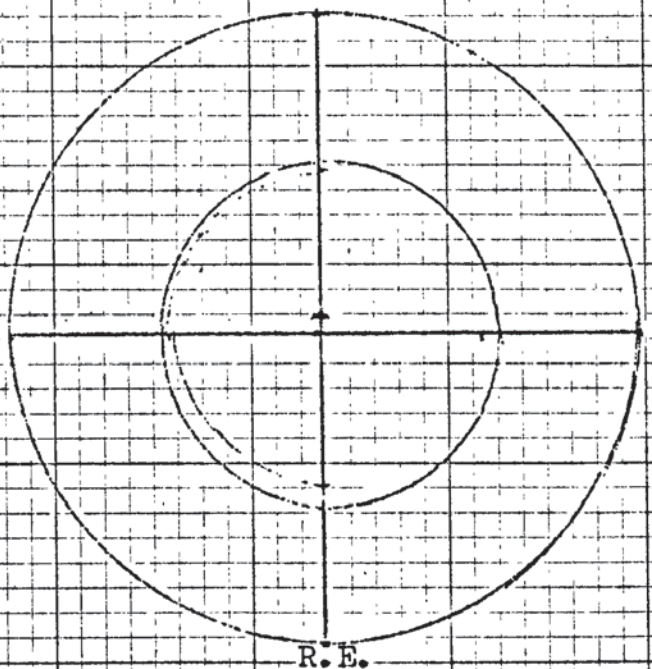
5) Visual acuity:- After correction of the refractive errors found in section 4 the visual acuity of each patient was recorded on the letter chart mentioned in part 2)

6) Corneal vital staining:- An investigation of corneal epithelial disturbances was made with the aid of 2% sodium fluorescein. After the instillation of one drop of fluorescein solution and a time lapse of one minute to allow for even distribution a slit lamp examination of the cornea was undertaken. As part of this examination it was hoped to record corneal stain on a quantitative basis, and to this end a modified form of instrument was used. A photographic replica of the area of graph paper shown in figure 8 was made on a glass plate. When developed and fixed the plate was cut to size and mounted in one (x10) eye piece of a Haag Streit slit lamp. The size of the graticule was such that the image of the limbus of a normal cornea of thirteen millimeters diameter coincided with the outer circle of the graph, when the instrument was in the x10 position. In cases of corneas larger or smaller than this value the instrument was set slightly out of focus until coincidence was achieved. The area of stain was determined by counting squares, and transferring the results to graph paper marked in a manner similar to the

CORNEAL STAINING

CLASIFICATION

1.
2.
3.
4.
5.
6.
7.



R.E.

CLASIFICATION

1.
2.
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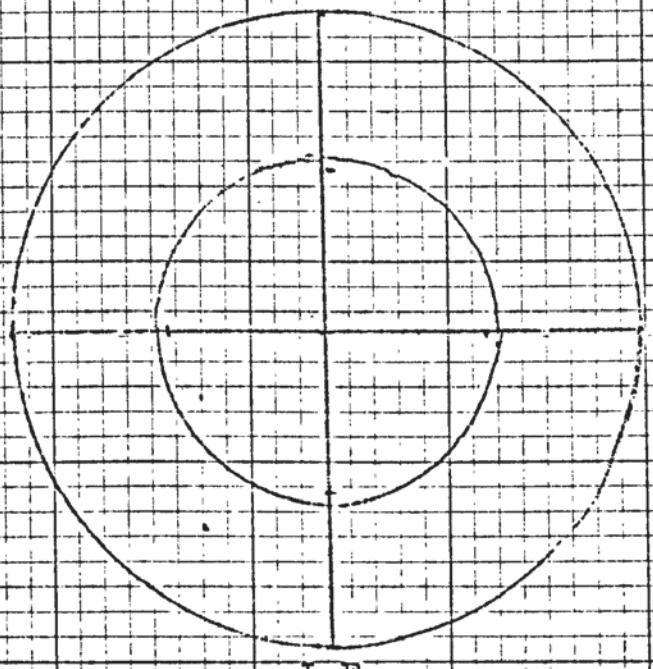


L.E.

Fig. 8 Graph used for the recording of corneal staining patterns.

original sheet. Since the diameters of the cornea vary among individuals, the results are expressed as a percentage of the total corneal area, each square representing an area of 0.75%.

The examination of areas of corneal stain was initially made under conditions of sclerotic scatter. After location of a disturbed area a more detailed examination was made under direct focal illumination using a narrow beam of light approximately 0.5 millimeters wide. It was under these conditions of illumination that an assessment of the depth of stain was made. The shadowing of underlying tissue was a troublesome artifact. However, by rotating the slit beam an approximate estimate of staining penetration could be made. Following the examination of individual staining areas the location and staining area was assessed using direct focal illumination with the slit beam fully opened. Following the slit lamp examination of the cornea, any stain found was classified according to:- a) type; b) severity and c) area.

a) Type:- After examination of the literature and particularly the previously mentioned work of Cochet and Bonnet (page 3) and Shulman (page 4), it was decided to adopt four categories of stain:-

(1) Punctate stain:- which was defined as a small localised area of stain, not exceeding 0.75% of the total corneal area, and having a distinct margin. Punctate stain was found singly or in groups with a clear area of undisturbed epithelium between each punctate spot.

(2) Diffuse stain:- An area of stain having an undifferentiated appearance with ill defined margins. The total area

may be from 0.75% to 100% of the corneal surface and may overlie areas of differing types of disturbance.

(3) Line stain:- a continuous staining area being at least ten times as long as it was broad and not more than 0.75% of the corneal area in width. Line stain was not necessarily straight and could be joined, or lie adjacent to other line stains.

(4) Other types of stain:- The fourth category of stain was left undefined since it was not known what types of stain, if any, might be encountered during long periods of gel lens wear. When stain which did not conform to one of the first three definitions was encountered it was defined and recorded separately.

b) Depth of stain:- Three depths of stain were considered:-

(1) Superficial stain:- An area of stain confined to the outermost layers of the corneal epithelium.

(2) Moderate depth of stain:- A staining area involving the corneal epithelium down to Bowmans membrane. Some slight stromal stain was permissible in this category, but fluorescein penetration of Descemet's membrane was classified as Deep stain.

(3) Deep stain:- Staining involving the entire thickness of the cornea with evidence of fluorescein penetration into the aqueous humour.

c) Area:- The determination of corneal staining areas has previously been mentioned (page 81).

7) Corneal sensitivity:- An assessment of corneal sensitivity was made using the aesthesiometer of Cochet and Bonnet[60] The sensitivity was assessed in five regions of the cornea:

(1) Central

(2) Superior

(3) Inferior

(4) Nasal

(5) Temporal

The areas (2) to (5) refer to the appropriate zone in the horizontal or vertical meridian approximately one millimeter inwards from the limbal region.

8) Corneal curvature:- Corneal shape was assessed with the aid of a topographical keratometer after Bonnet[61] and manufactured by Guilbert-Routet Ltd.

The values of corneal radius were measured at five degree intervals along the two principle cornea meridians. In the case of spherical corneal the horizontal and vertical meridians were recorded on a concentric ring chart (Appendix).

9) Visual stability:- At the completion of the survey, after twenty weeks of lens wear, the stability of vision was measured. Each patient was asked to view the letter chart and read the lowest line visible at twenty second intervals for a period of five minutes. The patients were instructed to attempt to distinguish between what they could see and what they could remember.

10) Patients' symptoms:- A questionnaire (Appendix) which has been widely used in the Contact Lens Clinic of this University[62] was completed by each patient. In addition to this general questionnaire a supplementary sheet was prepared which was completed by each patient at the end of the survey (Appendix).

11) Oedema (objective):- On the last occasion on which each patient was seen in the survey, the presence of corneal oedema was assessed objectively. Initially the presence of the normal physiological oedema[63] present in the limbal region was determined. The general impression taken from a number of such cases was accepted as a criteria of judgement for oedema of the central epithelium of the cornea. Retro-illumination, whilst viewing against the iris/pupil margin was the slit lamp technique employed in each case. The illumination beam was set at approximately thirty degrees to the microscope system. A slit width of approximately half a millimeter on the cornea was utilised in conjunction with a magnification of sixteen times.

Section 5

Lens Fitting and Storage Techniques

5.1 The fitting of gel lenses

The fitting technique adopted for gel lenses was that previously described on page 62. Each patient was fitted from 0.1 to 0.2 mm flat on the mean keratometric value, with the optimum lens being "bracketed" with the results of slightly flatter and steeper lenses.

Gel lenses were stored in approximately 5 ml of sterile physiological saline. Before being issued to the patients, each lens was autoclaved in sealed glass containers for twenty minutes at a pressure of 15 lbs in ^{2}. The lenses were also partially sterilised by the patients on each occasion on which they were removed from the eye; the lens and container being boiled for approximately five minutes, immediately following lens wear.

5.2 Corneal lens fitting procedure

Following a search of the literature and some discussion, it was decided to adopt a tetracurve lens of the following specification:

C4/K-a;7.00/(K-a)+0.50:8.20/(K-a)+1.00:9.30/12.25:9.70/

Where K = the central keratometric value of the flatter of the two corneal meridians

and a = 0.10, 0.15 or 0.20 millimeters.

The value of 'a' was determined on the basis of fluorescein assessment of the lens fit. Initially a tetracurve corneal lens was fitted 0.15 mm steep on the flatter 'K'. The lens was then judged; a good fit; flat; or steep, on the basis of examination with 2% sodium fluorescein solution. In the case

of the latter assessments, the appropriate lens of 0.10 or 0.20 mm steep on the flatter 'K' was fitted. At the completion of the second fit a decision was made as to which lens represented the closest approximation to an ideal fit, and this lens was prescribed. In the interests of uniformity these variations in lens back curvature were the only adjustments made. No changes were made in the overall lens diameter, and the tetracurve specification was adopted for all patients.

Corneal lens storage solutions

Corneal lenses were stored in approximately 5 ml of a solution of 7.5% v/v of Chlorhexidine Gluconate B.P. and 15% w/v of Cetrimide B.P. diluted to 1:1000, with distilled water.

Section 6

Results: Recording and Treatment

6.1 Recording of Results

The results were recorded on separate sheets of paper which were grouped together to form individual patient records. The records were broken down into separate groups in order to facilitate analysis, and at the completion of the survey were reassembled to form a permanent clinical record for each patient. A sample of a complete patient record is included (appendix).

6.2 Treatment of Results

Although the survey was initiated with twenty eight patients in each group, a number of factors forced some patients to withdraw. A thorough investigation of the reasons for the withdrawal was made, and the causes are listed below.

1) Gel lens wearing group:-

Two patients failed to complete the survey:-

(a) Patient male aged 23: An undergraduate architectural student engaged on industrial training. This patient withdrew after nine weeks of apparently satisfactory gel lens wear. He complained that the instability to which it has been shown gel lenses are generally subject proved unacceptable in the fine design drawings upon which he was engaged. In particular he found it 'virtually impossible' to draw 'cross hatch' work accurately and requested to be refitted with traditional lenses. An investigation of the results for this patient was made at eight weeks. Apart from the instability in vision the visual acuity was comparable to the remainder of the group at $^{6}/_{6}$. There was no staining and no change

had taken place in any of the factors under consideration.

(b) Patient male aged 22:- An undergraduate student also reading architecture and engaged on design drawing in the fourth year of University based training. This patient withdrew from the experiment after eight weeks of wear; he complained of similar visual symptoms to the previous subject and found it 'impossible' to carry out the type of fine detailed drawing which he was called upon to do. Again an examination of the patient's record was made and none of the factors under consideration had changed.

Discussion

The incidence of the special visual tasks required of these two patients would seem to constitute a special case. The lack of change in the factors under examination was later shown to be common for this group at eight weeks, and it was therefore felt that their exclusion did not introduce an element of bias into this group. Hence with the exception of the interpretation of the results of visual stability the withdrawal of these two subjects has been ignored in the interpretation of the other factors under comparison.

2) Corneal lens wearing group:-

One patient failed to complete the survey:-

Patient female aged 19: An undergraduate student reading psychology. This patient stated she would not continue corneal lens wear five weeks after fitting. When questioned as to her reasons for ceasing lens wear she stated 'the lenses do not improve my appearance as much as I had hoped'. Further questionning revealed that the lenses were 'not particularly comfortable', and that seven days prior to

being seen she had suffered a 'stye' on the lower left eyelid. An examination of the lid margin was carried out with the aid of fluorescein and a slit lamp, and an enlargement of the opening of a meibomian duct on the nasal aspect of the left lower lid was noted. The patient had persisted in contact lens wear during the period of the infection, in spite of a specific instruction not to do so at the time of lens supply. However, contact lenses had not been worn for six days prior to the appointment. The patient was advised to visit her general practitioner immediately although the infection had now apparently ceased. The patient agreed to do this but was firm in her decision not to resume contact lens wear.

Discussion

The absence of any special factor in this patient's history posed problems with respect to any group bias, her withdrawal from the experiment might cause. However, her persistent refusal to continue lens wear presented an impasse to any further investigation. It was not possible to compare the factors under examination for this patient to those of the group as a whole since lens wear had ceased prior to the patient being seen. The question of group bias cannot therefore be satisfactorily answered for the corneal lens wearing group, and no estimate of what changes in the conclusions for this group would have been brought about, had this patient not withdrawn from the survey, can be made. All that may be claimed is that this patient was only one of twenty eight and her parameters would have had to be very extreme to affect the general group results; since this patient was passed at mass

screening, there is no evidence that this was the case.

3) Control group:

One patient failed to complete the survey:-

Patient female aged 19: At the twelfth week of the experiment the father of this patient, who was resident in Canada, died. The patient wrote informing me of her father's death and her decision to return to Canada. A comparison of the results of this patient were made for twelve, four and zero weeks, and no change was found in any of the factors measured.

The death of this patient's father represented a special case for this subject and there is no reason to suppose that her withdrawal would introduce any bias into the control group.

6.3 Rejection of patients

At the time of the analysis of the results one patient's results were not included:-

Patient male aged 22: The patient was a member of the group of subjects wearing gel lenses. At the fourth week of the experiment he contracted a sub-acute conjunctivitis. Lens wear ceased and medical treatment prescribed by his general practitioner was taken. After three weeks his doctor was of the opinion that lens wear could be resumed. After a further two weeks both lenses were extensively damaged when the container was boiled dry. A second pair of lenses were ordered and gel lens wear resumed ten days later. Three weeks after the supply of the replacement lenses the right lens was lost. A further right lens was supplied. Two weeks after the supply of the second right lens, both lenses were again boiled dry and

irretrievably damaged. A replacement pair of lenses were again supplied and lens wear resumed after a further ten days. Three weeks later the replacement left lens was torn in two by the patient's three year old son. At this point the patient had completed the twenty weeks schedule of the survey but had never attained a wearing period of more than four weeks. The repeated replacements combined with the periods of non lens wear and the conjunctivitis were regarded by the writer as too atypical to warrant inclusion with the results of the remainder of the group and the patient's record is not included in the analysis.

6.4 Broken appointments

In addition to the patients who withdrew from the survey, a number of patients failed to keep various appointments. Every effort was made in the form of appointment reminders to ensure patients kept to schedule but there were occasions due to illness or travel when appointments were broken. A summary of unkept appointments is given below.

Group	Initial	4 weeks	12 weeks	20 weeks
	No. of Broken Appointments			
Gel	0	1 T 1 I	2 T 1 I	0 T 2 I
Corneal	0	3 T 1 I	2 T 1 I	0 T 1 I
Control	0	1 T 0 I	0 T 0 I	2 T 1 I

I indicates that the patient was ill for a period seven days after the appointment date.

T indicates the patient was out of the country for seven days before and after the date of the appointment.

The calculation of missing values[64] was applied during the analysis of results to provide balanced groups of twenty five members each. In order to achieve this number for the control and corneal lens wearing groups two patients were randomly rejected from each of these groups on the basis of the random numbers previously allocated to these groups (page80). The application of missing values is indicated in the tabulated results by the presence of an asterisk against the appropriate results.

6.5 Analysis of group examination and wearing times

a) Time of examination

The time of examination after lens insertion was recorded for each patient:-

	Mean Examination Time		
	4 weeks*	12 weeks*	20 wecks*
	hours	hours	hours
Gel lens wearing subjects	4.50	4.61	4.59
Corneal lens wearing subjects	4.44	4.64	4.55

* The tabulated individual results are given on pages 97, 98.

Analysis of Variance

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
a) Between lenses	1	0.0450	0.0450	0.0093
Residual	48	233.5350	4.8653	
b) Between lenses	1	4.0613	4.0613	0.4818
Residual	48	404.5950	8.4290	
c) Between lenses	1	13.5200	13.5200	1.9900
Residual	48	326.1100	6.7939	

Values analysed

(a) Times of wearing at appointment, for gel and corneal lens subjects after four weks of wear.

(b) Times of wearing at appointment, for gel and corneal lens subjects after 12 weeks of wear.

(c) Times of wearing at appointment for gel and corneal lens subjects after 20 weeks of wear.

Discussion

The appropriate value of the F ratio from tables for a probability (p) of 0.10 is 2.8 Since this value is not exceeded by any of the calculated ratios the null hypothesis cannot be rejected and no significant difference exists between the results at this level of testing. Since the aim of the experimental design (page 71) was to achieve a situation where no bias would be introduced into the survey by different group examination times, it seems reasonable to assume that this criteria has been met.

Daily wearing times

Each patient was asked to assess their maximum and average daily wearing times on each occasion of which they were seen:

	4 weeks		12 weeks		20 weeks	
	Aver. Mean	Max. Mean	Aver. Mean	Max. Mean	Aver. Mean	Max. Mean
	hours		hours		hours	
Gel	7.4*	11.4	10.1	14.5	12.2	19.3
Corneal	6.6	8.2	10.1	12.6	11.3	13.2

* Tabulated individual results pages 97 and 98.

One way analysis of variance was applied to the estimated values.

Source of Variance	Degrees of freedom	Sum of squares	Variance Estimate	F Ratio
a) Between lenses	1	8.8200	8.8200	1.89
Residual	48	224.0000	4.6660	
b) Between lenses	1	0.0000	0.0000	0.00
Residual	48	749.2800	15.6100	
c) Between lenses	1	3.3800	3.3800	0.21
Residual	48	752.2400	15.6718	
d) Between lenses	1	3.3800	3.3800	0.58
Residual	48	279.0400	5.8133	
e) Between lenses	1	79.3800	79.3800	2.63
Residual	48	1448.0000	30.1666	
f) Between lenses	1	332.8200	332.8200	5.17
Residual	48	3086.9600	64.3116	

Values Analysed

a) Average gel and corneal lens wearing times after four weeks of wear.

b) Average gel and corneal lens wearing times after twelve weeks of wear.

c) Average gel and corneal lens wearing times after twenty weeks of wear.

d) Maximum gel and corneal lens wearing times after four weeks of wear.

e) Maximum gel and corneal lens wearing times after twelve weeks of wear.

f) Maximum gel and corneal lens wearing times after twenty weeks of wear.

Discussion

The calculated F ratio a) after four weeks of wear, exceeds the appropriate value of F from tables (1.4) by 0.49 for a probability (p) of 0.20. However, it is itself exceeded by 0.11 when the probability (p) is raised to 0.05, when the F ratio

contd p99.

Tabulated Results

Corneal lens wearing times (in hours)

Pat. No.	After 4 weeks of wear			After 12 weeks of wear			After 20 weeks of wear		
	Exam. Time	Aver. Wear. Time	Max. Wear. Time	Exam. Time	Aver. Wear. Time	Max. Wear. Time	Exam. Time	Aver. Wear. Time	Max. Wear. Time
1	4	6	12	7½	12	16	2½	12	14
2	5¾	6	6	2	10	16	8	12	14
3	6½	8	8¼	7	15	17	3	15	23
4	1	6	6½	1	8	13	1	9	10½
5	8	6	8	5	6	8	3¼	4	6
6	5	2	6	2¾	3	3	1	3	4
7	2¾	4	4	3	4	4	10¼	7	8
8	2¾	8	8	3	5	7	7	3	6
9	8	10	12	7	14	16	4½	15	15
10	7¾	8	9	11½	16	21	4½	16	21
11	4½	4	8	1	3	6	1¼	5	6
12	1½	8	10	3	8	15	3½	15	17
13	2¼	6	6¼	4½	5	8	6	9	11
14	6½	6	8	2	14	16	6	15	17
15	5	6	6	4	4	8	1	5	6
16	6½	10	11	2	11	11	7	14	14
17	4½	6	8	5½	12	12	3½	12	15
18	2½	8	8	5	13	15	9	15½	18
19	5	9	12	8	12	15	9	16	20
20	5	4	6	2	18	18	3½	19	22
21	1	3	6	4½	7	12½	7	12	16
22	6	10	12	6¼	18	18	1	18	20
23	4¼	7	7½	5	14	16	6	16	18
24	4	8	10	8	16	19	3½	16	22
25	1	6	7	2	10	12	1¼	12	16

Tabulated Results

Gel lens wearing times (in hours)

Pat. No.	After 4 weeks of wear			After 12 weeks of wear			After 20 weeks of wear		
	Exam. Time	Aver. Wear. Time	Max. Wear. Time	Exam. Time	Aver. Wear. Time	Max. Wear. Time	Exam. Time	Aver. Wear. Time	Max. Wear. Time
1	6½	8	8	5½	8	8	5	8	10
2	6	6	6	9	12	16	5½	17	20
3	4	8½	9½	4½	10	11	3	17	20
4	4½	13	16	6¾	14	18	8½	16	18
5	1	6	6	6	10	14	7½	12	14
6	5¾	8	8½	8½	15	18½	7½	16	18½
7	2	5	7	1½	5	8	7	8	10
8	5½	3	5¾	6	10	15	2	10	15
9	3½	4	6	8	14½	36	9	15	38
10	8	8	9	5	11	14	4	11	17
11	7¾	8	8	8¼	8	18	1½	16	36
12	3½	10½	12	3½	12	24	8¼	15	20
13	4¾	8	8	5½	12	15	2¾	12	14
14	2	6	8	7¼	10	20	6	15	38
15	9	8	12	10¼	8	12	2	13	16
16	1½	12	12	1½	12	12	2	12	36
17	1	9	11	1½	10½	12	7½	12	14
18	6½	7	10	4½	12	19	3	12	16
19	5	6	6	2	7	8	2¼	12	16
20	3	8	8	4½	10	12	5½	11	18
21	3½	8	8	8¾	8	12	3	8	8
22	3	7	7	1	12	18	7	14	18
23	2¾	6	6	4	13	14	2¼	15	22
24	7	5½	11	7½	8	12	5¼	8	14
25	5½	8	9	1	10	16	10	11	16

from tables is 2.0. This would suggest the possible rejection of the null hypothesis, with the implication that gel lens wearing patients may have increased their wearing times more rapidly over the first four weeks of wear than corneal lens wearing patients.

In this respect the questionnaire relating to lens comfort is of interest. At the end of four weeks wear 17 of the twenty five gel lens wearers considered their lenses to be 'very comfortable', whilst 8 considered them to be 'fairly comfortable' and none 'not comfortable'. The comparable figures for corneal lens wearers are 5 'very comfortable', 17 'fairly comfortable' and 3 'not comfortable'. This would appear to suggest that an initial improved comfort with gel lenses gave rise to somewhat longer wearing times. The increase in wearing times was not, however, maintained. The F ratio from tables exceed the calculated value of F, for a probability (p) of 0.20 at twelve and twenty weeks by 1.4 and 1.2 respectively. Hence the possible group bias was not maintained throughout the experiment, and for this reason is not considered a critical factor in the general analysis.

Significant differences were, however, found in the maximum wearing times reported by patients. The calculated F ratio at four weeks (d) is exceeded by the value of F from tables (1.4, p 0.20) but at twelve and twenty weeks the reverse is the case. The value of F from tables for a probability p of 0.05 (2.0) is exceeded at twelve weeks by 0.63 and at twenty weeks by 3.18 by the respective calculated values of F. This would indicate a significant increase in the maximum wearing times of gel lens subjects at a reasonable level of

probability (95%). Examination of the original results (page 97) indicates that no corneal lens wearing patient ever exceeded a wearing period of twenty four hours. Amongst gel lens wearing subjects two had worn lenses for twenty four hours or more, after twelve weeks of wear and four at the end of twenty weeks of wear. These wearing periods were carried out against the advice given to patients at the time of lens supply, but they did indicate the possibility that gel lenses could be worn on a twenty four hour a day basis; a potentially important factor for this type of contact lens.

The significant increase in maximum wearing times among gel lens wearing patients indicates a group bias. The effect of this bias could be to increase the severity of ocular changes among gel lens subjects, if a relationship exists between the period of lens wear and a change in any particular parameter. As far as is known no such relationship has been established for gel lens wearers and the question must therefore be left open. Reference is later made, however, to this problem in the interpretation of results of this group of patients.

Having established the general conditions of the groups in terms of examination and wearing times, an investigation of the factors under comparison was made.

Section 7

The analysis of the parameters under investigation

7.1 The form of analysis

In the following sections the factors under investigation are analysed. A general scheme of presentation has been adopted for each factor. Following the tabulated results of each parameter, two way analysis of variance is applied to the results.

Initially the cell totals for each group of patients on each occasion on which they were seen, is given. Each cell total represents the sum of the figures given in the corresponding column of the tabulated results. For example on page 118 the cell total for control subjects at 0 weeks is the sum of all the values in column 2, page 110.

Following the cell totals the values for the variance found are set out. Under the heading 'source' are set out the four main subdivisions of the overall variance found among the tabulated results. The term residual refers to the variance found within the individual columns of results, and this represents the 'natural variation found among differing subjects. The expression 'between visits' refers to the variance found between the column of figures for any one group of patients, and is an indication of the way the results of the groups as a whole changed with time. The term 'between lenses' indicates the variation found between the three different groups of patients. The expression (c) interaction (a) x (b) is the product of the between visits and between lenses terms. The interaction indicates if a progressive

change with time is taking place in one or more of the groups.

The values of the variance estimate for each of the three terms (a), (b) and (c) is divided by the residual or 'natural' variance found to be present between the subjects taking part in the experiment: thus producing the F ratio at the end of each table. The F ratio is in turn tested against the value of F from tables. This value has been previously calculated to show the highest value of F which may be expected, at a certain level of probability, to arise from naturally occuring variation. If the calculated value exceeds the value of F from tables, it is probable that more than the natural variation is present and some external factor is present which is causing the increased variation among the results. For example, on page 111 the calculated value of F for the between lenses expression exceeds the value of F from tables by 78.81. This would indicate that the variation between lenses is greater than could be accounted for by the natural variation in the results. It is therefore probable that the lenses are behaving in a different manner to one another for this particular factor.

Following the table of variance, tables for orthogonal comparisons are frequently given. These are comparisons aimed at determining which group is showing variation. The between lenses term in the variance table, may indicate that one group is different from the others. It does not, however, indicate which group of results this is. A comparison is therefore made of each of the experimental groups against the control or spectacle lens wearers. The result is two F ratios:

one for the comparison of corneals to control and the other for the comparison of gels to control. The two F ratios are each tested against the value of F from tables to determine if one or both are significantly different.

Following the analysed results the clinical interpretation is given in the form of a short discussion and conclusion for each parameter analysed.

Section 8

The tabuled results of:

Lens riding position: visual acuity with

contact lens: induced astigmatism: symptoms

of corneal oedema: visual acuity with spectacle lenses.

Corneal Lens Wearing Subjects: 4 Weeks

Pat. No.	Lens Riding Position	Visual Acuity with C.L.'s	Induced Astigmatism		Oedema Symptoms	Visual Acuity without C.L.'s
			power	axis		
1	1	0.8	0.50	105	-	0.6
2	2*	0.6*	0.25*	90*	-	0.8*
3	1	1.0	0.75	135	-	0.8
4	1	0.8	0.75	90	-	0.8
5	1	0.6	0.00	-	-	0.6
6	1	0.6	0.50	90	1	0.8
7	1	0.6	0.00	-	-	0.6
8	1	0.6	0.25	80	-	1.0
9	1	0.6	0.00	-	-	0.6
10	2	0.6	0.50	90	1	0.6
11	2	0.6	0.75	125	1	0.6
12	1	0.8	0.00	-	-	0.6
13	2	0.6	0.50	110	-	0.6
14	1	0.8	1.00	80	-	0.6
15	1	0.8	0.50	115	-	0.8
16	1*	0.8*	0.50*	90*	-	0.6*
17	1	0.8	0.25	90	-	0.8
18	1*	0.6*	1.00*	85*	-*	0.8*
19	2	0.6	0.50	95	-	0.6
20	3	0.6	0.50	115	-	0.8
21	1	0.6	0.75	80	-	0.8
22	1	0.6	0.50	100	1	0.8
23	1	1.0	0.25	95	-	0.6
24	1*	0.6*	0.75*	70*	1*	0.6*
25	1	0.6	0.00	-	-	0.8

1) Lens riding position is expressed as described on page 80: 1 = high, 2 = central, 3 = low.

2) Visual acuity is expressed as a quotient e.g. $^{6}/_{6} = 1$.

3) The power of induced astigmatism is expressed in dioptres (-ve) and the axis in degrees.

4) The presence of oedema is indicated by the number 1.

Corneal Lens Wearing Subjects: 12 Weeks

Pat. No.	Lens Riding Position	Visual Acuity with C.L.'s	Induced Astigmatism		Oedema Symptoms	Visual Acuity without C.L.'s
			power	axis		
1	1	0.6	0.25	105	1	1.0
2	1	0.6	0.00	-	-	0.6
3	1	0.8	0.50	140	-	0.8
4	1*	0.8*	1.00*	80*	-	0.8*
5	1	0.6	0.00	-	-	0.6
6	1	0.6	0.75	85	1	0.6
7	2	0.6	0.25	140	-	0.6
8	2	0.8	0.50	60	-	0.6
9	1	0.6	0.25	85	-	0.6
10	1*	0.8*	0.50*	65*	-*	1.0*
11	1	0.6	0.50	90	-	1.2
12	2	0.6	0.00	-	-	0.6
13	1*	0.6*	0.50*	125*	-*	0.6*
14	1	0.8	0.75	90	-	0.8
15	1	0.8	0.25	100	-	0.6
16	1	0.6	0.75	70	-	0.6
17	1	0.6	0.25	110	-	0.6
18	2	0.6	0.75	85	-	0.6
19	2	0.6	0.50	80	-	0.8
20	1	0.8	0.50	95	-	0.8
21	3	0.6	0.50	90	-	0.8
22	2	0.6	0.75	90	-	0.8
23	1	0.6	0.75	90	-	0.6
24	2	0.8	0.50	60	-	1.2
25	1	0.8	0.00	-	-	1.5

Corneal Lens Wearing Subjects: 20 Weeks

Pat. No.	Lens Riding Position	Visual Acuity with C.L.'s	Induced Astigmatism		Oedema Symptoms	Visual Acuity without C.L.'s
			power	axis		
1	1	0.6	0.50	90	-	0.6
2	1	0.8	0.00	-	-	1.0
3	1	0.6	0.50	130	-	0.8
4	2	0.6	0.75	90	-	0.6
5	2	0.6	0.00	-	-	0.6
6	1*	0.6*	0.75*	90*	-*	1.0*
7	1	0.8	0.25	140	-	0.8
8	1	0.6	0.50	100	-	0.6
9	2	0.6	0.50	70	-	0.6
10	1	0.6	0.75	80	-	1.5
11	1	0.6	1.25	115	-	1.2
12	1	0.6	0.00	-	-	0.8
13	1	0.6	0.75	110	-	0.8
14	2	0.6	0.75	90	-	0.6
15	1	0.6	0.25	95	-	0.6
16	1	1.0	0.25	80	-	0.8
17	1	0.6	0.75	100	-	1.0
18	1	0.6	0.50	90	-	0.8
19	1	0.6	1.00	85	-	0.8
20	1	0.6	0.75	100	-	0.8
21	1	0.8	0.50	80	-	1.0
22	1	0.6	0.75	90	-	1.2
23	2	0.6	0.50	90	-	0.8
24	1	0.6	0.50	60	-	1.2
25	1	0.6	0.00	-	-	1.5

Gel Lens Wearing Subjects: 4 Weeks

Pat. No.	Lens Riding Position	Visual Acuity with C.L.'s	Induced Astigmatism		Oedema Symptoms	Visual Acuity without C.L.'s
			power	axis		
1	1	1.2	0.00	-	-	0.6
2	3*	0.8*	0.50*	140*	-*	0.8*
3	2	0.8	0.00		-	0.6
4	2	0.8	0.00	-	-	1.0
5	2	0.8	0.25	175	-	0.6
6	2	1.0	0.00	-	-	0.6
7	3	0.8	0.00	-	-	0.6
8	2	1.0	0.50	160	-	0.6
9	2	2.0	0.50	50	-	0.8
10	3	1.5	0.00	-	-	0.6
11	2	1.0	0.75	25	-	0.8
12	3	0.8	0.75	85	-	0.8
13	1	1.0	0.50	60	-	0.6
14	2	1.0	0.00	-	-	0.6
15	2	0.6	0.25	50	-	0.6
16	1	1.0	0.00	-	-	0.8
17	2	1.0	0.00	-	-	0.6
18	3	1.5	0.00	-	1	0.8
19	2*	0.8*	0.50*	75*	-*	0.8*
20	2	1.2	0.00	-	-	0.6
21	1	1.2	0.75	50	-	0.6
22	2	0.8	0.00	-	-	0.6
23	2	3.0	0.00	--	-	0.6
24	3	0.8	0.25	180	-	0.6
25	2	3.0	0.00	-	-	0.8

Gel Lens Wearings Subjects: 12 Weeks

Pat. No.	Lens Riding Position	Visual Acuity with C.L.'s	Induced Astigmatism		Oedema Symptoms	Visual Acuity without C.L.'s
			power	axis		
1	1	1.0	0.00	-	-	0.6
2	3	1.0	0.25	165	-	0.8
3	1	0.8	0.00	-	-	0.6
4	3	1.2	0.00	-	-	0.6
5	2	3.0	0.00	-	-	0.8
6	2	0.8	0.00	-	-	0.6
7	1	1.5	0.25	120	-	0.8
8	3	0.6	0.25	170	-	0.6
9	2*	0.8*	0.00*	-*	-*	0.6*
10	2*	3.0*	0.00*	-*	-*	0.8*
11	2	1.0	0.00	-	-	0.8
12	2	1 5	0.00	-	-	0.6
13	2	0.8	0.00	-	-	0.6
14	2	1.0	0.50	135	-	0.8
15	2	1.0	0.25	110	-	0.6
16	2	1.2	0.00	-	-	0.6
17	3	0.8	0.00	-	-	0.8
18	3	1.0	0.00	-	-	0.6
19	2	1.2	0.50	80	-	0.8
20	2	1.0	0.50	150	-	0.6
21	2*	1.0*	0.00*	-*	-*	0.6*
22	3	0.8	0.50	170	-	0.8
23	1	0.6	0.00	-	-	0.6
24	2	1.2	0.00	-	-	0.8
25	2	1.0	0.50	155	1	0.6

Gel Lens Wearing Subjects: 20 Weeks

Pat. No.	Lens Riding Position	Visual Acuity with C.L.'s	Induced Astigmatism		Oedema Symptoms	Visual Acuity without C.L.'s
			power	axis		
1	1	0.8	0.50	180	-	0.8
2	2	0.6	0.00	-	-	0.6
3	2	0.6	0.00	-	-	0.6
4	3	1.0	0.00	-	-	0.6
5	2	0.8	0.00	-	-	0.6
6	2	1.2	0.00	-	-	1.0
7	2	0.6	0.00	-	-	0.6
8	2	1.0	0.00	-	-	0.6
9	3	0.8	0.00	-	-	0.6
10	2	1.0	0.00	-	-	1.0
11	2	1.5	0.50	140	-	0.6
12	2	0.8	0.00	-	-	0.6
13	2*	0.8*	0.50*	5*	-*	0.6*
14	2	0.8	0.00	-	-	0.6
15	2	0.8	0.50	180	1	0.6
16	2	1.0	0.50	160	-	0.6
17	3	1.0	0.50	60	-	1.0
18	3	0.6	0.00	-	-	0.6
19	2	1.2	0.00	-	-	0.6
20	2	1.5	0.00	-	-	0.8
21	2	0.8	0.50	75	-	0.8
22	2	0.6	0.25	90	-	0.6
23	3*	1.0*	0.50*	30*	-*	0.8*
24	3	0.8	0.00	-	-	0.6
25	2	0.8	0.50	120	-	0.6

Control Subjects
Oedema Symptoms: Visual Acuity with Spectacle Lenses

Patient No.	Initial		4 weeks		12 weeks		20 weeks	
	Oedema	Visual Acuity	Oedema	Visual Acuity	Oedema	Visual Acuity	Oedema	Visual Acuity
1	-	1.0	-	1.0	-	0.8	-	0.8
2	-	0.6	-	0.6	-	0.6	-	0.6
3	-	0.6	-	0.6	-	0.6	-	0.6
4	-	0.8	-	0.8	-	0.8	-	0.8
5	-	0.6	-	0.6	-	0.6	-	0.6
6	-	0.8	-	0.6	-	0.6	-	0.6
7	1	0.8	1	0.6	1	0.6	1	0.8
8	-	0.8	-	0.6	-	0.6	-	0.6
9	-	0.8	-*	0.6*	-	0.8	-	0.6
10	-	0.6	-	0.6	-	0.6	-	0.6
11	-	0.6	-	0.8	-	0.8	-	0.8
12	-	0.8	-	0.6	-	0.6	-	0.6
13	-	0.6	-	0.6	-	0.6	-	0.6
14	-	0.6	-	0.6	-	0.6	-*	0.6*
15	-	0.6	-	0.6	-	0.6	-	0.6
16	-	0.8	-	0.8	-	0.8	-	0.8
17	-	0.8	-	0.6	-	0.6	-*	0.6*
18	-	0.6	-	0.6	-	0.6	-	0.6
19	-	0.6	-	0.6	-	0.6	-	0.6
20	-	0.6	-	0.6	-	0.6	-*	0.6*
21	-	0.6	-	0.6	-	0.6	-	0.6
22	-	0.8	-	0.6	-	0.6	-	0.6
23	-	0.8	-	0.6	-	0.6	-	0.6
24	-	0.6	-	0.6	-	0.6	-	0.6
25	-	0.8	-	0.8	-	0.8	-	0.8

Gel and Corneal Lens wearing Subjects: Initial Values of: Oedema Symptoms and Visual Acuity with Spectacle Lenses

	Gel		Corneal	
	Oedema Symptoms	Visual Acuity	Oedema Symptoms	Visual Acuity
	-	0.6	-	0.6
	-	0.6	-	0.6
	-	0.6	-	0.6
	-	0.6	-	0.8
	-	0.6	-	0.8
	-	0.6	-	0.8
	-	0.6	-	0.8
	-	0.8	-	0.6
	-	0.8	-	0.8
	-	0.8	-	0.6
	-	0.8	-	0.6
	-	0.6	-	0.8
	-	0.8	-	0.6
	-	0.8	-	0.8
	-	0.6	-	0.8
	-	0.6	-	0.8
	-	0.6	-	0.8
	-	0.6	-	0.6
	-	0.8	-	0.6
	-	0.6	-	0,6
	-	0.6	-	0.8
	-	1.0	-	0.8
	-	0.8	-	1.0
	-	0.6	-	0.8
	-	0.8	-	0.8
	-	0.8	-	0.8

8.3 Analysis of variance (two way factorial)

Lens riding position

Cell totals (sum of 25 values)

Group	Week 4	Week 12	Week 20
Corneal	32	34	30
Gel	52	52	55

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0400	0.0200	0.0647
(b) Between lenses	1	26.4600	26.4600	85.6643
(c) Interaction (a) x (b)	2	0.5200	0.2600	0.8417
Residual	129	44.4800	0.3089	

Value of F from tables

Between lenses (probability p = 0.01) = 6.85

Discussion: Lens riding position

Analysis of variance shows the riding positions of the two lenses to differ significantly from one another; the calculated value of F for the between lenses expression exceeding the value of F from tables by 78.81. Examination of the group means (page 112) shows gel lenses to ride in a central to low position on the cornea, whilst corneal lenses rode central to high.

Conclusion

Whilst a search of the literature failed to reveal a reference to a controlled study of the optimum riding positions for contact lenses, a number of writers of text books strongly propose the hypothesis that corneal lenses should ride central to high on the cornea for optimum results [65, 66]. Similarly whilst on a visit to Prague a number of practitioners, working with gel lenses were of the opinion that they should ride low on the cornea. It would therefore seem that the present results conform to general clinical opinion in this respect.

Group mean of contact lens riding position

	4 weeks	12 weeks	20 weeks
Gel lenses	2.08	2.08	2.20
Corneal lenses	1.3	1.3	1.3

8.4 Analysis of variance (two way factorial)

Induced Astigmatism

Cylindrical power

Cell totals (sum of 25 values)

Group	Week 4	Week 12	Week 20
Corneal	11.25	11.25	13.00
Gel	5.00	3.00	4.75

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.3024	0.1512	2.1185
(b) Between lenses	1	3.4506	3.4506	48.3483
(c) Interaction (a) x (b)	2	0.1369	0.0684	0.9589
Residual	129	10.2775	0.0714	

Value of F from tables

Between lenses (probability p = 0.01) = 6.85

Discussion: contact lens induced astigmatism

Analysis of variance shows a significant difference to exist between the two contact lens wearing groups; the calculated value of F exceeding the value from tables by 41.49, for the between lenses term. The character of the astigmatism in the two groups is, also, different. Among corneal lens wearing subjects the axis of the induced astigmatism was distributed around 90°, the first standard deviation being 16°. Among gel lens wearing subjects the axis of the induced astigmatism was randomly distributed; the first standard deviation being 58° and the histogram of axis value against number being flat (Fig.9).

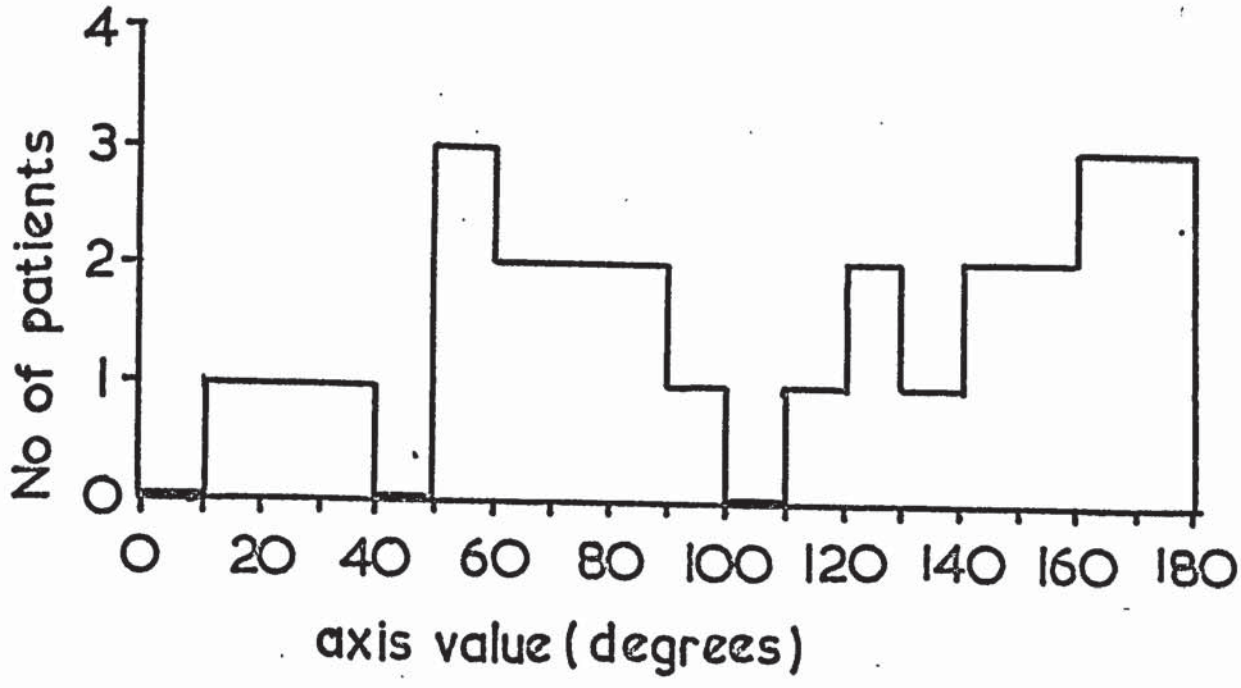


Fig. 9 Histogram of number of patients against axis value.

Conclusion

The results of corneal lens wearing subjects would suggest that the amount of induced astigmatism found, did not affect these subjects adversely. Examination of patients' symptoms show only one out of the group of 25 to be dissatisfied with their level of vision for near or distant work (page The explanation of this apparent anomaly may lie in the axis at which the astigmatism was found. It has been widely reported [67,68]. that astigmatism lying close to the horizontal or vertical meridians is less visually disturbing than oblique axis astigmatism.

The reduced amount of astigmatism found among gel lens wearing patients is not reflected in an improvement in visual acuity and reference is made in the next section to this question (page 116).

8.5 Analysis of variance (two way factorial)

Visual acuity with

Contact lenses

Cell totals (sum of 25 values)

Group	Week 4	Week 12	Week 20
Corneal	17.2	16.8	16.0
Gel	29.4	27.8	22.4

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.7312	0.3656	2.5484
(b) Between lenses	1	5.8405	5.8404	40.7114
(c) Interaction (a) x (b)	2	0.3755	0.1877	1.3089
Residual	129	20.6584	0.1435	

Value of F from tables

Between lenses (probability p = 0.01) = 6.85
Interaction (probability p = 0.1) = 2.35
Between visits (probability p = 0.1) = 2.35

Discussion: Visual acuity

A significant difference is shown to exist between the two contact lens wearing groups. The value of F from tables being exceeded by the calculated value of F by 33.86. Although the interaction term is not significant at this level of analysis, the between visits term is significant for a probability (p)

of 0.1. This would suggest a possible change in acuity for one or more of the cell totals. Examination of the totals shows a progressive decrease for those subjects wearing gel lenses.

Conclusion

The comparatively poor visual acuity of gel lens wearing patients as compared to those patients wearing corneal lenses, is an obvious drawback for this type of contact lens. This shortcoming is reflected in the subjective impressions recorded by patients and summarised below:

Group	Satisfied with level of vision		Not satisfied	
	Close work	Distance Vision	Close	distance
Corneal lenses	24	25	1	0
Gel lenses	12	15	13	10

The shortcomings in visual performance suffered by gel lens wearing subjects were not such as to prevent any patient from completing the survey. The reduced vision, would, however, prohibit the use of such lenses in day to day practice, particularly when coupled with the visual instability to which it was later shown gel lenses are subject (page 252).

It would be tempting to speculate that the reduced vision among gel lense wearers is a product of the astigmatic effects found. Such a relationship may in fact exist. However, with the limited knowledge of gel lenses at present available, it is equally possible that other, perhaps numerous, factors are also at play. The question must therefore be left open until such time as a more basic interpretation is achieved.

8.6 Symptoms of corneal oedema

The incidence of the symptoms of corneal oedema is summarised below:-

Group	Visit (week number)			
	0	4	12	20
Gel	0	1	0	0
Corneal	0	5	2	0
Control	1	1	1	1

The results do not lend themselves to analysis due to the number of groups with no members reporting the previously mentioned symptoms. The present results are therefore considered in conjunction with the results of the objective examination for corneal oedema on page 258.

8.7 Analysis of variance (two way factorial)

Visual Acuity

Spectacle Lenses

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20	Row Totals
Control	17.60	16.20	16.20	16.20	66.20
Corneal	18.60	17.60	19.30	22.00	77.50
Gel	17.60	17.00	17.00	17.00	68.60

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.1417	0.0472	2.2132
(b) Between lenses	2	0.7103	0.3551	16.6419
(c) Interaction (a) x (b)	6	0.3538	0.0589	2.7629
Residual	269	6.1480	0.0213	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Sum of squares	F ratio
Treatment totals	66.20	77.50	68.60			
Comparison and number						
Corneal vs. Control	+1	-1	0	11.30	0.39	18.60
Gel vs. Control	+1	0	-1	2.40	0.29	1.37

Value of F from tables

Orthogonal comparisons	(probability p = 0.01)	= 6.63
	(probability p = 0.1)	= 2.71
Interaction	(probability p = 0.01)	= 2.80
	(probability p = 0.05)	= 2.10

Discussion: Visual acuity with spectacle lenses

The initial analysis of variance shows a significant difference to exist for the between lenses term; the calculated value of F exceeding the value from tables by 10.01. The interaction term is also significant at the 5% level although not at the 1% . Orthogonal comparison isolated the group of diminishing visual acuity to be those subjects wearing corneal lenses; the calculated value of F being raised in the orthogonal comparison from 16.64 to 18.60.

It has been maintained for some time that corneal lenses reduce visual acuity with spectacles.[69,70] Rengstorff[71] in particular has shown a small percentage of such changes to become irreversible after a number of years. The present demonstration of reducing visual acuities after only six months of corneal lens wear is an indication of the rapid onset of this effect among wearers of these lenses. The lack of any discernible difference, at this level of analysis, in visual acuity between the control and gel lens wearing group is a further improvement, in terms of ocular response, for this new type of contact lens.

Section 9

The Tabulated Results and Analysis of the Values of Corneal Sensitivity

9.1

Tabulated results

Corneal sensitivity grams mm^{-2}

Corneal lens wearing patients

	Initial					4 weeks					12 weeks					20 weeks				
	C	S	I	T	N	C	S	I	T	N	C	S	I	T	N	C	S	I	T	N
1	0.96	1.40	1.16	1.16	1.08	0.96	3.20	3.20	3.20	4.60	1.84	3.20	3.20	2.40	2.40	1.40	3.20	3.20	1.40	1.40
2	0.96	0.96	1.16	0.96	0.96	1.08*	1.84*	3.20*	1.84*	1.40*	1.40	4.60	3.20	1.84	2.40	1.40	3.20	4.60	3.20	1.84
3	0.96	1.08	1.16	0.96	0.96	1.08	1.16	1.84	1.40	1.40	1.08	1.84	6.64	2.40	2.40	1.84	3.20	4.60	2.40	2.40
4	0.96	1.16	1.40	1.08	1.08	0.96	1.16	1.84	1.16	1.08	1.84*	3.20*	3.20*	2.40*	2.40*	2.40	2.40	4.60	2.40	2.40
5	0.96	0.96	1.40	1.08	1.16	0.96	1.40	3.20	1.84	1.40	1.84	4.60	6.64	3.20	3.20	2.40	3.20	8.84	2.40	2.40
6	0.96	1.08	1.84	0.96	0.96	0.96	2.40	4.60	1.84	1.84	1.16	4.60	8.84	3.20	3.20	1.40*	2.40*	4.60*	1.40*	1.40*
7	0.96	0.96	2.40	0.96	0.96	0.96	1.08	1.08	1.08	1.08	1.16	1.84	4.60	2.40	2.40	1.84	4.60	8.84	2.40	2.40
8	0.96	1.08	1.40	0.96	0.96	1.16	1.84	3.20	1.84	1.40	1.08	1.40	1.40	1.16	1.16	4.60	6.64	8.84	4.60	4.60
9	0.96	1.16	2.40	0.96	1.08	1.08	1.16	1.16	1.84	1.40	0.96	1.84	4.60	2.40	3.20	2.40	3.20	6.64	4.60	2.40
10	1.08	0.96	1.16	1.16	1.16	0.96	1.84	3.20	1.84	1.40	1.84*	3.20*	6.64*	2.40*	2.40*	1.84	2.40	8.84	1.84	2.40
11	0.96	1.08	1.16	0.96	0.96	0.96	1.08	1.08	1.08	1.08	1.84	3.20	4.60	1.84	1.84	1.40	3.20	6.64	4.60	4.60
12	0.96	1.08	1.08	1.08	0.96	1.08	1.84	4.60	1.84	2.40	1.40	1.40	3.20	1.40	1.40	2.40	3.20	8.84	6.64	4.60
13	0.96	1.16	1.40	1.08	1.08	1.16	1.40	3.20	1.89	1.84	1.16*	1.40*	2.40*	1.16*	1.16*	2.40	4.60	6.64	4.60	2.40
14	0.96	1.16	3.20	1.08	1.40	0.96	3.20	2.40	2.40	1.40	1.16	4.60	2.40	1.16	1.16	1.84	3.20	2.40	2.40	3.20
15	0.96	1.16	1.84	0.96	1.40	1.08	1.08	2.40	1.08	1.08	3.20	3.20	8.84	4.60	4.60	1.40	2.40	4.60	1.40	1.40
16	0.96	1.08	1.84	1.08	1.16	0.96*	1.08*	1.40*	1.40*	1.40*	2.40	4.60	8.44	2.40	2.40	2.40	4.60	4.60	2.40	2.40
17	0.96	1.08	1.84	1.08	1.08	1.08	4.60	4.60	2.40	3.20	1.84	2.40	4.60	1.84	1.84	1.40	2.40	6.64	1.84	1.40
18	0.96	1.08	1.84	1.08	1.16	0.96*	1.16*	1.84*	1.16*	1.40*	1.40	1.84	3.20	1.40	1.40	2.40	4.60	3.20	3.20	3.20
19	0.96	1.16	1.40	0.96	1.16	1.16	1.40	2.40	1.16	1.16	1.40	2.40	6.64	1.84	2.40	1.40	2.40	3.20	1.84	1.84
20	0.96	0.96	1.16	1.16	1.16	1.40	1.16	2.40	1.40	1.40	1.84	4.60	6.64	3.20	1.84	1.84	2.40	4.60	1.84	1.84
21	0.96	0.96	1.16	0.96	0.96	1.84	4.60	8.84	3.20	2.40	1.40	3.20	4.60	1.84	1.84	1.84	3.20	4.60	3.20	2.40
22	0.96	0.96	1.84	0.96	0.96	1.16	1.40	4.60	1.84	1.84	1.16	1.16	3.20	1.16	1.16	1.84	6.64	4.60	1.84	2.40
23	0.96	1.08	0.96	0.96	0.96	0.96	1.40	2.40	1.84	1.84	1.84	3.20	4.60	2.40	2.40	2.40	6.64	4.60	2.40	3.20
24	0.96	0.96	1.16	1.08	2.40	0.96*	3.20*	3.20*	1.16*	1.84*	1.84	2.40	4.60	3.20	3.20	1.40	2.40	6.64	2.40	1.84
25	0.96	1.08	1.40	0.96	1.08	1.08	3.20	2.40	1.08	1.40	1.16	2.40	4.60	1.84	1.84	1.84	3.20	4.60	2.40	2.40

The letters C, S, I. T and N indicate the central, inferior, superior, temporal and nasal aspects of the cornea respectively.

Tabulated results

Corneal sensitivity grams mm^{-2}

Gel lens wearing patients

	Initial					4 weeks					12 weeks					20 weeks				
	C	S	I	T	N	C	S	I	T	N	C	S	I	T	N	C	S	I	T	N
1	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.40	0.96	0.96
2	0.96	1.08	1.84	0.96	1.16	0.96*	0.96*	1.40*	0.96*	1.16*	0.96	1.40	1.40	1.16	1.16	0.96	1.40	1.16	1.08	1.08
3	0.96	0.96	1.16	0.96	0.96	0.96	1.08	1.16	1.08	1.08	0.96	1.16	1.16	1.08	1.08	0.96	1.08	1.40	1.08	0.96
4	1.08	1.16	1.16	0.96	1.08	1.08	0.96	1.16	0.96	1.08	0.96	1.40	1.16	1.16	1.16	0.96	1.40	1.16	0.96	0.96
5	0.96	1.40	1.40	1.40	1.84	0.96	1.08	1.40	1.40	1.16	0.96	1.16	1.84	1.08	1.08	0.96	1.16	1.40	1.08	1.08
6	0.96	0.96	1.16	0.96	0.96	0.96	1.08	1.16	0.96	1.08	0.96	1.16	1.40	1.08	1.08	0.96	1.08	1.84	0.96	0.96
7	0.96	1.84	1.40	1.16	1.16	1.08	1.08	1.16	1.08	1.08	0.96	1.16	1.40	1.16	1.16	1.08	1.08	1.16	1.08	1.08
8	0.96	0.96	1.40	0.96	0.96	0.96	1.08	1.40	0.96	1.16	0.96	1.40	1.08	1.16	1.16	0.96	1.40	1.16	0.96	0.96
9	0.96	1.08	1.16	0.96	1.08	0.96	1.16	1.40	1.08	1.16	1.08*	1.16*	1.84*	1.08*	1.08*	0.96	1.16	1.40	1.08	1.08
10	0.96	1.16	1.40	0.96	1.08	0.96	1.16	1.40	0.96	1.08	0.96*	1.40*	1.84*	1.16*	1.08*	1.08	1.16	1.84	0.96	0.96
11	0.96	1.08	1.40	0.96	0.96	0.96	1.08	1.16	0.96	1.08	1.08	1.16	1.84	1.16	1.16	0.96	1.08	1.84	0.96	0.96
12	0.96	1.08	1.16	1.08	1.08	0.96	1.84	1.40	1.08	1.40	0.96	1.08	1.08	0.96	0.96	0.96	1.16	1.40	1.08	1.08
13	0.96	1.08	1.40	0.96	0.96	0.96	1.16	1.16	1.16	0.96	0.96	1.08	1.16	1.08	1.16	0.96*	0.96*	1.16*	1.08*	0.96*
14	0.96	1.08	1.16	1.08	1.40	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.16	0.96	0.96	0.96	0.96	1.08	0.96	0.96
15	0.96	1.16	1.16	1.16	1.16	0.96	1.16	1.40	1.16	0.96	0.96	0.96	1.40	1.16	1.16	1.08	1.16	1.16	1.16	1.16
16	0.96	1.16	1.40	1.08	1.16	0.96	1.08	1.16	1.16	1.16	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.16	0.96	0.96
17	0.96	1.08	1.16	0.96	0.96	0.96	1.16	1.16	1.16	1.40	1.08	1.16	1.40	1.08	1.08	0.96	1.16	1.16	1.16	1.16
18	0.96	1.40	1.40	1.16	1.08	0.96	1.16	1.40	0.96	1.16	0.96	0.96	1.40	1.40	1.16	0.96	1.40	1.08	0.96	0.96
19	0.96	0.96	1.08	0.96	0.96	0.96*	1.16*	1.40*	1.08*	0.96*	0.96	1.16	1.16	0.96	0.96	0.96	1.16	1.40	0.96	0.96
20	0.96	1.08	1.16	0.96	1.16	0.96	1.08	1.16	1.08	1.16	0.96	1.16	1.40	1.08	1.08	0.96	1.08	1.40	1.08	1.08
21	0.96	0.96	1.08	0.96	1.08	0.96	1.40	1.40	1.40	0.96	0.96*	1.16*	1.16*	1.08*	1.08*	0.96	0.96	1.16	0.96	0.96
22	0.96	1.08	1.40	1.16	1.16	0.96	1.16	1.84	1.16	1.16	0.96	1.08	1.16	1.16	1.08	0.96	1.08	1.08	1.08	1.08
23	0.96	1.40	1.16	1.08	1.08	0.96	1.08	1.40	1.08	1.08	0.96	1.08	1.40	1.08	1.08	0.96*	0.96*	1.40*	0.96*	0.96*
24	0.96	1.08	1.40	0.96	1.16	0.96	1.08	1.16	0.96	1.08	0.96	1.16	1.16	1.08	1.08	0.96	0.96	1.40	0.96	0.96
25	0.96	0.96	1.40	0.96	1.16	0.96	1.16	1.84	0.96	1.08	0.96	1.16	1.40	1.08	1.08	0.96	1.08	1.08	1.08	1.16

Tabulated results

Corneal sensitivity grams mm^{-2}

Control Patients

	Initial					4 weeks					12 weeks					20 weeks				
	C	I	S	T	N	C	S	I	T	N	C	S	I	T	N	C	S	I	T	N
1	0.96	1.16	1.08	0.96	1.08	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.84	1.16	1.40	0.96	1.40	1.16	1.08	1.08
2	0.96	0.96	1.08	0.96	0.96	0.96	1.16	1.40	1.08	1.08	1.08	1.16	1.16	1.08	1.08	0.96	1.08	1.40	0.96	0.96
3	0.96	0.96	1.20	0.96	1.16	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.40	1.08	0.96	0.96	0.96	1.16	0.96	0.96
4	0.96	1.16	1.08	0.96	1.08	0.96	1.08	1.40	0.96	1.08	0.96	1.16	1.08	1.16	1.16	1.08	1.16	1.40	1.08	1.08
5	0.96	1.08	1.40	1.08	1.08	0.96	1.08	2.40	1.08	1.08	0.96	1.16	1.40	1.08	1.08	0.96	1.84	2.40	1.16	1.08
6	0.96	1.08	1.40	0.96	1.08	0.96	1.16	1.08	1.08	1.08	0.96	1.08	1.40	1.08	1.08	0.96	1.08	1.40	0.96	0.96
7	0.96	1.08	1.84	1.08	1.16	0.96	1.08	1.08	1.08	1.08	0.96	1.16	1.08	1.08	1.08	0.96	0.96	1.16	0.96	0.96
8	0.96	0.96	1.08	1.08	1.08	0.96	1.08	1.16	0.96	1.16	0.96	1.40	1.84	1.08	1.08	0.96	1.16	1.40	1.16	1.08
9	0.96	1.08	1.84	1.08	1.08	0.96*	0.96*	1.08*	0.96*	0.96*	0.96	1.08	1.16	1.08	1.08	0.96	1.08	1.40	1.08	1.16
10	0.96	0.96	1.08	0.96	0.96	0.96	1.08	1.40	1.08	1.08	0.96	1.16	1.08	1.08	1.08	0.96	1.08	1.16	1.08	1.08
11	0.96	0.96	1.40	1.08	1.08	0.96	1.08	1.84	0.96	0.96	0.96	1.16	1.16	1.16	1.08	0.96	1.08	1.16	0.96	1.08
12	0.96	1.08	1.40	1.08	1.08	0.96	1.16	1.84	1.08	1.08	0.96	1.16	1.84	1.08	1.16	0.96	1.40	1.84	1.16	1.08
13	0.96	1.84	1.20	0.96	1.08	1.08	1.16	1.08	1.16	1.16	0.96	1.08	1.08	1.08	1.08	0.96	1.08	1.40	1.08	1.08
14	0.96	1.08	1.64	1.08	1.16	0.96	1.16	1.84	1.08	1.08	0.96	1.16	1.84	1.08	1.16	0.96*	1.16*	1.16*	0.96*	0.96*
15	0.96	1.84	2.40	1.84	0.96	0.96	1.08	1.16	1.08	1.08	1.08	1.16	1.16	1.16	1.08	1.08	1.16	1.40	1.16	1.16
16	0.96	1.08	1.64	1.16	1.40	0.96	1.08	1.40	1.08	1.08	0.96	1.08	1.08	1.08	0.96	1.08	2.40	4.60	1.08	1.40
17	0.96	1.08	1.84	0.96	1.08	0.96	1.08	1.08	1.08	0.96	1.08	1.08	0.96	1.08	0.96*	1.16*	1.16*	1.16*	0.96*	0.96*
18	0.96	1.16	1.20	1.08	1.16	0.96	1.08	1.16	1.08	1.08	0.96	1.16	1.16	1.08	1.08	0.96	1.08	1.16	1.08	1.08
19	1.16	1.08	1.40	0.96	1.08	0.96	1.08	1.16	1.08	1.08	0.96	1.16	1.40	1.16	1.08	0.96	1.16	1.16	1.08	1.08
20	0.96	0.96	1.84	1.08	1.08	1.16	0.96	1.08	1.84	1.16	1.08	0.96	1.16	1.40	1.08	1.08	0.96*	1.16*	1.84*	1.08*
21	0.96	1.08	1.84	1.16	1.08	0.96	1.08	1.08	1.08	0.96	0.96	1.40	1.84	1.16	1.08	0.96	1.08	1.16	1.08	1.08
22	0.96	1.16	1.64	1.40	0.96	0.96	0.96	1.40	1.40	0.96	0.96	1.08	1.16	1.40	1.08	0.96	1.40	1.08	1.40	1.08
23	0.96	0.96	1.16	0.96	1.16	0.96	1.16	1.40	1.08	1.08	0.96	1.16	1.84	0.96	1.16	0.96	1.08	1.08	0.96	0.96
24	0.96	0.96	1.40	1.08	1.08	0.96	1.16	1.16	1.08	1.08	0.96	1.16	1.40	1.16	1.40	0.96	1.16	1.40	0.96	1.08
25	0.96	2.10	1.20	2.40	1.08	0.96	1.16	1.40	2.40	1.08	0.96	1.40	1.40	2.40	1.08	0.96	1.16	1.40	2.40	1.08

9.2 Analysis of variance (two way factorial)

Corneal Sensitivity

Central Corneal Region

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20	Row Total
Control	24.20	24.12	24.24	24.36	96.9
Corneal	24.12	26.96	39.24	49.73	139.9
Gel	24.12	24.24	24.36	24.36	97.1

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	2.9200	0.9734	12.6116
(b) Between lenses	2	13.0963	6.5482	84.8427
(c) Interaction (a) x (b)	6	10.2280	1.7047	22.0867
Residual	269	22.2304	0.0772	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Sum of squares	F ratio
Treatment totals	96.90	139.90	97.10			
Comparison and number						
Corneal vs. Control	+1	-1	0	43.0128	92.0162	1192.68
Gel vs. Control	+1	0	-1	0.2168	0.0023	

Value of F from tables

Orthogonal comparisons	$p = 0.1$	= 2.71
	$p = 0.01$	= 6.63
Between visits	$p = 0.01$	= 3.78
Interaction	$p = 0.01$	= 2.80

Analysis of variance (two way factorial)

Corneal sensitivity

Superior Corneal Regions

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20	Row Total
Control	29.20	27.40	29.08	30.52	116.20
Corneal	26.84	48.88	72.32	89.52	237.56
Gel	28.32	28.56	29.00	28.00	113.78

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	31.4140	10.4713	26.3988
(b) Between lenses	2	100.1012	50.0506	126.1802
(c) Interaction (a) x (b)	6	58.6021	9.7670	24.6231
Residual	269	114.2390	0.3966	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Sum of squares	F rati
Treatment totals	116.20	237.56	113.78			
Comparison and number						
Corneal vs. Control	+1	-1	0	121.36	730.00	8629.6
Gel vs. Control	+1	0	-1	- 2.42	0.02	0.0

Value of F from tables

Orthogonal comparisons	(p = 0.1)	= 2.71
	(p = 0.01)	= 6.63
Between visits	(p = 0,01)	= 3.78
Interaction	(p = 0.01)	= 2.80

Analysis of variance (two way factorial)

Corneal sensitivity

Temporal region---

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20	Row Total
Control	28.32	28.32	28.88	27.76	113.28
Corneal	25.68	42.76	55.08	69.64	193.16
Gel	25.84	26.96	27.60	25.60	106.00

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	13.4585	4.4862	17.2963
(b) Between lenses	2	46.7109	23.3555	90.0469
(c) Interaction (a) x (b)	6	28.1501	4.6917	18.0887
Residual	269	74.6992	0.2594	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Sum of squares	F ratio
Treatment totals	113.28	193.16	106.00			
Comparison and number						
Corneal vs. Control	+1	-1	0	79.88	31.64	101.698
Gel vs. Control	+1	0	-1	-7.28	0.2758	1.06

Value of F from tables

Orthogonal comparisons	$p = 0.1$	= 2.71
	$p = 0.01$	= 6.63
Between visits	$p = 0.01$	= 3.78
Interaction	$p = 0.01$	= 2.80

Analysis of variance (two way factorial)

Corneal sensitivity

Inferior corneal region

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20	Row Total
Control	36.04	34.16	34.28	37.04	141.56
Corneal	38.76	74.28	121.92	137.96	372.92
Gel	36.16	33.00	33.72	32.88	135.76

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	96.0962	33.0321	32.3739
(b) Between lenses	2	372.6645	186.3322	188.3209
(c) Interaction (a) x (b)	6	161.1185	26.8531	27.1397
Residual	269	284.9596	0.9894	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Sum of squares	F ratio
Treatment totals	141.56	372.92	135.76			
Comparison and number						
Corneal vs. Control	+1	-1	0	230.36	265.73	278.34
Gel vs. Control	+1	0	-1	-5.80	0.076	0.07

Value of F from tables

Orthogonal comparisons $\begin{cases} p = 0.1 \\ p = 0.01 \end{cases}$ = 2.71, 6.63

Between visits $(p = 0.01)$ = 3.78

Interaction $(p = 0.01)$ = 2.80

Analysis of variance (two way factorial)

Corneal sensitivity

Nasal corneal region

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20	Row Total
Control	27.32	26.76	27.72	26.64	108.44
Corneal	28.24	42.68	55.64	62.76	189.32
Gel	27.80	27.80	27.28	25.44	108.32

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	18.7003	6.2334	42.6335
(b) Between lenses	2	43.6753	21.8376	149.3580
(c) Interaction (a) x (b)	6	23.5059	3.9176	26.7947
Residual	269	42.1093	0.1462	

Orthogonal comparisons

Treatment	Control	corneal	Gel	Treatment difference	Sum of squares	F ratio
Treatment totals	108.44	189.32	108.32			
Comparison and number						
Corneal vs. Control	+1	-1	0	80.88	322.41	232.87
Gel vs. Control	+1	0	-1	-0.12	0.006	0.0004

Value of F from tables

Orthogonal comparisons	p = 0.1	= 2.71
	p = 0.01	= 6.63
Between visits	p = 0.01	= 3.78
Interaction	p = 0.01	= 2.80

Discussion

The analysed values for all regions of the cornea show a similar pattern. The basic analysis shows a significant change between both visits and lens groups together with a significant interaction term. The orthogonal comparison isolates the changing lens group to be those subjects wearing corneal contact lenses. The value of F from tables being exceeded by 1186.05, 8622.98, 2727.49, 1010.35 and 2322.16 for the Central, Superior, Inferior, Temporal and Nasal corneal regions respectively. The isolation of corneal lens wearing subjects along to differ from the control group, would suggest the interaction term to apply almost exclusively to this group. This would imply a progressive and significant reduction in corneal sensitivity during corneal lens wear.

No significant difference exists between the gel lens and the control group at this level of measurement. The value of F from tables exceeding the calculated value of F by 2.70, 2.70, 2.64, 1.65, and 2.70, for the Central, Superior, Inferior, Temporal and Nasal regions respectively; for a probability (p) of 0.1.

Conclusions

The progressive reduction in the corneal sensitivity of corneal lens wearing subjects was an anticipated phenomenon of this group. The results conform both to general clinical opinion and to the reports of several workers[72,73,74]. Although the survey covered a twenty week period of wear there was no evidence of a revised stable corneal sensitivity threshold being achieved by corneal lens wearing patients.

The absence of a discernible difference between the control and gel lens wearing subjects suggests an advantage

over corneal lens wearers in this respect. It may be held that the reduced corneal sensitivity attained in corneal lens wear allows particles which would normally be felt by the eye to abrade the corneal surface, undetected and to open the path for ocular infection. Whether or not this is true, the principle that contact lenses should leave the eye totally unaffected, has only been achieved in respect of corneal sensitivity by gel lens wearing subjects.

Section 10

The Tabulated Results and Analysis of the Criteria of Corneal Staining

10.1 Tabulated results

Corneal stain - control subjects

Initial staining

	Severity			
	Number	1	2	3
No discernible stain	20	-	-	-
Punctate stain	8	8	-	-
Diffuse stain	0	-	-	-
Line stain	0	-	-	-

Area

1	1	1	1	1	1	2	1

Mean Area 0.67%

Four weeks

	Severity			
	Number	1	2	3
No discernible stain	17	-	-	-
Punctate stain	8	8	-	-
Diffuse stain	-	-	-	-
Line stain	1	1	-	-

Area

1	1	2	1	1	2	1	1

Mean Area 0.75%

Length

5

Mean length 3.75%

Twelve weeks

	Severity			
	Number	1	2	3
No discernible stain	14	-	-	-
Punctate stain	9	9	-	-
Diffuse stain	-	-	-	-
Line stain	2	2	-	-

Area (punctate)

1	1	1	1	2	1	3	1	1

Mean Area 0.90%

Length (line)

5	17

Mean length 16.5%

Twenty weeks

	Number	Severity 1	2	3
No discernible stain	13	-	-	-
Punctate stain	16	16	-	-
Diffuse stain	1	1	-	-
Line stain	1	1	-	-

Area (Punctate)	1	1	1	1	1	1	6	1	2	1	1	2	1	4	Mean Area 0.8
Area (Diffuse)	1												1	3	Mean Area 0.7
Length (line)	3														Mean Leng.2.25

Tabulated Results

Corneal stain

Gel lens wearing subjects

Initial staining

	Number	Severity 1	2	3
No discernible stain	22	-	-	-
Punctate stain	5	5	-	-
Diffuse stain	0	-	-	-
Line stain	0	-	--	-

Area (punctate) 1 3 6 1 1

Mean Area 1.65%

Four weeks

	Number	Severity 1	2	3
No discernible stain	14	-	-	-
Punctate stain	13	13	-	-
Diffuse stain	1	-	-	-
Line stain	1	1	-	-

Area (punctate) 2 1 1 7 1 3 2 4 2 5 2 2 1 1

Area (diffuse) 2 — Mean area 1.95%

Length (line) 1 — Mean area 1.50%

Mean length 0.75%

Twelve weeks

	Number	Severity 1	2	3
No discernible stain	12	-	-	-
Punctate stain	11	11	-	-
Diffuse stain	0	-	-	-
Line stain	0	-	-	-

Area (punctate) 2 1 3 4 1 1 3 1 1 2 2 — Mean Area 0.82%

Twenty weeks

	Severity			
	Number	1	2	3
No discernible stain	17	-	-	-
Punctate stain	5	5	-	-
Diffuse stain	1	1	-	-
Line stain	0	-	-	-

Area (punctate) 1 1 1 2 3 — Mean Area 1.2%

Area (diffuse) 2 — Mean Area 1.5%

Tabulated Results

Corneal stain

Corneal lens wearing subjects

Initial staining

	Number	Severity 1	2	3
No discernible stain	21	-	-	-
Punctate stain	4	4	-	-
Diffuse stain	2	2	-	-
Line stain	1	1	-	-

Area (punctate) 1 1 1 2 — Mean area 1.12%

Area (diffuse) 1 1 — Mean area 0.75%

Length (line) 6 — Mean length 4.50%

Four weeks

	Number	Severity 1	2	3
No discernible stain	4	-	-	-
Punctate stain	16	16	-	-
Diffuse stain	4	4	-	-
Line stain	2	2	-	-
Dimple stain	2	2	-	-
Oedematous 'haze' stain	2	-	-	-

Area (punctate) 5 3 3 13 14 9 9 2 1 6 5 4 4 1 1 1

Area (diffuse) 2 4 1 2 — Mean area 4.65%

Length (line) 9 2 — Mean area 1.57%

Area (dimple) 5 3 — Mean length 4.12%

Mean area 3.00%

Area ('haze) 40 51 — Mean area 33.82%

Twelve weeks

	Severity			
	Number	1	2	3
No discernible stain	4	-	-	-
Punctate stain	17	17	-	-
Diffuse stain	4	3	1	-
Line stain	8	8	-	-
Dimple stain	2	2	-	-
Oedematous 'haze' stain	2	2	-	-

Area (punctate)	7 4 19 12 6 2 3 5 4 3 3 3 3 1	
	14 4 37	Mean area 4.41%
Area (diffuse)	5 8 3 2	Mean area 3.13%
Length (line)	3 15 4 10 4 32 3 4	Mean length 13.95%
Area (dimple)	4 4	Mean area 3.00%
Area ('haze')	11 48	Mean area 21.37%

Twenty weeks

	Severity			
	Number	1	2	3
No discernible stain	3	-	-	-
Punctate stain	12	12	-	-
Diffuse stain	3	3	-	-
Line stain	2	2	-	-
Dimple stain	1	1	-	-
Oedematous 'haze' stain	1	1	-	-

Area (punctate)	7 17 3 1 7 12 4 4 1 13 2 3	Mean Area 4.57%
Area (diffuse)	1 21 4	Mean Area 6.15%
Length (line)	1 3	Mean Length 1.50
Area (dimple)	4	Mean Area 3.00%
Area ('haze')	32	Mean Area 24.00%

Analysis of variance (two way factorial)

Area of corneal stain

Punctate

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	9	10	12	28
Corneal	6	91	130	74
Gel	12	33	21	8.

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	136.8674	45.6224	4.6032
(b) Between lenses	2	367.7296	183.8648	18.5514
(c) Interaction (a) x (b)	6	209.1526	34.8588	3.5171
Residual	269	2584.4000	9.9111	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Sum of squares	F ratio
Treatment totals	59	301	74			
Comparison and number						
Corneal vs. Control	+1	-1	0	242	380.78	37.07
Gel vs. Control	+1	0	-1	15	2.316	0.23

Value of F from tables

Orthogonal comparisons	probability p = 0.01	= 6.63
	probability p = 0.1	= 2.71
Interaction	probability p = 0.01	= 2.80

Discussion

Analysis of variance shows the results for punctate corneal stain to differ significantly from one another. Orthogonal comparisons identify the varying group to be those subjects wearing corneal lenses. The value of F for the corneal, control comparison exceeds the value from tables by 30.44. The changes in corneal staining are also related to time; the value of F for the interaction term exceeding the value from tables by 0.70. However, inspection of all the totals shows the corneal changes to decrease at twenty weeks after initial increases over the first three examinations.

The orthogonal comparison for gel lens wearing patients shows no discernible difference, at this level of replication. with the results for the group of control subjects.

The incidence of both diffuse and line stain among both control and gel lens wearing subjects is spasmodic, and for this reason these results are not analysed.

Two types of stain were encountered among gel lens wearing subjects which were not encountered among the other groups in the survey; dimple and oedematous 'haze' staining. Dimple stain is defined as a series of regular indentations in the cornea from 0.75% to .6% of the corneal surface in diameter. They were encountered in small groups and had the property that the pools of fluorescein lying in the depressions could be washed out with 2% sodium bicarbonate solution. Oedematous haze stain was encountered on an area of very superficial 'haze' in the corneal epithelium. It was included in the staining category when fluorescence was combined with the haze, and is therefore distinguished from the simple unstained bedewing of the area in cases of oedema.

Conclusion

The significant increase in punctate corneal stain among corneal lens wearing subjects, combined with the presence of two types of stain not formerly encountered suggests a general high level of epithelial disturbance for this group. These results conform to general clinical experience and the work of Bonnet[75] and Shulman.[76] The corneal epithelium is held by Duke Elder[77] and others[78,79] to be the 'primary barrier against infection in the eye'. Its partial disruption in corneal lens wear is therefore a cause for some concern, a fact borne out by the slight but significant[80] increase in the incidence of ocular infections among wearers of these lenses. The absence of discernible change between the control and gel lens wearing groups suggests a distinct advantage for this type of contact lens. This advantage must be weighed however, against the inconvenient boiling routines to which gel lenses are subject for partial sterilisation. Without the elimination of this time consuming routine, and the increased risks of lens contamination, when it is not applied the improvements in the integrity of the corneal epithelium could easily be outweighed by poor patient hygiene.

Section 11

The Tabulated Results and Analysis of the Spectacle Prescription Values

Tabulated results

Spectacle Rx value (dioptres)

Control subjects

	Initial			4 weeks			12 weeks			20 weeks		
No.	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS
1	-2.00	-0.50	175	-1.75	-0.25	175	-2.00	-0.50	175	-2.00	-0.75	175
2	-3.25	-0.25	30	-3.25	0.00	-	-3.00	-0.25	40	-3.00	-0.50	20
3	-5.00	-0.50	80	-5.00	-0.50	80	-4.50	-0.75	95	-4.50	-0.75	70
4	-5.00	-0.50	140	-4.50	-0.50	130	-4.25	-0.50	145	-4.25	-0.50	125
5	-2.75	-0.25	95	-2.25	-0.75	80	-2.00	-0.50	85	-2.25	-0.75	95
6	-5.25	-1.00	170	-5.00	-0.50	175	-5.25	-1.00	170	-5.50	-1.00	175
7	-4.50	-1.00	90	-4.50	-0.75	85	-4.00	-1.00	95	-4.00	-1.00	90
8	-4.00	-0.50	50	-4.50	-0.50	35	-4.00	0.00	-	-4.50	-0.50	40
9	-2.25	-0.25	65	-2.25	-0.25	85	-1.75	-0.50	80	-2.00	-0.50	80
10	-2.25	0.00	-	-2.50	-0.25	70	-2.50	-0.50	80	-2.00	-0.50	40
11	-4.75	0.00	-	-4.50	-0.25	80	-4.25	-0.25	65	-4.00	-0.50	95
12	-7.50	-0.25	95	-7.00	-0.50	70	-6.75	-0.25	110	-6.75	0.00	-
13	-2.00	-0.50	50	-2.00	-0.25	45	-2.50	-0.50	65	-2.25	-0.50	70
14	-3.50	-0.50	60	-4.00	-0.50	90	-4.25	-0.50	90	-4.00	-0.50	80
15	-4.00	-0.50	85	-4.00	-0.50	50	-4.25	-0.50	45	-4.50	0.00	-
16	-3.25	-0.75	150	-3.75	-0.50	90	-3.50	-0.75	85	-3.50	-0.50	100
17	-2.00	-0.50	5	-2.00	-0.50	5	-2.00	0.00	-	-1.75	-0.25	45
18	-3.00	-0.50	170	-3.50	-0.50	90	-3.00	-0.25	125	-3.50	-0.50	100
19	-2.25	-1.00	75	-2.25	-1.00	80	-2.25	-0.75	70	-2.25	-0.75	70
20	-4.00	0.00	-	-3.75	-0.50	90	-3.50	-0.50	100	-3.50	-0.50	100
21	-5.50	-0.75	90	-5.25	-0.75	70	-5.50	-0.50	75	-5.25	-0.50	80
22	-3.25	-0.50	10	-3.25	-0.75	175	-3.25	-0.75	20	-3.00	-0.25	170
23	-2.00	-0.50	70	-1.75	-0.50	80	-1.75	0.00	-	-2.00	0.50	90
24	-5.00	-1.00	180	-4.75	-1.00	5	-4.50	-1.00	180	-5.00	-1.00	180
25	-3.00	-0.25	90	-2.75	-0.50	80	-3.25	-0.25	60	-2.75	-0.25	110

Tabulated results

Spectacle Rx value (dioptres)

Corneal lens wearing subjects

	Initial			4 weeks			12 weeks			20 weeks		
No.	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS
1	-5.75	-0.25	140	-5.50	-0.50	155	-6.25	-0.50	150	7.25	-0.50	145
2	-1.50	-0.25	45	-1.75	-0.25	65	-1.50	-0.75	95	-2.00	-0.75	115
3	-3.50	-0.50	70	-5.75	-0.50	40	-3.25	-0.50	140	-3.50	-0.50	110
4	-3.75	-0.50	155	-3.75	-0.50	155	-4.50	-0.75	175	-5.00	-0.75	165
5	-4.00	-1.00	175	-5.00	-0.25	25	-5.00	-0.50	20	-4.50	-0.50	55
6	-3.75	-0.50	30	-5.00	-0.50	5	-3.50	-0.75	40	-4.00	-1.00	5
7	-2.75	-0.25	90	-3.00	-0.25	105	-3.75	-0.50	180	-3.25	-0.25	85
8	-3.50	-0.50	170	-3.25	-0.50	170	-3.25	-0.50	180	-2.75	-1.00	165
9	-4.75	-0.50	30	-6.50	0.00	-	-5.00	-0.50	15	-5.50	-0.75	20
10	-3.75	-0.50	175	-3.75	-0.50	90	-5.00	-0.50	55	-4.00	-0.75	90
11	-2.50	-0.25	10	-3.25	0.00	-	-2.75	0.00	-	-2.50	0.00	-
12	-8.50	-1.00	170	-8.00	-1.25	175	-8.75	-1.25	175	-8.75	-2.00	160
13	-7.00	0.00	-	-7.25	0.00	-	-7.75	0.00	15	-5.00	-1.50	105
14	-5.00	-0.50	170	-6.00	-0.50	135	-5.50	0.00	-	-5.00	-0.50	80
15	-1.75	0.00	-	-2.25	0.00	-	-2.00	0.25	110	-2.25	-0.25	140
16	-3.75	-1.00	180	-5.25	-0.50	175	-4.75	0.00	-	-3.75	0.00	-
17	-4.25	0.00	-	-4.25	0.00	-	-4.25	0.00	-	-3.75	-0.25	140
18	-3.75	-0.25	165	-4.50	-0.75	180	-3.75	0.00	-	-3.75	-0.25	140
19	-1.25	-1.00	40	-2.25	-0.50	180	0.00	-0.50	40	-0.50	-1.00	60
20	-6.75	-0.50	175	-6.50	-0.25	130	-6.75	0.00	135	-6.25	-0.50	100
21	-2.50	0.00	-	-3.50	-0.50	130	-2.50	-0.50	90	-2.00	-0.50	120
22	-3.25	0.00	-	-4.00	-0.25	85	-3.00	-0.25	95	-3.50	-0.75	50
23	-1.75	-0.50	100	-3.00	-0.25	180	-2.25	-0.50	100	-1.75	-0.50	90
24	-1.00	-0.50	175	-1.75	-0.50	180	-1.50	-0.50	170	-1.00	-0.25	150
25	-3.75	-0.50	135	-3.00	-1.00	105	-2.50	-1.25	110	-2.00	-1.25	115

Tabulated results

Spectacle Rx value (dioptres)

Gel lens wearing subjects

	Initial			4 weeks			12 weeks			20 weeks		
No.	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS
1	-2.25	0.00	-	2.25	-0.25	95	-2.25	-0.25	75	-2.25	-0.25	80
2	-3.00	-0.75	165	-3.00	-1.00	5	-3.00	-1.00	180	-2.50	-1.00	180
3	-2.25	0.00	-	-2.25	-0.25	120	-2.00	-0.50	80	-2.50	-0.50	105
4	-5.00	-0.50	80	-5.25	-1.00	90	-6.00	-0.50	90	-5.00	-0.75	115
5	-7.25	-0.25	145	-7.00	0.00	-	-7.25	-0.25	75	-7.00	-0.50	80
6	-6.25	-0.75	25	-6.00	-0.25	35	-6.25	-0.75	45	-6.50	-0.50	20
7	-1.25	0.00	-	-1.00	0.00	-	-1.25	-0.25	150	-1.25	-0.50	115
8	-2.75	-0.50	110	-2.50	-0.50	20	-2.75	-0.25	60	-3.00	0.00	-
9	-7.00	-0.50	160	-7.25	-0.50	180	-6.75	0.00	-	-6.75	-0.50	170
10	-2.25	-0.50	70	-2.50	-0.25	25	-2.50	0.00	-	-2.25	-0.25	50
11	-2.50	-0.50	115	-2.25	-0.50	115	-2.50	-0.50	110	-2.75	-0.75	120
12	-3.50	-0.25	120	-3.75	0.00	-	-3.50	0.00	-	-3.50	0.00	-
13	-1.75	-0.75	25	-1.75	-0.50	80	-1.50	-0.50	70	-1.50	0.00	-
14	-5.75	0.00	-	-5.75	0.00	-	-5.50	-0.25	135	-5.50	-0.25	65
15	-2.50	0.00	-	-2.75	-0.25	80	-2.25	-0.25	40	-2.75	0.00	-
16	-3.50	-0.50	90	-3.50	-0.75	105	-3.50	-0.50	80	-3.50	-0.50	90
17	-2.50	-0.75	95	-2.25	-0.50	125	-2.50	-0.50	110	-2.25	-0.50	70
18	-4.50	-0.25	95	-4.50	-0.50	15	-4.50	0.00	-	-4.75	-0.25	95
19	-2.00	-1.00	85	-2.00	-1.00	90	-2.00	-1.00	80	-2.25	-0.50	115
20	-4.00	-0.50	90	-4.25	-0.50	85	-4.25	-0.50	90	-4.50	-0.25	30
21	-4.75	-1.00	180	-5.00	-0.50	5	-4.75	-0.75	15	-5.00	-0.75	5
22	-4.50	-1.00	105	-4.50	-0.75	90	-4.75	-1.00	110	-4.50	-1.00	115
23	-1.50	-0.50	55	-1.75	0.00	-	-1.75	-0.25	90	-1.50	-0.25	75
24	-3.00	-0.50	10	-3.00	0.00	90	-2.50	0.00	-	-2.75	-0.25	180
25	-7.50	-0.50	95	-7.50	-0.75	90	-7.25	-0.75	90	-7.25	-0.50	45

11.2 Analysis of variance (two way factorial)

Spectacle prescription value

Spherical component

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	91.25	90.00	87.75	88.00
Corneal	93.75	108.00	99.00	94.00
Gel	93.00	93.50	93.25	93.25

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	1.8363	0.6121	0.20
(b) Between lenses	2	7.1879	3.5939	1.22
(c) Interaction (a) x (b)	6	3.7732	0.6288	0.62
Residual	269	847.5700	2.9429	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Spectacle prescription value

Cylindrical component

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	12.25	12.75	12.25	13.25
Corneal	10.75	10.00	10.75	16.25
Gel	11.75	10.50	10.50	10.50

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.3978	0.1326	1.29
(b) Between lenses	2	0.2688	0.1344	1.31
(c) Interaction (a) x (b)	6	0.6834	0.1139	1.11
Residual	269	29.5350	0.1026	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Spectacle prescription value

Cylinder axis component

Cell total (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	1755.00	1675.00	1815.00	1820.00
Corneal	2400.00	2070.00	2090.00	2040.00
Gel	1915.00	1540.00	1775.00	1875.00

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	5174.2660	1724.7553	0.71
(b) Between lenses	2	19136.8750	9568.4375	3.96
(c) Interaction (a) x (b)	6	3982.6090	663.7681	0.27
Residual	269	549625.5000	2410.7565	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 4.61
Interaction (p = 0.1) = 1.77

Discussion

Analysis of variance of the spherical and cylindrical components of the spectacle refraction show no significant change to occur in either of these parameters. The value of F from tables exceeding the calculated values by 1.87, 1.08 and 1.14 for the spherical component, and 0.79, 0.99 and 0.66 for the cylindrical component. The axis of the cylindrical component also remains unaffected, the value of F from tables exceeding the calculated values by 1.27 for the between visits term and 0.65 for the between lenses term.

Conclusion

The absence of group differences does not preclude the possibility of both increases and decreases occuring in one group without affecting the group totals. Rengstorff[81] states this situation to occur among corneal lens wearing subjects. It was decided to examine the changes of the within group cell totals to examine this possibility.

11.3 Tabulated results

Change in spectacle Rx value (dioptres)

Corneal lens wearing subjects

	Initial and 4 weeks			4 and 12 weeks			12 and 20 weeks		
No.	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS
1	-0.25	+0.25	+15	+0.75	0.00	+5	+1.00	0.00	-5
2	+0.25	0.00	+20	-0.25	+0.50	+30	+0.50	0.00	+20
3	+2.25	0.00	-30	-2.50	0.00	+100	+0.25	0.00	-30
4	0.00	0.00	[illegible]	+0.75	+0.25	+20	+0.50	0.00	-10
5	+1.00	-0.75	-15	0.00	+0.25	-5	-0.50	0.00	+35
6	+1.25	0.00	-25	-1.50	-0.25	+35	+0.50	+0.25	-35
7	+0.25	0.00	+15	+0.75	-0.25	-75	-0.50	-0.25	-95
8	-0.25	0.00	0	0.00	0.00	+10	-0.50	+0.50	-15
9	+2.75	-0.50	-30	-1.50	-0.50	0	+0.50	+0.25	+5
10	0.00	0.00	-85	+1.25	0.00	-35	-1.00	-0.25	+35
11	+0.75	-0.25	0	-0.50	0.00	0	-0.25	0.00	0
12	-0.50	+0.25	+ 5	+0.75	0.00	0	0.00	+0.75	-15
13	+0.25	0.00	0	+0.50	0.00	0	-2.75	+1.50	0
14	+1.00	0.00	-45	-0.50	-0.50	0	-0.50	+0.50	0
15	+0.50	0.00	0	-0.25	+0.25	0	+0.25	0.00	+30
16	+1.50	-0.50	-5	-0.50	-0.50	0	-1.00	0.00	0
17	0.00	0.00	0	0.00	0.00	0	0.00	+0.25	0
18	+0.75	+0.50	+15	-0.75	-0.75	0	0.00	+0.25	0
19	+1.00	-0.50	+140	-2.25	0.00	-140	+0.50	+0.50	20
20	-0.25	-0.25	-35	+0.25	-0.25	0	-0.50	+0.50	0
21	+1.00	+0.50	0	-1.00	0.00	0	-0.50	0.00	+30
22	+0.75	+0.25	0	-1.00	0.00	0	+0.50	+0.50	-45
23	+1.25	-0.25	+80	-0.75	+0.25	-80	-0.50	0.00	-10
24	+0.75	0.00	+5	-0.25	0.00	10	-0.50	0.25	-20
25	-0.75	+0.50	-30	-0.50	+0.25	+5	-0.50	0.00	+5

Tabulated results

Change in spectacle Rx value (dioptres)

Control subjects

	Initial and 4 weeks			4 and 12 weeks			12 and 20 weeks		
No.	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS
1	-0.25	-0.25	0	+0.25	+0.25	0	0.00	+0.25	0
2	0.00	-0.25	0	-0.25	+0.25	0	0.00	+0.25	0
3	0.00	0.00	-	-0.50	+0.25	+15	0.00	0.00	-25
4	-0.50	0.00	-10	-0.25	0.00	+15	0.00	0.00	-20
5	-0.50	+0.50	-15	-0.35	-0.25	+ 5	+0.25	+0.25	+10
6	-0.25	-0.50	+ 5	+0.25	+0.50	-5	+0.25	0.00	+5
7	0.00	-0.25	-15	-0.50	+0.25	+10	0.00	0.00	-5
8	+0.50	0.00	-15	-0.50	-0.50	0	+0.50	+0.50	0
9	0.00	0.00	+20	-0.50	+0.25	-5	+0.25	0.00	0
10	+0.25	+0.25	0	0.00	+0.25	+10	-0.50	0.00	-40
11	-0.25	+0.25	0	-0.25	0.00	-15	-0.25	+0.25	+30
12	-0.50	+0.25	-25	-0.25	-0.25	+40	0.00	-0.25	0
13	0.00	-0.25	-5	+0.50	+0.25	+20	-0.25	0.00	+5
14	+0.50	0.00	+30	+0.25	0.00	0	-0.25	0.00	-10
15	0.00	0.00	-35	+0.25	0.00	-5	+0.25	-0.50	-
16	+0.50	-0.25	-60	-0.25	+0.25	-5	0.00	-0.25	+15
17	0.00	0.00	0	0.00	-0.50	-	-0.25	+0.25	-
18	+0.50	0.00	-60	-0.50	-0.25	+5	+0.50	-0.25	-25
19	0.00	0.00	-5	0.00	-0.25	-10	0.00	0.00	0
20	-0.25	+0.50	0	-0.25	0.00	0	0.00	0.00	0
21	-0.25	0.00	+20	+0.25	-0.25	+5	-0.25	0.00	+5
22	0.00	+0.25	+15	0.00	0.00	+25	-0.25	-0.50	-30
23	-0.25	0.00	+10	0.00	-0.50	-	+0.25	+0.50	-
24	-0.25	0.00	+5	-0.25	0.00	+5	+0.50	0.00	0
25	-0.25	+0.25	-10	+0.50	-0.25	-20	-0.50	0.00	+50

Tabulated results

Change in spectacle Rx value (dioptres)

Gel lens wearing subjects

	Initial and 4 weeks			4 and 12 weeks			12 and 20 weeks		
No.	SPH	CYL	AXIS	SPH	CYL	AXIS	SPH	CYL	AXIS
1	0.00	+0.25	-	0.00	0.00	-20	0.00	0.00	+5
2	0.00	+0.25	+20	0.00	0.00	-5	-0.50	0.00	0
3	0.00	+0.25	-	-0.25	+0.25	-40	+0.50	0.00	+25
4	+0.25	+0.50	+10	+0.75	-0.50	0	-1.00	+0.25	+25
5	-0.25	-0.25	-	+0.25	+0.25	-	-0.25	+0.25	+5
6	-0.25	-0.50	+10	+0.25	+0.50	+10	+0.25	-0.25	-25
7	-0.25	0.00	-	+0.25	+0.25	-	0.00	+0.25	-35
8	-0.25	0.00	-90	+0.25	-0.25	+40	+0.25	-0.25	-
9	+0.25	0.00	+20	-0.50	-0.50	-	0.00	+0.50	-
10	+0.25	-0.25	-55	0.00	-0.25	-	-0.25	+0.25	-
11	-0.25	0.00	0	+0.25	0.00	-5	+0.25	+0.25	+10
12	+0.25	-0.25	-	-0.25	0.00	-	0.00	0.00	-
13	0.00	-0.25	+55	-0.25	0.00	-10	0.00	-0.50	-
14	0.00	0.00	-	-0.25	+0.25	-	0.00	0.00	-50
15	+0.25	+0.25	-	-0.50	0.00	-40	+0.50	-0.25	-
16	0.00	+0.25	+15	0.00	-0.25	-25	0.00	0.00	+10
17	-0.25	-0.25	+30	-0.25	0.00	-15	-0.25	0.00	-40
18	0.00	+0.25	-70	0.00	-0.50	-	+0.25	+0.25	-
19	0.00	0.00	+5	0.00	0.00	-10	+0.25	-0.50	+35
20	+0.25	0.00	-5	0.00	0.00	+5	+0.25	-0.25	60
21	+0.25	-0.50	+5	-0.25	+0.25	+10	+0.25	0.00	-10
22	0.00	-0.25	-15	+0.25	+0.25	+20	-0.25	0.00	+5
23	+0.25	-0.50	-	0.00	+0.25	-	-0.25	0.00	-15
24	0.00	-0.50	-	-0.50	0.00	-	+0.25	-0.25	-
25	0.00	+0.25	-5	-0.25	0.00	0	0.00	-0.25	45

11.4 Analysis of variance (two way factorial)

Spectacle prescription change

Spherical component

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	5.75	6.75	5.25
Corneal	19.25	19.50	14.00
Gel	3.50	5.50	5.75

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.3044	0.1522	1.00
(b) Between lenses	2	11.9025	5.9513	39.34
(c) Interaction (a) x (b)	4	0.6359	0.1590	1.05
Residual	269	32.6700	0.1513	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Sum of squares	F ratio
Treatment totals	17.75	52.75	14.75			
Comparison and number						
Corneal vs. Control	+1	-1	0	35.00	8.14	48.86
Gel vs. Control	+1	0	-1	-3.00	0.60	4.00

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.85
Orthogonal comparison	(p = 0.01)	= 6.63
	(p = 0.05)	= 3.84

Analysis of variance (two way factorial)

Change in spectacle prescription value

Cylindrical component

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	4.00	5.50	4.00
Corneal	5.25	4.75	6.50
Gel	5.75	5.50	4.50

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0052	0.0026	0.05
(b) Between lenses	2	0.0652	0.0326	0.71
(c) Interaction (a) x (b)	4	0.1548	0.0387	0.84
Residual	269	9.9100	0.0459	

Value of F from tables

Between visits (p = 0.1) = 2.30
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.85

Analysis of variance (two way factorial)

Spectacle prescription change

Cylinder Axis component

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	290.00	235.00	280.00
Corneal	420.00	315.00	330.00
Gel	365.00	255.00	340.00

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	2128.2788	1064.1394	1.85
(b) Between lenses	2	760.3740	380.1870	0.66
(c) Interaction (a) x (b)	4	458.0735	114.5183	0.19
Residual	269	7222.2667	573.2402	

Value of F from tables

Between visits (p = 0.1) = 2.35
Between lenses (p = 0.1) = 2.35
Interaction (p = 0.1) = 1.99

Discussion - spherical component

Analysis of the group changes, irrespective of sign shows a significant difference between groups. Orthogonal comparisons show this change to be attributable to those subjects wearing corneal lenses; the calculated value of F exceeding the value of F from tables by 42.23. The absence of a significant interaction term; the value of F from tables exceeds the calculated F value by 0.80, implies that the change is not progressive with time over the period of the experiment. The nature of the changes in the spherical component of the spectacle prescription conform to the anticipated pattern, the changes being summarised below:

Weeks composed	Initial and four weeks	Four and twelve weeks	Twelve and twenty weeks
Number of increases	17	5	9
Number of decreases	6	15	13
No change	2	4	3
Mean increase	1.00 dioptres	1.10 dioptres	0.50 dioptres
Mean decrease	0.31 dioptres	0.95 dioptres	0.73 dioptres

There also exists a significant change among those subjects wearing gel lenses. The F value from tables for a probability (p) of 0.05 being exceeded by 0.14 by the calculated value of F. However, this value is in turn exceeded by 2.63 when the significance level is raised to a probability of 0.01. Examination of the totals shows this change to be a reduction in the changes of the spherical component among gel lens wearing subjects.

Cylindrical component:

Analysis of the results of the cylindrical component of

the spectacle refraction shows no significant difference to be discernible among the cell totals; the value of F from tables exceeding the calculated values of F by 2.24, 1.29 and 1.01 for the visits, lens group and interaction term respectively. The change in axis of the cylindrical component is also insignificant at this level of replication.

Conclusions

The type of spherical refractive change found among corneal lens wearing subjects conforms to the pattern found by Rengstorff (page 148).

The possible reduction of spherical changes among gel lens wearing subjects is only moderately significant at the 95% level. Examination of the cell totals (page152) shows that this result is at least partially attributable to a particularly low value for the initial to four week examination. This factor combined with the absence of a significant interaction term strongly suggests the results arise through a random effect, and probably does not represent a real treatment effect.

The absence of significant detectable differences in the cylindrical and axis components of the spectacle refraction, agrees with the work of Hodd [82] for corneal lens wearing subjects. The lack of change in these factors combined with the lack of change in the spherical component for gel lens wearing subjects, implies that the clinical phenomenon of spectacle blur was not encountered in this period of wear. This conclusion is supported by the subjective symptoms for contact lens wearing subjects. Among gel lens wearers only two subjects reported a reduction in vision upon removal of the lenses; and this reduction only lasted for five minutes

in each case. The comparable figures of corneal lens wearing subjects are given below:-

Week of examination	0	4	12	20
Number of subjects reporting reduced vision	0	11	7	11
Mean period of reduction	-	2.02 hours	2.40 hours	10.4 hours.

Section 12

The Tabulated Results and Analysis of the Values of Corneal Topography

12.1 Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at initial examination

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.76	8.06	7.80	7.66	7.60	7.62	7.62	7.70	7.88	8.36
2	8.58	8.26	8.10	8.08	8.00	7.96	8.00	8.10	8.54	9.02
3	8.54	8.42	8.28	8.20	8.10	8.20	8.24	8.32	8.42	8.90
4	8.92	8.34	8.14	8.06	8.02	8.02	8.06	8.18	8.44	9.02
5	10.70	9.25	8.44	8.22	8.06	8.00	8.06	8.14	8.30	8.90
6	8.50	8.24	8.04	7.46	7.44	7.90	7.44	8.04	8.20	8.60
7	8.32	8.02	7.96	7.96	7.96	7.96	8.00	8.04	8.14	8.32
8	7.66	7.47	7.34	7.28	7.34	7.44	7.52	7.76	8.22	8.42
9	8.30	7.88	7.72	7.62	7.58	7.58	7.58	7.60	7.90	8.20
10	8.48	8.18	8.10	8.02	8.00	8.02	8.08	8.12	8.28	8.62
11	8.52	8.16	8.04	7.98	7.96	8.00	8.10	8.28	8.68	9.00
12	7.04	7.84	7.76	7.66	7.70	7.72	7.82	7.96	8.04	8.20
13	8.66	8.14	7.88	7.76	7.70	7.66	7.72	7.78	7.94	8.18
14	8.88	8.34	8.08	7.98	7.92	7.92	7.94	8.06	8.22	8.56
15	8.48	7.90	7.74	7.64	7.62	7.62	7.70	7.76	7.94	8.32
16	8.04	7.72	7.52	7.42	7.32	7.40	7.40	7.46	7.56	7.80
17	8.46	8.12	7.92	7.84	7.84	7.86	7.84	7.88	7.88	8.20
18	9.02	8.54	8.14	8.08	8.08	8.08	8.14	8.30	8.58	8.86
19	9.22	8.56	8.36	8.10	8.08	8.06	8.12	8.24	8.40	8.66
20	9.08	8.54	8.20	8.26	8.14	8.16	8.22	8.40	8.70	9.26
21	9.08	8.62	8.36	8.20	8.02	8.18	8.20	8.28	8.42	8.76
22	8.44	8.02	7.76	7.70	7.68	7.70	7.78	7.88	8.06	8.46
23	8.34	7.86	7.68	7.60	7.64	7.62	7.70	7.80	8.16	8.52
24	8.78	8.30	8.02	7.86	7.72	7.80	7.84	7.92	8.16	8.70
25	8.50	8.06	7.98	7.96	7.62	7.98	8.02	8.10	8.20	8.56

N indicates the nasal aspect of the cornea

T indicates the temporal aspect of the cornea

The values of the radius of curvature are measured at 5 degree intervals along each meridian.

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at initial examination

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.26	8.20	7.70	7.50	7.40	7.44	7.42	7.62	7.78	8.04
2	8.40	7.90	7.62	7.70	7.76	7.92	8.02	8.22	8.54	8.90
3	9.14	8.38	8.10	8.10	8.12	8.20	8.32	8.46	8.66	9.00
4	8.48	8.04	7.94	7.94	7.94	7.98	8.10	8.18	8.30	8.74
5	8.80	8.26	7.96	7.60	7.74	7.64	7.76	8.08	8.32	8.70
6	8.42	7.96	7.88	7.88	7.88	7.88	7.90	7.94	8.06	8.34
7	8.54	7.98	7.68	7.58	7.58	7.58	7.66	7.66	7.96	8.50
8	7.80	7.54	7.40	7.34	7.34	7.38	7.36	7.58	7.92	8.28
9	8.44	7.86	7.56	7.46	7.40	7.40	7.50	7.62	7.84	8.20
10	8.46	8.34	8.34	8.06	8.00	7.96	8.08	8.14	8.24	8.40
11	9.28	8.18	8.16	8.08	8.10	8.16	8.08	8.08	8.08	8.20
12	7.84	7.52	7.54	7.54	7.56	7.66	7.76	7.94	8.04	8.48
13	7.98	7.74	7.68	7.56	7.56	7.58	7.62	7.76	7.98	7.82
14	8.30	8.00	7.82	7.76	7.76	7.80	7.86	8.00	8.24	8.74
15	8.04	7.74	7.64	7.64	7.58	7.64	7.64	7.70	7.76	8.08
16	7.74	7.40	7.26	7.18	7.18	7.24	7.36	7.38	7.84	8.14
17	9.54	8.28	7.52	7.48	7.66	7.64	7.82	8.00	8.42	8.96
18	8.90	8.26	7.82	7.72	8.04	7.96	8.04	8.02	8.42	9.06
19	8.60	8.04	7.98	7.94	7.86	7.88	7.94	8.14	8.42	8.90
20	8.54	8.26	8.10	8.00	7.98	8.04	8.14	8.30	8.60	9.10
21	8.62	8.02	8.02	8.02	8.00	8.04	8.12	8.18	8.30	8.58
22	8.90	8.00	7.76	7.68	7.70	7.72	7.76	7.90	8.26	8.66
23	8.26	7.92	7.60	7.56	7.62	7.62	7.68	7.76	7.86	8.22
24	8.30	7.96	7.84	7.76	7.70	7.74	7.78	7.98	8.18	8.46
25	8.38	7.94	7.76	7.66	7.62	7.76	7.80	7.94	8.22	8.62

I indicates the inferior aspect of the cornea

S indicates the superior aspect of the cornea.

The values of the radius of curvature are measured at 5 degree intervals along each meridian.

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at four weeks

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.42	7.96	7.76	7.64	7.60	7.58	7.60	7.68	7.90	8.36
2	8.56	8.24	8.02	8.00	8.00	7.98	8.00	8.12	8.60	8.98
3	8.78	8.44	8.34	8.22	8.14	8.16	8.20	8.30	8.44	8.94
4	9.30	8.34	8.16	8.10	8.04	8.06	8.10	8.20	8.46	8.92
5	10.64	8.94	8.34	8.16	8.06	7.98	8.02	8.22	8.40	9.04
6	8.72	8.26	8.06	7.98	7.96	7.94	7.94	8.06	8.20	8.54
7	8.32	8.02	7.96	7.96	7.96	7.96	7.98	8.02	8.06	8.28
8	8.24	7.70	7.46	7.40	7.26	7.36	7.44	7.56	7.70	8.16
9	8.22*	7.86*	7.68*	7.60*	7.60*	7.58*	7.60*	7.68*	7.94*	8.56*
10	8.48	8.16	8.08	8.00	8.00	8.00	8.02	8.10	8.26	8.56
11	8.98	8.50	8.10	8.00	7.96	8.00	8.08	8.30	8.66	8.98
12	8.48	8.10	7.90	7.78	7.70	7.72	7.72	7.84	8.00	8.26
13	8.80	8.12	7.86	7.78	7.74	7.72	7.76	7.82	8.00	8.22
14	8.64	8.26	8.10	8.00	7.94	7.94	7.96	8.06	8.22	8.48
15	8.90	8.40	7.92	7.70	7.60	7.58	7.60	7.68	7.72	8.32
16	8.04	7.70	7.56	7.44	7.38	7.42	7.46	7.48	7.64	7.84
17	8.46	8.10	7.94	7.86	7.86	7.90	7.86	7.92	8.00	8.16
18	8.84	8.44	8.20	8.12	8.10	8.14	8.18	8.30	8.58	9.18
19	9.06	8.50	8.30	8.20	8.08	8.12	8.18	8.26	8.46	9.00
20	9.00	8.56	8.36	8.26	8.18	8.22	8.30	8.42	8.64	9.20
21	8.96	8.46	8.32	8.22	8.18	8.16	8.20	8.28	8.38	8.58
22	8.30	7.84	7.76	7.70	7.66	7.66	7.78	7.88	8.06	8.42
23	8.42	7.94	7.72	7.66	7.66	7.66	7.74	7.90	8.30	8.98
24	8.90	8.38	8.02	7.88	7.78	7.80	7.82	7.98	8.26	8.96
25	8.44	8.06	8.00	7.94	7.80	7.96	8.00	8.08	8.22	8.44

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at four weeks

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.46	7.82	7.66	7.50	7.50	7.42	7.50	7.56	7.76	8.16
2	8.22	7.92	7.64	7.74	7.78	7.92	8.08	8.20	8.60	8.94
3	8.96	8.34	8.12	8.10	8.12	8.20	8.36	8.46	8.62	9.00
4	8.68	8.14	7.90	7.98	7.90	7.98	8.06	8.14	8.14	8.78
5	8.60	8.24	7.90	7.82	7.74	7.78	7.84	8.04	8.38	9.40
6	8.54	7.90	7.90	7.90	7.90	7.86	7.92	8.00	8.14	8.40
7	8.34	7.94	7.66	7.56	7.56	7.60	7.64	7.72	7.92	8.34
8	8.16	7.50	7.44	7.32	7.30	7.28	7.30	7.60	8.00	8.28
9	8.64*	7.84*	7.56*	7.46*	7.44*	7.46*	7.50*	7.58*	7.88*	8.00 *
10	8.44	8.30	8.32	8.10	8.02	7.90	8.00	8.12	8.26	8.62
11	9.26	8.18	8.10	8.10	8.06	8.18	8.20	8.22	8.20	8.32
12	7.62	7.60	7.58	7.58	7.56	7.70	7.80	8.02	8.32	8.50
13	8.12	7.76	7.70	7.62	7.60	7.60	7.68	7.74	7.88	8.58
14	8.24	8.04	7.88	7.80	7.78	7.82	7.90	8.02	8.22	8.64
15	8.00	7.76	7.60	7.58	7.56	7.66	7.68	7.72	7.78	8.18
16	7.82	7.40	7.20	7.20	7.20	7.22	7.40	7.54	7.94	8.32
17	8.72	7.76	7.54	7.52	7.48	7.70	7.82	7.94	8.30	8.80
18	8.68	8.18	7.88	7.98	7.96	8.00	8.06	8.22	8.40	9.38
19	8.58	8.24	8.10	8.06	7.96	7.96	8.00	8.02	8.20	8.74
20	8.32	8.22	8.16	7.96	8.08	8.10	8.18	8.30	8.56	9.00
21	8.36	8.00	8.00	8.00	7.94	8.00	8.06	8.20	8.30	8.52
22	8.82	7.96	7.76	7.68	7.70	7.70	7.76	7.90	8.10	8.50
23	8.40	7.78	7.72	7.60	7.60	7.66	7.72	7.78	7.90	8.42
24	8.36	8.28	7.88	7.86	7.72	7.74	7.80	7.92	8.22	9.00
25	8.26	7.98	7.78	7.78	7.76	7.80	7.86	7.96	8.26	8.56

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at twelve weeks

	N					Horizontal Meridian				T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.46	8.10	7.82	7.70	7.62	7.60	7.60	7.70	7.88	8.20
2	8.64	8.30	8.12	8.06	8.00	8.00	8.06	8.14	8.56	8.96
3	8.60	8.40	8.30	8.24	8.20	8.18	8.24	8.34	8.46	8.70
4	8.30	8.10	8.02	8.00	7.98	8.02	8.12	8.20	8.54	9.12
5	10.72	9.14	8.34	8.16	8.06	8.02	8.06	8.22	8.42	8.94
6	8.68	8.30	8.08	7.96	7.96	7.96	7.96	8.02	8.20	8.68
7	8.30	8.02	7.96	7.94	7.92	7.96	7.96	8.00	8.06	8.24
8	7.94	7.72	7.50	7.40	7.40	7.42	7.46	7.56	7.74	8.10
9	8.32	7.86	7.72	7.62	7.54	7.54	7.58	7.70	7.84	8.32
10	8.42	8.26	8.16	8.06	7.94	8.02	8.10	8.20	8.26	8.46
11	8.46	8.22	8.14	8.06	8.02	8.06	8.18	8.36	8.74	9.02
12	8.54	8.12	7.90	7.82	7.70	7.72	7.78	7.84	8.06	8.24
13	8.50	8.14	7.86	7.78	7.74	7.72	7.76	7.84	7.96	8.32
14	8.66	8.24	8.10	8.02	7.94	7.96	7.96	8.04	8.26	5.50
15	8.36	7.94	7.72	7.64	7.64	7.62	7.70	7.78	7.94	8.30
16	8.00	7.62	7.54	7.48	7.40	7.42	7.42	7.48	7.58	7.94
17	8.70	8.06	7.96	7.88	7.76	7.84	7.86	7.88	8.04	8.24
18	9.00	8.54	8.26	8.14	8.10	8.16	8.20	8.28	8.58	9.32
19	9.42	8.68	8.30	8.20	8.10	8.10	8.14	8.20	8.40	8.94
20	9.24	8.34	8.32	8.24	8.16	8.18	8.26	8.40	8.82	9.64
21	8.78	8.50	8.32	8.22	8.16	8.16	8.20	8.26	8.40	8.66
22	8.26	7.92	7.76	7.68	7.64	7.70	7.72	7.80	8.12	8.44
23	8.52	7.86	7.70	7.62	7.60	7.62	7.70	7.84	8.14	8.68
24	9.00	8.30	8.06	7.92	7.82	7.80	7.84	7.90	8.22	8.60
25	8.38	8.04	7.96	7.92	7.96	7.96	8.00	8.10	8.22	8.66

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at twelve weeks

	I				Vertical Meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.36	7.80	7.72	7.58	7.50	7.50	7.48	7.60	7.92	8.30
2	8.04	7.86	7.60	7.72	7.80	7.90	8.04	8.20	8.46	8.90
3	8.82	8.26	8.18	8.02	8.04	8.18	8.32	8.50	8.60	8.96
4	8.24	7.98	7.92	7.88	7.92	7.92	8.02	8.18	8.30	8.64
5	8.96	8.36	8.00	7.82	7.66	7.74	7.80	8.06	8.48	9.20
6	8.36	7.90	7.86	7.86	7.88	7.94	8.00	8.00	8.10	8.38
7	8.24	7.86	7.64	7.52	7.58	7.60	7.64	7.72	7.98	8.58
8	7.80	7.54	7.40	7.40	7.30	7.32	7.40	7.64	7.96	8.54
9	8.18	7.66	7.54	7.46	7.40	7.44	7.50	7.64	7.88	8.14
10	8.44	8.16	8.06	7.94	8.02	8.02	8.10	8.32	8.66	9.06
11	8.64	8.02	7.98	8.00	8.04	8.10	8.14	8.10	8.10	8.44
12	7.74	7.60	7.60	7.54	7.58	7.70	7.84	8.04	8.24	8.32
13	8.00	7.74	7.68	7.62	7.64	7.64	7.70	7.76	7.94	8.62
14	8.10	8.00	7.90	7.84	7.80	7.82	7.92	8.18	8.30	8.72
15	7.92	7.70	7.62	7.60	7.64	7.64	7.64	7.66	7.78	8.04
16	7.74	7.30	7.22	7.20	7.22	7.26	7.44	7.66	8.00	8.60
17	8.86	7.72	7.54	7.54	7.60	7.76	7.86	7.96	8.40	8.96
18	8.70	8.20	7.88	7.92	7.92	8.02	8.06	8.24	8.42	9.28
19	8.50	8.12	8.06	8.00	7.98	8.00	8.06	8.12	8.38	9.10
20	8.44	8.16	8.12	8.00	8.00	8.04	8.16	8.26	8.64	9.68
21	8.24	8.10	8.04	7.98	8.00	8.04	8.12	8.22	8.38	8.52
22	8.94	8.38	7.88	7.76	7.70	7.80	7.86	8.06	8.16	8.74
23	8.20	7.88	7.58	7.58	7.58	7.68	7.68	7.80	7.92	8.10
24	8.18	8.04	7.84	7.80	7.76	7.76	7.82	7.94	8.20	8.58
25	8.28	8.04	7.80	7.76	7.72	7.76	7.78	8.00	8.26	8.72

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at twenty weeks

	N									T
	Horizontal meridian									
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.42	8.02	7.86	7.70	7.66	7.60	7.62	7.70	7.86	8.22
2	8.48	8.26	8.10	8.06	8.02	8.02	8.06	8.20	8.48	9.06
3	8.66	8.42	8.26	8.20	8.16	8.20	8.24	8.34	8.44	8.70
4	8.84	8.40	8.20	8.10	8.00	8.04	8.10	8.20	8.40	8.74
5	9.68	9.02	8.36	8.18	8.04	8.00	8.02	8.18	8.38	8.86
6	8.56	8.24	8.08	7.98	7.94	7.94	7.94	8.02	8.20	8.56
7	8.24	8.00	7.98	7.94	7.92	7.96	7.96	7.98	8.10	8.24
8	8.08	7.68	7.48	7.40	7.40	7.40	7.48	7.60	7.72	8.20
9	8.32	7.80	7.66	7.58	7.54	7.54	7.62	7.70	7.92	8.40
10	8.30	8.28	8.12	8.02	7.96	8.02	8.08	8.16	8.32	8.60
11	8.42	8.20	8.12	8.06	8.00	8.04	8.14	8.38	8.86	9.96
12	8.44	8.10	7.90	7.80	7.72	7.74	7.76	7.84	7.96	8.30
13	8.80	8.02	7.90	7.76	7.72	7.72	7.76	7.80	7.96	8.22
14	8.70*	8.24*	8.08*	7.98*	7.92*	7.96*	8.00*	8.06*	8.24*	8.40*
15	8.18	7.80	7.70	7.64	7.64	7.60	7.66	7.76	7.94	8.16
16	7.94	7.66	7.54	7.44	7.44	7.44	7.44	7.48	7.60	7.78
17	8.02*	7.94*	7.88*	7.84*	7.82*	7.88*	7.94*	8.08*	8.48*	8.96*
18	9.10	8.60	8.28	8.20	8.14	8.18	8.24	8.30	8.60	9.54
19	9.02	8.56	8.24	8.14	8.10	8.10	8.14	8.24	8.42	8.94
20	9.06*	8.52*	8.32*	8.24*	8.18*	8.20*	8.26*	8.34*	8.64*	9.20*
21	8.96	8.50	8.30	8.76	8.70	8.70	8.24	8.78	8.42	8.64
22	8.34	8.16	7.84	7.70	7.64	7.70	7.76	7.88	8.06	8.36
23	8.28	7.86	7.70	7.64	7.60	7.68	7.72	7.90	8.22	8.86
24	9.10	8.24	8.06	7.88	7.86	7.82	7.86	7.96	8.14	8.60
25	8.42	8.00	7.96	7.96	7.96	7.98	8.02	8.08	8.20	8.54

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Control subjects at twenty weeks

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.26	7.84	7.60	7.58	7.50	7.48	7.50	7.64	7.88	8.28
2	8.24	7.82	7.68	7.72	7.80	7.90	8.04	8.20	8.48	8.96
3	8.60	8.32	8.14	8.10	8.06	8.16	8.34	8.50	8.66	8.92
4	8.40	8.10	7.98	7.96	7.9	8.00	8.10	8.14	8.40	9.20
5	8.56	8.18	7.90	7.82	7.76	7.76	7.82	8.02	8.28	9.20
6	8.16	7.94	7.84	7.84	7.86	7.92	7.98	8.04	8.16	8.36
7	8.16	7.84	7.60	7.52	7.52	7.60	7.64	7.70	7.90	8.50
8	7.76	7.52	7.28	7.26	7.30	7.28	7.38	7.52	7.90	8.32
9	8.32	7.84	7.60	7.52	7.40	7.46	7.52	7.62	7.88	8.34
10	8.28	8.12	8.00	7.96	8.00	8.04	8.14	8.36	8.60	9.44
11	8.32	8.00	7.96	7.96	8.04	8.04	8.06	8.12	8.12	8.42
12	7.64	7.56	7.52	7.60	7.64	7.74	7.86	8.02	8.30	8.50
13	7.94	7.76	7.68	7.60	7.58	7.62	7.70	7.80	8.08	8.80
14	8.34*	7.98*	7.84*	7.76*	7.78*	7.80*	7.86*	7.96*	8.14*	8.76*
15	7.96	7.72	7.64	7.60	7.60	7.60	7.64	7.64	7.80	8.20
16	7.64	7.38	7.22	7.20	7.18	7.36	7.40	7.60	7.96	8.40
17	8.32*	7.70*	7.52*	7.56*	7.62*	7.74*	7.86*	8.16*	8.44*	9.08*
18	8.76	8.22	7.86	7.90	7.92	8.00	8.08	8.30	8.48	9.40
19	8.42	8.10	8.02	7.94	7.94	7.90	7.94	7.94	8.16	8.88
20	8.08*	8.20*	8.04*	7.96*	8.00*	8.02*	8.14*	8.32*	8.54*	9.02*
21	8.46	8.04	8.02	8.02	8.00	8.06	8.08	8.16	8.30	8.56
22	8.54	8.12	7.72	7.70	7.70	7.70	7.78	7.92	8.16	8.50
23	8.24	7.66	7.62	7.62	7.60	7.68	7.74	7.80	7.94	8.40
24	8.16	7.94	7.80	7.76	7.70	7.72	7.80	7.98	8.18	8.50
25	8.34	7.90	7.76	7.76	7.76	7.80	7.90	8.04	8.18	8.12

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects at the initial examination

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.60	8.14	7.94	7.80	7.76	7.74	7.76	7.89	7.96	8.20
2	8.16	7.86	7.78	7.74	7.74	7.72	7.72	7.78	7.88	8.24
3	8.92	8.14	8.22	8.00	8.12	8.20	8.24	8.30	8.42	8.86
4	8.50	8.14	8.06	8.04	8.02	8.04	8.08	8.14	8.38	9.08
5	7.84	7.74	7.70	7.64	7.64	7.64	7.66	7.80	8.06	8.40
6	8.40	7.84	7.62	7.60	7.60	7.60	7.68	7.76	7.98	8.14
7	8.64	8.22	8.06	8.02	8.00	8.02	8.02	8.04	8.24	8.98
8	8.50	8.20	7.86	7.82	7.84	7.82	7.88	8.10	8.32	8.76
9	8.22	7.96	7.84	7.80	7.76	7.80	7.86	7.98	8.24	8.96
10	8.12	7.92	7.76	7.72	7.72	7.66	7.72	7.76	7.86	8.32
11	8.00	7.92	7.82	7.74	7.70	7.64	7.64	7.68	7.80	7.90
12	8.66	8.34	8.10	8.04	7.98	7.94	7.98	8.18	8.88	9.86
13	8.92	8.36	8.16	8.10	8.08	8.06	8.12	8.22	8.76	9.54
14	8.10	7.86	7.76	7.68	7.64	7.62	7.62	7.72	7.82	8.22
15	8.60	8.26	8.04	7.92	7.88	7.86	7.88	8.00	8.22	8.64
16	9.02	8.50	8.12	7.96	7.90	7.82	7.88	7.92	8.02	8.24
17	9.94	7.74	7.66	7.64	7.60	7.58	7.62	7.68	7.76	7.92
18	8.76	8.28	8.02	7.86	7.80	7.82	7.88	8.02	8.32	8.90
19	8.74	8.44	8.32	8.30	8.24	8.28	8.32	8.52	8.90	9.42
20	9.12	8.62	8.26	8.12	8.06	8.04	8.12	8.26	8.52	9.20
21	8.68	8.18	7.96	7.82	7.80	7.82	7.90	8.04	8.24	8.70
22	9.36	8.66	8.24	8.08	8.04	8.02	8.08	8.20	8.52	9.32
23	8.58	8.34	8.20	8.14	8.10	8.08	8.08	8.16	8.30	8.54
24	7.82	7.70	7.66	7.60	7.54	7.50	7.50	7.50	7.52	7.64
25	7.96	7.80	7.72	7.66	7.64	7.62	7.64	7.76	7.90	8.12

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects at the initial examination

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	7.84	7.64	7.54	7.64	7.68	7.77	7.80	7.84	7.94	8.32
2	7.80	7.56	7.42	7.54	7.54	7.58	7.56	7.68	7.78	8.08
3	9.58	8.50	8.16	8.12	8.00	8.02	8.04	8.10	8.28	8.64
4	8.38	8.14	8.00	8.02	7.96	8.00	8.06	8.30	8.60	8.94
5	7.44	7.26	7.22	7.22	7.26	7.32	7.44	7.56	7.82	8.08
6	7.98	7.80	7.68	7.50	7.46	7.44	7.52	7.58	7.80	8.20
7	8.94	8.14	7.90	7.78	7.74	7.84	7.86	8.02	8.24	8.78
8	8.50	8.20	7.88	7.76	7.70	7.76	7.76	7.86	7.84	8.28
9	8.34	7.86	7.74	7.70	7.72	7.74	7.74	7.84	7.98	8.28
10	8.30	7.74	7.74	7.70	7.58	7.64	7.66	7.76	7.94	8.30
11	7.58	7.52	7.38	7.36	7.38	7.42	7.54	7.66	7.86	8.18
12	8.26	8.04	7.96	7.80	7.80	7.80	7.94	8.14	8.52	8.74
13	8.96	8.34	8.14	8.10	8.14	8.10	8.10	8.20	8.36	8.72
14	7.60	7.46	7.40	7.48	7.40	7.40	7.44	7.48	7.70	8.16
15	8.42	7.86	7.80	7.74	7.76	7.78	7.84	7.92	7.88	8.20
16	7.84	7.64	7.54	7.54	7.50	7.64	7.72	8.00	8.32	8.74
17	8.12	7.84	7.38	7.36	7.38	7.34	7.34	7.46	7.54	8.10
18	8.39	8.02	7.82	7.50	7.54	7.54	7.62	7.92	8.36	8.94
19	8.62	8.20	8.22	8.08	8.04	8.04	8.08	8.26	8.60	8.96
20	8.10	7.86	7.76	7.70	7.62	7.72	7.84	8.02	8.46	8.98
21	9.32	8.28	7.76	7.58	7.60	7.60	7.64	7.66	8.22	8.64
22	9.16	8.32	7.94	7.86	7.86	7.88	8.02	8.24	8.68	9.16
23	8.16	7.94	7.86	7.80	7.84	7.90	8.02	8.26	8.62	9.04
24	7.66	7.44	7.40	7.40	7.48	7.48	7.54	7.60	7.70	7.98
25	7.84	7.64	7.46	7.44	7.48	7.52	7.58	7.66	7.88	8.38

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects after four weeks of wear

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.18	8.00	7.82	7.70	7.60	7.62	7.84	7.92	7.96	8.30
2	8.32*	7.96*	7.78*	7.72*	7.68*	7.70*	7.70*	7.76*	7.96*	8.34*
3	9.26	8.48	8.32	8.16	8.02	8.08	8.10	8.24	8.44	8.94
4	8.50	8.24	8.06	7.84	7.70	7.74	7.84	8.12	8.40	9.00
5	7.86	7.70	7.60	7.54	7.60	7.64	7.76	7.86	8.00	8.24
6	8.42	8.02	7.66	7.54	7.46	7.40	7.46	7.80	8.22	8.56
7	8.96	8.42	7.96	7.96	7.92	7.90	7.98	7.96	8.60	9.20
8	8.28	7.98	7.84	7.80	7.76	7.80	7.96	8.12	8.46	9.16
9	8.32	8.22	7.98	7.96	7.94	7.86	7.88	7.98	8.32	8.80
10	8.72	8.10	7.90	7.70	7.64	7.62	7.74	7.78	7.96	8.48
11	8.20	7.94	7.82	7.56	7.46	7.50	7.64	7.80	7.90	8.06
12	8.78	8.24	8.10	7.98	7.88	7.86	8.02	8.16	8.50	9.42
13	9.00	8.42	8.30	8.20	8.00	7.96	8.06	8.18	8.38	8.72
14	8.20	8.00	7.72	7.68	7.64	7.60	7.64	7.66	7.88	8.30
15	8.66	8.40	8.06	7.84	7.78	7.80	7.92	8.04	8.26	8.64
16	9.14*	8.56*	8.20*	7.94*	7.70*	7.64*	7.72*	7.90*	8.10*	8.34*
17	7.82	7.76	7.70	7.64	7.40	7.40	7.52	7.64	7.76	7.90
18	9.28*	8.42*	8.08*	7.76*	7.70*	7.62*	7.72*	8.10*	8.66*	8.88*
19	8.84	8.46	8.40	8.26	8.10	8.12	8.30	8.50	8.82	9.58
20	9.04	8.58	8.32	8.08	7.90	7.88	7.92	8.14	8.50	9.00
21	9.18	8.20	7.80	7.70	7.70	7.66	7.68	7.88	8.48	9.20
22	9.10	8.70	8.44	8.06	8.00	8.00	8.02	8.24	8.54	9.56
23	8.68	8.46	8.22	8.04	8.02	8.02	8.08	8.24	8.34	8.64
24	7.78*	7.68*	7.60*	7.52*	7.50*	7.46*	7.50*	7.64*	7.70*	7.82*
25	7.96	7.86	7.66	7.60	7.52	7.48	7.54	7.78	7.98	8.32

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects after four weeks of wear

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	7.78	7.58	7.58	7.54	7.58	7.64	7.74	7.90	7.94	8.20
2	7.68*	7.52*	7.42*	7.46*	7.50*	7.54*	7.66*	7.66*	7.86*	8.10*
3	9.26	8.40	8.12	7.98	7.84	8.08	8.22	8.26	8.32	8.74
4	8.36	8.26	8.98	7.82	7.76	7.90	8.10	8.40	8.66	9.22
5	7.48	7.22	7.18	7.16	7.20	7.32	7.50	7.64	7.72	7.98
6	8.16	7.74	7.40	7.22	7.26	7.58	7.74	7.68	7.92	8.26
7	8.82	8.16	7.20	7.62	7.60	7.66	7.82	8.10	8.60	9.60
8	8.42	7.98	7.74	7.66	7.68	7.70	7.82	7.84	8.02	8.20
9	8.36	7.84	7.70	7.62	7.62	7.66	7.72	7.86	8.06	8.36
10	8.32	7.70	7.70	7.62	7.48	7.52	7.62	7.64	7.96	8.20
11	7.84	7.52	7.26	7.22	7.26	7.28	7.44	7.66	7.92	8.32
12	8.10	8.08	7.70	7.86	7.80	8.00	7.94	7.94	8.26	8.56
13	8.44	8.24	8.12	8.00	7.90	7.90	8.10	8.30	8.42	9.08
14	7.94	7.58	7.38	7.36	7.36	7.36	7.46	7.56	7.78	8.34
15	8.26	7.74	7.70	7.74	7.64	7.86	7.88	7.96	8.08	8.24
16	8.00*	7.76*	7.42*	7.36*	7.26*	7.44*	7.78*	7.96*	8.30*	8.90*
17	7.52	7.44	7.36	7.36	7.36	7.42	7.42	7.54	7.48	7.84
18	8.64*	8.06*	7.70*	7.54*	7.54*	7.54*	7.80*	8.02*	8.30*	9.02*
19	8.64	8.24	8.12	7.88	8.00	8.08	8.10	8.10	8.40	8.64
20	8.18	7.80	7.58	7.58	7.56	7.64	7.80	8.04	8.40	8.96
21	9.04	8.14	7.48	7.40	7.32	7.28	7.50	7.68	8.20	8.94
22	9.04	8.30	7.86	7.84	7.82	7.90	8.06	8.30	8.40	8.70
23	8.44	7.96	7.82	7.86	7.78	7.78	7.88	8.26	8.46	8.90
24	7.30*	7.22*	7.24*	7.46*	7.50*	7.58*	7.68*	7.66*	7.88*	8.10*
25	8.04	7.54	7.32	7.28	7.36	7.52	7.66	7.78	7.90	8.36

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects after twelve weeks of wear

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.26	8.06	8.00	7.72	7.60	7.52	7.54	7.86	8.06	8.28
2	8.04	7.90	7.84	7.74	7.64	7.56	7.56	7.66	7.94	8.18
3	8.78	8.42	8.24	8.12	8.10	8.10	8.10	8.32	8.48	8.92
4	8.60*	8.32*	8.20*	8.20*	8.02*	8.04*	8.10*	8.18*	8.36*	8.60*
5	7.90	7.76	7.68	7.60	7.58	7.62	7.78	7.94	8.06	8.32
6	8.42	7.98	7.78	7.58	7.56	7.52	7.52	7.84	8.18	8.48
7	8.90	8.24	8.02	8.02	8.02	8.02	7.96	8.00	8.24	9.00
8	9.66	8.44	7.86	7.76	7.78	7.80	7.92	8.08	8.64	9.10
9	8.70	7.96	7.82	7.74	7.64	7.72	7.84	8.06	8.36	9.06
10	8.36*	8.04*	7.86*	7.70*	7.56*	7.56*	7.78*	7.92*	8.00*	8.40*
11	8.06	7.98	7.86	7.88	7.72	7.70	7.72	7.76	7.82	8.02
12	8.68	8.42	8.16	7.98	7.94	7.94	8.06	8.22	8.44	9.28
13	9.24*	8.54*	8.30*	8.08*	8.06*	8.14*	8.14*	8.56*	9.54*	9.86*
14	8.12	7.92	7.72	7.70	7.62	7.66	7.64	7.70	7.88	8.24
15	8.32	8.22	8.10	7.86	7.82	7.86	7.96	8.10	8.24	8.54
16	8.90	8.40	8.06	7.84	7.66	7.70	7.80	7.94	8.08	8.40
17	7.86	7.76	7.66	7.58	7.38	7.36	7.46	7.60	7.76	8.20
18	9.16	8.60	8.48	8.30	8.20	8.14	8.30	8.64	8.84	9.40
19	9.02	8.50	8.38	8.28	8.08	8.20	8.42	8.68	8.94	9.78
20	9.08	8.54	8.30	8.04	7.94	7.92	7.96	8.16	8.60	9.26
21	9.16	8.48	7.92	7.78	7.72	7.70	7.72	7.86	8.52	9.08
22	9.28	8.68	8.44	8.08	8.04	8.04	8.14	8.40	8.58	9.60
23	8.68	8.50	8.26	8.02	8.00	8.00	8.06	8.30	8.42	8.68
24	7.98	7.72	7.62	7.52	7.50	7.48	7.58	7.62	7.70	7.90
25	8.12	7.98	7.78	7.64	7.54	7.56	7.64	7.74	8.04	8.40

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects after twelve weeks of wear

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	7.82	7.62	7.52	7.48	7.50	7.76	7.84	7.80	8.02	8.02
2	7.92	7.52	7.44	7.52	7.58	7.56	7.72	7.60	7.72	8.08
3	8.84	8.34	8.10	8.10	8.00	8.02	8.04	8.02	8.02	8.56
4	8.64*	8.54*	8.18*	8.12*	7.92*	8.16*	8.16*	8.26*	8.54*	9.22*
5	7.82	7.24	7.20	7.20	7.18	7.30	7.54	7.64	7.78	7.96
6	8.20	7.90	7.48	7.34	7.32	7.64	7.64	7.62	7.82	8.08
7	8.88	8.06	7.82	7.82	7.74	7.70	7.88	8.00	8.22	8.94
8	8.54	8.12	7.92	7.84	7.72	7.72	7.76	7.84	8.16	9.44
9	8.32	7.98	7.66	7.64	7.54	7.70	7.88	7.90	8.00	8.28
10	8.24*	7.78*	7.62*	7.56*	7.42*	7.58*	7.74*	7.86*	7.98*	8.14*
11	7.90	7.74	7.52	7.52	7.48	7.60	7.60	7.50	7.62	8.08
12	8.42	8.18	8.04	7.96	7.82	8.04	8.08	7.92	8.26	8.38
13	8.66*	8.24*	8.10*	8.10*	7.94*	8.10*	8.14*	8.32*	8.44*	8.94*
14	7.82	7.58	7.40	7.40	7.38	7.42	7.44	7.60	7.70	8.28
15	8.06	7.80	7.68	7.70	7.74	8.00	8.06	7.84	7.98	8.26
16	7.80	7.50	7.32	7.32	7.32	7.54	7.86	7.94	8.34	9.08
17	7.46	7.34	7.32	7.34	7.36	7.40	7.56	7.56	7.62	7.92
18	8.68	8.32	8.20	8.06	8.14	8.14	8.02	8.06	8.40	8.80
19	8.62	8.20	8.10	7.82	8.02	8.10	8.16	8.20	8.42	8.64
20	8.22	7.84	7.60	7.60	7.58	7.68	7.80	7.98	8.22	9.04
21	9.00	8.28	7.62	7.40	7.30	7.26	7.48	7.70	8.26	8.92
22	9.04	8.26	8.00	7.88	7.92	7.90	8.14	8.26	8.44	8.84
23	7.98	7.80	7.80	7.76	7.74	7.82	8.26	8.26	8.46	8.92
24	7.32	7.40	7.40	7.50	7.58	7.70	7.68	7.70	7.98	8.32
25	8.08	7.60	7.50	7.44	7.46	7.60	7.62	7.76	7.88	8.24

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects after twenty weeks of wear

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	8.36	8.04	8.02	7.70	7.60	7.50	7.50	7.68	8.10	8.30
2	8.12	7.96	7.86	7.70	7.62	7.50	7.48	7.58	7.88	8.16
3	8.88	8.44	8.24	8.14	8.12	8.12	8.08	8.30	8.46	8.86
4	8.56	8.22	8.12	8.06	7.94	7.98	8.26	8.26	8.30	8.98
5	7.84	7.80	7.58	7.52	7.42	7.62	8.04	7.86	8.04	8.40
6	8.36*	7.92*	7.80*	7.52*	7.44*	7.42*	7.44*	7.78*	8.00*	8.36*
7	8.82	8.52	8.02	7.90	7.90	7.88	7.86	8.00	8.88	8.68
8	9.16	8.30	7.78	7.82	7.78	7.84	7.94	8.02	8.50	9.70
9	8.28	8.00	7.84	7.72	7.70	7.76	7.86	8.04	8.30	8.50
10	8.20	7.92	7.82	7.76	7.68	7.68	7.76	7.80	7.92	8.30
11	8.02	7.98	7.92	7.88	7.70	7.70	7.74	7.80	7.88	7.94
12	8.68	8.28	8.12	8.02	7.94	7.92	8.18	8.26	8.38	9.00
13	9.20	9.68	8.32	8.10	8.00	8.06	8.12	8.60	9.60	10.00
14	8.16	7.90	7.70	7.90	7.64	7.60	7.60	7.70	7.98	8.18
15	8.48	8.30	8.06	7.90	8.00	7.88	8.10	8.12	8.18	8.44
16	8.80	8.44	8.04	7.82	7.72	7.72	7.76	8.02	8.16	8.32
17	7.92	7.80	7.68	7.60	7.50	7.46	7.48	7.58	7.80	8.24
18	9.14	8.62	8.44	8.26	8.10	8.18	8.26	8.44	8.92	9.54
19	9.22	8.62	8.32	8.28	8.16	8.10	8.28	8.70	8.88	9.32
20	8.78	8.48	8.22	8.10	8.00	8.00	8.00	8.16	8.46	9.00
21	9.28	8.56	7.98	7.70	7.64	7.60	7.76	7.90	8.62	9.24
22	9.10	8.64	8.12	8.08	8.00	8.06	8.08	8.24	8.72	9.22
23	8.72	8.42	8.18	7.98	7.98	7.98	8.10	8.36	8.58	8.82
24	8.00	7.92	7.66	7.52	7.48	7.46	7.56	7.66	7.72	7.98
25	8.10	7.92	7.78	7.64	7.58	7.62	7.64	7.70	7.84	8.16

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Corneal lens wearing subjects after twenty weeks of wear

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	7.86	7.58	7.52	7.42	7.46	7.68	7.86	7.96	8.40	8.60
2	7.92	7.54	7.46	7.58	7.68	7.72	7.80	7.68	7.82	8.20
3	8.90	8.18	8.08	8.04	8.06	8.02	8.04	8.14	8.30	8.70
4	8.56	8.40	8.32	8.20	8.04	8.00	8.04	8.04	8.40	8.90
5	7.50	7.48	7.28	7.24	7.24	7.28	7.38	7.56	7.54	7.80
6	8.10*	7.60*	7.28*	7.20*	7.28*	7.60*	7.66*	7.70*	7.80*	8.04*
7	8.12	7.78	7.66	7.62	7.62	7.84	8.00	8.18	8.18	8.98
8	8.70	7.96	7.76	7.78	7.74	7.74	7.80	8.02	8.34	8.72
9	8.18	7.80	7.66	7.66	7.58	7.74	7.84	7.92	8.06	8.14
10	8.10	7.78	7.66	7.66	7.60	7.60	7.68	7.74	8.06	8.32
11	7.80	7.66	7.56	7.56	7.50	7.64	7.66	7.58	7.52	7.84
12	8.16	8.10	8.00	7.90	7.80	8.00	8.04	8.04	8.40	8.66
13	8.68	8.36	8.16	8.02	7.94	8.02	8.20	8.30	8.48	9.00
14	7.80	7.54	7.44	7.40	7.40	7.42	7.54	7.54	7.74	8.20
15	8.24	7.96	7.66	7.62	7.78	8.10	8.12	7.90	7.80	7.94
16	8.02	7.44	7.46	7.42	7.32	7.42	7.56	7.88	8.32	9.00
17	7.58	7.40	7.28	7.22	7.32	7.60	7.62	7.70	7.82	7.98
18	8.24	8.22	8.04	8.12	8.06	8.10	8.12	8.30	8.64	9.42
19	8.00	8.00	7.90	8.06	8.18	8.32	8.38	8.58	8.60	8.82
20	8.24	7.80	7.68	7.64	7.64	7.70	7.82	8.06	8.24	8.74
21	8.42	7.68	7.32	7.28	7.22	7.46	7.66	7.70	8.16	8.82
22	8.80	8.16	7.86	7.76	7.84	7.88	8.10	8.16	8.46	8.94
23	8.02	7.82	7.68	7.70	7.68	7.72	8.22	8.28	8.50	9.10
24	7.48	7.40	7.38	7.46	7.50	7.62	7.74	7.82	8.02	8.48
25	8.10	7.58	7.46	7.50	7.56	7.60	7.66	7.76	7.90	8.66

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects: initial examination

Horizontal

	20	15	10	5	0	5	10	15	20	25
1	8.80	8.18	7.94	7.90	7.82	7.90	8.00	8.20	8.66	9.20
2	8.88	8.42	8.20	8.04	7.94	7.94	7.94	8.02	8.26	8.66
3	7.84	7.56	7.52	7.46	7.40	7.40	7.42	7.56	7.72	8.06
4	8.02	7.76	7.64	7.64	7.62	7.62	7.62	7.66	7.88	8.12
5	8.16	8.08	8.00	7.94	7.86	7.94	7.98	8.12	8.28	8.60
6	8.94	8.42	8.00	7.88	7.82	7.80	7.88	8.00	8.26	8.58
7	8.32	8.04	7.92	7.86	7.84	7.86	7.92	8.02	8.20	8.70
8	8.56	8.38	8.30	8.20	8.14	8.24	8.34	8.50	8.76	9.30
9	8.54	8.20	8.16	8.08	8.04	8.10	8.24	8.42	8.70	9.22
10	8.24	7.98	7.90	7.88	7.90	7.88	7.96	8.10	8.38	8.86
11	9.06	8.24	8.16	8.06	8.06	8.10	8.12	8.28	8.46	9.22
12	8.50	8.22	8.02	7.96	7.86	7.90	7.94	8.04	8.24	8.60
13	8.46	8.20	7.98	7.88	7.84	7.86	7.86	7.90	8.00	8.22
14	8.44	8.06	7.90	7.80	7.80	7.86	7.94	8.20	8.84	8.32
15	8.02	7.74	7.64	7.62	7.58	7.58	7.62	7.68	7.80	8.26
16	8.16	8.00	7.80	7.74	7.74	7.72	7.78	7.86	7.94	8.26
17	8.12	7.82	7.74	7.70	7.64	7.66	7.72	7.76	7.92	8.26
18	8.90	8.42	8.20	8.10	8.08	8.08	8.12	8.20	8.42	8.90
19	8.12	7.84	7.68	7.16	7.56	7.58	7.58	7.62	7.68	7.76
20	8.48	8.16	7.98	7.92	7.82	7.82	7.80	7.88	7.98	8.14
21	8.64	8.24	8.08	7.86	7.88	7.92	8.02	8.18	8.42	8.96
22	8.34	7.84	7.60	7.46	7.46	7.44	7.46	7.50	7.72	7.98
23	8.32	8.06	7.92	7.84	7.80	7.80	7.82	7.86	8.00	8.24
24	8.70	8.38	8.14	8.06	7.98	8.00	8.00	8.10	8.24	8.52
25	8.28	7.96	7.78	7.70	7.64	7.60	7.64	7.72	7.98	8.44

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects: initial examination

Vertical

	20	15	10	5	0	5	10	15	20	25
1	9.14	8.34	7.86	7.74	7.72	7.74	7.80	7.98	8.34	9.20
2	8.10	7.82	7.76	7.76	7.80	7.82	7.88	8.00	8.16	8.50
3	7.80	7.38	7.40	7.30	7.30	7.28	7.40	7.38	7.62	7.92
4	7.54	7.40	7.46	7.48	7.52	7.56	7.58	7.58	7.66	8.04
5	8.16	7.96	7.80	7.76	7.76	7.80	7.86	7.96	8.10	8.36
6	8.44	7.92	7.70	7.66	7.66	7.66	7.74	8.02	8.68	9.40
7	8.12	7.84	7.74	7.74	7.68	7.70	7.74	7.98	8.26	8.76
8	9.28	8.90	8.28	8.10	8.00	8.00	8.04	8.16	8.46	8.84
9	8.54	8.20	8.02	8.02	7.98	8.00	8.02	8.02	8.10	8.38
10	8.24	7.90	7.78	7.76	7.72	7.76	7.76	7.90	8.10	8.56
11	8.54	7.98	7.84	7.88	7.90	7.98	8.02	8.16	8.44	9.40
12	8.32	8.10	7.88	7.80	7.78	7.76	7.76	7.90	8.10	8.66
13	8.10	7.98	7.92	7.90	7.86	7.86	7.86	7.92	8.02	8.22
14	8.18	8.02	7.90	7.80	7.74	7.80	7.84	7.94	8.24	8.90
15	8.02	7.66	7.52	7.40	7.40	7.52	7.54	7.60	7.74	8.20
16	7.98	7.72	7.72	7.32	7.66	7.68	7.26	7.92	8.26	8.88
17	8.06	7.82	7.64	7.62	7.68	7.66	7.74	7.82	8.00	8.24
18	8.76	8.20	8.08	8.02	7.94	8.00	8.02	8.02	8.24	8.24
19	8.22	7.90	7.68	7.64	7.68	7.62	7.58	7.54	7.58	7.74
20	8.02	7.88	7.88	7.72	7.70	7.72	7.78	7.90	8.14	8.50
21	8.56	7.94	7.76	7.74	7.68	7.68	7.70	7.78	8.04	8.50
22	8.18	7.88	7.50	7.56	7.54	7.60	7.64	7.94	8.36	8.74
23	8.02	7.76	7.72	7.70	7.70	7.70	7.78	7.78	7.68	7.80
24	8.06	7.82	7.80	7.80	7.74	7.84	7.90	7.96	8.16	8.46
25	8.34	7.94	7.70	7.56	7.56	7.62	7.76	7.96	8.64	9.16

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects after four weeks of wear

Horizontal

	20	15	10	5	0	5	10	15	20	25
1	8.76	8.24	7.90	7.82	7.80	7.84	7.94	8.20	8.80	9.22
2	8.74*	8.34*	8.12*	8.00*	7.90*	7.88*	7.98*	8.04*	8.30*	8.58*
3	7.84	7.56	7.50	7.40	7.42	7.42	7.42	7.58	7.72	8.06
4	8.00	7.68	7.60	7.56	7.56	7.54	7.60	7.68	7.90	8.30
5	8.32	8.16	8.00	7.94	7.94	7.86	7.96	8.00	8.30	8.90
6	9.04	8.42	8.02	7.82	7.80	7.78	7.82	8.00	8.24	8.66
7	8.20	8.06	7.90	7.82	7.82	7.82	7.88	8.02	8.16	8.66
8	8.86	8.52	8.32	8.28	8.22	8.26	8.32	8.40	8.72	9.22
9	8.60	8.28	8.18	8.10	8.08	8.14	8.22	8.48	8.74	9.08
10	8.10	7.96	7.92	7.90	7.88	7.88	7.96	8.08	8.30	8.74
11	9.06	8.28	8.10	8.02	8.02	8.06	8.14	8.24	8.48	9.22
12	8.46	8.12	7.98	7.9a	7.90	7.94	7.98	8.10	8.24	8.58
13	8.44	8.20	8.02	7.92	7.88	7.86	7.84	7.84	8.02	8.48
14	8.54	8.04	7.90	7.80	7.78	7.88	7.94	8.18	8.70	8.32
15	7.86	7.70	7.62	7.60	7.58	7.58	7.58	7.62	7.76	8.28
16	8.16	7.94	7.82	7.74	7.70	7.70	7.72	7.80	7.90	8.52
17	8.10	7.86	7.72	7.70	7.64	7.64	7.64	7.76	7.96	8.22
18	9.06	8.14	8.16	8.10	8.06	8.08	8.08	8.18	8.38	8.86
19	8.06*	7.84*	7.74*	7.66*	7.66*	7.66*	7.60*	7.60*	7.62*	7.86*
20	8.62	8.32	8.06	7.90	7.80	7.80	7.84	7.90	7.98	8.12
21	8.52	8.34	8.06	7.98	7.98	7.98	7.98	8.14	8.34	9.06
22	8.60	7.88	7.56	7.48	7.44	7.42	7.46	7.52	7.74	8.00
23	8.42	8.00	7.86	7.78	7.76	7.78	7.76	7.82	7.96	8.24
24	8.64	8.26	8.18	8.08	8.00	8.00	8.02	8.06	8.20	8.42
25	8.40	7.98	7.84	7.74	7.70	7.70	7.72	7.80	7.94	8.40

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects after four weeks of wear

Vertical

	20	15	10	5	0	5	10	15	20	25
1	9.06	8.30	7.84	7.76	7.74	7.74	7.82	7.86	8.38	9.06
2	8.30*	7.92*	7.70*	7.70*	7.64*	7.70*	7.82*	7.97*	8.24*	8.48*
3	7.80	7.38	7.40	7.30	7.30	7.28	7.38	7.40	7.62	7.92
4	7.94	7.54	7.38	7.40	7.44	7.48	7.58	7.62	7.72	7.92
5	8.04	7.94	7.80	7.74	7.74	7.80	7.86	7.94	8.20	8.28
6	8.32	7.78	7.56	7.56	7.58	7.66	7.96	7.96	8.60	9.46
7	8.16	7.92	7.70	7.76	7.68	7.74	7.78	7.98	8.26	8.98
8	9.84	8.92	8.44	8.14	8.10	8.02	8.06	8.16	8.44	8.90
9	8.54	8.20	8.04	7.94	7.94	8.00	8.04	8.04	8.06	8.16
10	8.30	7.88	7.78	7.74	7.72	7.72	7.80	7.84	7.96	8.60
11	8.32	7.92	7.70	7.76	7.84	7.96	8.02	8.20	8.70	9.36
12	8.32	8.04	7.86	7.82	7.80	7.80	7.80	7.86	8.12	8.64
13	8.04	7.94	7.88	7.88	7.92	7.90	7.88	7.80	8.26	8.52
14	8.36	8.00	7.82	7.80	7.80	7.80	7.82	8.00	8.44	8.90
15	7.56	7.50	7.40	7.40	7.44	7.50	7.56	7.48	7.54	8.06
16	7.92	7.58	7.54	7.66	7.68	7.72	7.80	7.86	8.10	8.84
17	8.00	7.66	7.64	7.64	7.62	7.64	7.66	7.72	7.92	8.20
18	8.30	8.16	8.10	8.06	8.04	8.04	8.02	8.04	8.28	8.66
19	8.22*	7.66*	7.62*	7.58*	7.72*	7.66*	7.56*	7.54*	7.56*	7.98*
20	8.18	8.06	7.86	7.76	7.78	7.78	7.78	7.84	8.08	8.30
21	8.58	8.02	7.74	7.64	7.62	7.74	7.76	7.84	8.00	8.36
22	8.18	7.86	7.58	7.56	7.52	7.62	7.62	7.92	8.40	8.16
23	7.86	7.68	7.70	7.70	7.72	7.72	7.72	7.68	7.86	8.00
24	8.24	7.94	7.76	7.74	7.78	7.80	7.90	7.96	8.10	8.64
25	8.04	7.96	7.66	7.56	7.58	7.64	7.82	8.06	8.10	9.20

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects after twelve weeks of wear

Horizontal

	20	15	10	5	0	5	10	15	20	25
1	8.74	8.22	7.90	7.80	7.82	7.84	7.96	8.12	8.64	9.18
2	8.80*	8.30*	8.12*	7.94*	7.94*	8.00*	8.00*	8.10*	8.24*	8.86*
3	7.86	7.60	7.46	7.40	7.36	7.36	7.38	7.46	7.66	8.18
4	7.96	7.70	7.56	7.50	7.46	7.54	7.58	7.66	7.96	8.16
5	8.26	8.06	7.94	7.88	7.90	7.84	7.92	8.02	8.34	8.68
6	9.12	8.54	8.02	7.88	7.74	7.76	7.80	7.90	8.22	8.84
7	8.30	8.10	7.90	7.86	7.84	7.84	7.88	8.04	8.38	8.68
8	8.86	8.50	8.30	8.30	8.14	8.26	8.34	8.56	8.76	9.22
9	8.60*	8.18*	8.08*	8.08*	8.08*	8.16*	8.24*	8.42*	8.84*	9.36*
10	8.32*	7.96*	7.94*	7.90*	7.90*	7.86*	7.92*	8.04*	8.40*	9.00*
11	9.10	8.26	8.16	8.10	8.08	8.08	8.08	8.20	8.56	8.60
12	8.48	8.18	8.02	7.86	7.90	7.90	7.96	8.08	8.20	8.72
13	8.50	8.14	8.00	7.90	7.80	7.80	7.80	7.82	7.94	8.40
14	8.52	8.20	7.96	7.88	7.88	7.88	7.88	7.88	7.98	8.32
15	7.90	7.78	7.66	7.60	7.60	7.60	7.60	7.66	7.84	8.18
16	8.22	7.98	7.82	7.74	7.76	7.76	7.76	7.80	7.90	8.34
17	8.10	7.90	7.76	7.74	7.62	7.62	7.72	7.74	7.86	8.32
18	8.94	7.80	7.76	7.72	7.60	7.72	7.78	7.94	8.30	9.20
19	8.10	7.78	7.72	7.72	7.64	7.64	7.66	7.76	7.90	8.24
20	8.42	8.12	7.94	7.86	7.82	7.78	7.80	7.88	8.00	8.00
21	8.64*	8.28*	8.08*	7.96*	8.00*	8.00*	8.00*	8.14*	8.40*	8.72*
22	8.40	7.82	7.56	7.40	7.30	7.34	7.42	7.60	7.76	8.10
23	8.46	8.04	7.90	7.82	7.66	7.76	7.78	7.86	8.02	8.24
24	8.52	8.22	8.12	8.04	8.02	8.00	7.98	7.98	8.08	8.68
25	8.50	8.04	7.80	7.70	7.62	7.64	7.68	7.72	7.94	8.30

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects after twelve weeks of wear

Vertical

	20	15	10	5	0	5	10	15	20	25
1	9.06	8.30	7.90	7.80	7.74	7.68	7.70	8.08	8.42	9.12
2	8.30	8.08	7.84	7.78	7.68	7.78	7.80	7.74	7.80	8.10
3	7.90	7.42	7.26	7.26	7.20	7.20	7.22	7.30	7.80	7.98
4	7.98	7.54	7.40	7.40	7.60	7.38	7.40	7.46	7.64	8.00
5	8.04	7.90	7.80	7.68	7.72	7.78	7.78	7.88	8.02	8.20
6	8.42	7.84	7.56	7.54	7.52	7.60	7.76	8.00	8.54	9.14
7	8.12	7.96	7.70	7.72	7.64	7.64	7.80	7.92	8.20	8.94
8	9.84	8.92	8.44	8.14	8.10	8.02	8.08	8.16	8.44	8.98
9	8.68*	8.32*	8.24*	8.00*	7.94*	8.02*	8.00*	7.98*	8.04*	8.18*
10	8.30*	7.98*	7.80*	7.78*	7.76*	7.76*	7.76*	7.86*	8.06*	8.48*
11	8.50	7.92	7.90	7.86	7.84	7.90	8.10	8.22	8.56	9.40
12	8.38	8.00	7.94	7.80	7.70	7.76	7.76	7.86	8.20	8.62
13	8.36	7.94	7.84	7.84	7.86	7.88	7.88	7.84	8.16	8.46
14	8.18	7.92	7.92	7.92	7.88	7.88	7.88	7.88	8.10	8.42
15	7.90	7.54	7.40	7.46	7.50	7.52	7.54	7.54	7.54	7.98
16	7.90	7.80	7.70	7.70	7.66	7.66	7.70	7.96	8.30	8.78
17	8.10	7.88	7.64	7.60	7.60	7.62	7.76	7.82	8.18	8.36
18	8.00	7.74	7.68	7.62	7.62	7.64	7.70	7.80	8.16	8.96
19	7.94	7.74	7.62	7.60	7.62	7.62	7.62	7.62	7.92	8.18
20	8.14	8.06	7.86	7.68	7.70	7.70	7.70	7.72	7.94	8.42
21	8.44*	8.00*	7.78*	7.72*	7.68*	7.70*	7.70*	7.78*	8.00*	8.40*
22	8.04	7.72	7.48	7.32	7.40	7.42	7.62	7.90	8.22	8.60
23	7.98	7.74	7.70	7.70	7.70	7.72	7.72	7.68	7.74	8.10
24	8.36	7.92	7.72	7.72	7.76	7.80	7.84	7.84	8.12	8.80
25	8.08	7.86	7.70	7.60	7.60	7.64	7.72	7.94	8.54	9.10

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects after twenty weeks of wear

Horizontal

	20	15	10	5	0	5	10	15	20	25
1	8.20	7.94	7.84	7.84	7.84	7.88	7.98	8.20	8.48	9.26
2	8.62	8.42	8.20	8.06	7.94	7.96	7.96	8.08	8.26	8.42
3	7.70	7.50	7.34	7.32	7.30	7.34	7.38	7.46	7.70	8.12
4	7.94	7.70	7.64	7.66	7.66	7.64	7.66	7.70	7.84	8.20
5	8.22	8.06	7.86	7.86	7.90	7.92	7.96	8.06	8.32	8.80
6	8.80	8.32	7.94	7.78	7.76	7.80	7.86	7.96	8.30	8.76
7	8.42	8.14	7.94	7.86	7.84	7.84	7.90	8.00	8.20	8.80
8	8.66	8.44	8.30	8.26	8.20	8.24	8.36	8.50	8.76	9.18
9	8.44	8.18	8.08	8.06	8.08	8.10	8.26	8.44	8.70	9.30
10	8.20	7.92	7.88	7.82	7.86	7.86	7.94	8.02	8.52	8.78
11	8.74	8.22	8.06	7.94	7.80	7.84	7.92	7.96	8.18	8.50
12	8.54	8.12	8.00	7.94	7.92	7.94	8.00	8.12	8.30	8.66
13	8.74*	8.16*	8.00*	7.90*	7.86*	7.88*	7.88*	7.90*	8.02*	8.44*
14	8.56	8.04	7.84	7.82	7.78	7.82	7.90	8.18	8.76	8.98
15	7.98	7.76	7.64	7.64	7.60	7.60	7.62	7.70	7.82	8.04
16	8.50	7.94	7.82	7.74	7.74	7.74	7.74	7.84	7.94	8.40
17	8.06	7.76	7.72	7.66	7.60	7.62	7.64	7.74	7.88	8.12
18	8.74	8.34	8.20	8.10	8.02	8.06	8.12	8.24	8.42	9.14
19	8.06	7.84	7.72	7.62	7.60	7.60	7.60	7.62	7.66	7.82
20	8.56	8.20	7.92	7.92	7.86	7.84	7.82	7.84	7.94	8.20
21	8.70	8.32	8.06	8.00	7.94	8.00	8.04	8.20	8.42	8.88
22	8.36	7.86	7.56	7.44	7.44	7.44	7.48	7.54	7.72	7.94
23	8.52*	8.10*	7.90*	7.90*	7.86*	7.82*	7.82*	7.84*	7.98*	8.32*
24	8.72	8.40	8.20	8.04	7.96	7.98	7.98	8.08	8.28	8.50
25	8.48	8.08	7.84	7.72	7.66	7.68	7.66	7.74	7.86	8.30

Tabulated Results

Corneal topography

Radius of curvature in millimeters

Gel lens wearing subjects after twenty weeks of wear

Vertical

	20	15	10	5	0	5	10	15	20	25
1	8.84	8.28	7.98	7.84	7.72	7.70	7.70	7.92	8.46	9.16
2	8.04	7.96	7.82	7.82	7.86	7.86	7.82	7.68	7.90	8.34
3	7.96	7.50	7.30	7.26	7.24	7.24	7.20	7.30	7.50	8.00
4	7.78	7.36	7.30	7.40	7.54	7.62	7.70	7.66	7.82	8.36
5	8.10	7.86	7.80	7.74	7.22	7.78	7.80	7.84	8.02	8.14
6	8.18	7.96	7.76	7.60	7.46	7.50	7.72	8.02	8.78	9.38
7	8.12	7.88	7.68	7.70	7.68	7.70	7.80	7.94	8.28	8.88
8	9.30	8.72	8.20	8.10	8.12	8.08	8.14	8.24	8.54	9.04
9	8.42	8.26	8.10	8.10	8.02	8.00	7.84	7.74	7.96	8.22
10	8.28	7.78	7.80	7.78	7.70	7.72	7.72	7.88	8.18	8.76
11	8.70	8.22	8.08	8.02	8.00	8.00	8.06	8.12	8.30	8.92
12	8.48	8.02	7.94	7.80	7.78	7.76	7.78	7.82	8.06	8.72
13	8.34*	7.96*	7.94*	7.90*	7.84*	7.84*	7.84*	7.86*	8.04*	8.26*
14	8.24	8.00	7.92	7.82	7.72	7.82	7.82	7.92	8.36	8.50
15	7.92	7.56	7.48	7.44	7.44	7.52	7.56	7.56	7.84	8.10
16	7.90	7.80	7.70	7.68	7.68	7.68	7.70	7.86	8.16	9.00
17	7.96	7.66	7.60	7.58	7.52	7.60	7.66	7.72	7.90	8.08
18	8.30	8.20	8.10	8.02	8.04	8.06	8.08	8.10	8.16	8.90
19	8.26	7.76	7.64	7.62	7.56	7.60	7.60	7.48	7.58	7.84
20	8.04	7.82	7.80	7.70	7.68	7.68	7.76	7.98	8.18	8.38
21	8.40	7.96	7.82	7.74	7.68	7.72	7.72	7.80	8.00	8.60
22	7.94	7.80	7.56	7.44	7.54	7.62	7.68	7.88	8.44	9.10
23	8.18*	7.78*	7.74*	7.70*	7.70*	7.72*	7.76*	7.78*	7.70*	7.86*
24	8.04	7.68	7.74	7.78	7.76	7.82	7.90	7.94	8.28	8.90
25	8.20	8.06	7.60	7.58	7.50	7.64	7.80	8.02	8.34	9.32

Tabulated Results

The meridians of corneal topography

Meridians in degrees

Patient No.	Control								Corneal								Gel							
	Initial		4 weeks		12 weeks		20 weeks		Initial		4 weeks		12 weeks		20 weeks		Initial		4 weeks		12 weeks		20 weeks	
	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V
1	0	87	2	91	8	87	10	93	1	90	2	93	1	91	2	93	11	98	7	93	2	92	7	94
2	17	106	16	110	15	96	27	119	42	120	23*	117*	30	120	25	115	12	95	10*	95*	8	91	4	92
3	11	94	14	94	4	92	5	90	6	92	4	90	3	91	4	91	10	83	8	85	6	88	10	83
4	7	97	9	47	5	95	10	96	5	93	1	91	1*	91*	0	89	11	98	15	102	20	112	19	108
5	3	94	2	93	2	90	5	94	0	83	4	92	0	90	2	91	1	90	2	89	2	92	2	92
6	14	82	10	90	11	94	14	91	5	82	6	81	0	92	1*	90*	4	91	1	92	5	97	2	92
7	1	81	3	92	4	89	2	92	0	90	2	91	1	92	2	90	0	88	4	87	2	92	7	89
8	9	95	9	98	19	106	4	92	10	78	8	82	6	84	5	88	27	79	14	77	18	72	17	79
9	12	93	0*	88*	4	91	11	99	7	94	1	92	5	94	3	91	6	98	13	100	4*	95*	5	100
10	7	96	5	94	4	90	4	94	7	83	9	83	2*	92*	6	98	8	78	0	80	12*	76*	5	83
11	0	92	12	76	5	90	2	74	0	88	1	90	8	95	4	94	26	127	26	125	24	128	28	126
12	0	91	2	91	4	86	3	90	1	90	1	91	5	96	5	96	9	96	10	98	3	92	7	96
13	1	90	2	91	0	89	3	91	0	90	2	90	2*	85*	0	86	2	90	2	93	1	92	1*	92*
14	8	100	4	92	10	95	7*	96*	7	87	2	91	6	97	4	94	4	94	2	92	5	94	0	91
15	6	97	7	97	4	93	4	92	11	102	25	110	5	98	8	102	8	99	1	92	2	92	6	96
16	2	92	6	97	8	96	1*	91*	7	93	4*	93*	5	93	3	90	0	90	3	88	2	92	0	90
17	5	84	1	91	0	90	4	83	1	82	2	92	0	89	1	91	7	96	1	91	2	93	4	91
18	9	97	10	94	8	96	5	95	7	96	2*	93*	1	91	0	90	0	92	0	90	0	90	2	91
19	6	96	6	94	2	94	6	100	13	87	10	86	2	92	4	92	0	89	4*	92*	1	90	1	90
20	4	94	8	98	6	94	4*	93*	6	93	6	96	2	89	0	92	19	75	21	73	17	80	22	71
21	0	92	2	92	5	95	10	98	3	92	2	91	5	91	2	94	4	84	3	85	2*	90*	0	88
22	11	89	8	90	3	90	2	89	8	96	8	83	10	85	8	84	0	88	0	91	2	92	2	94
23	5	92	4	90	2	92	6	94	1	90	3	91	1	89	0	91	3	95	4	90	3	91	0*	89*
24	0	90	0	90	7	92	8	92	0	89	0*	91*	8	95	4	93	10	99	17	107	15	105	8	96
25	22	72	18	70	20	76	20	71	3	85	10	72	13	82	7	77	4	95	4	96	7	95	2	91

H = Axis lying closest to the horizontal meridian.

V = Axis lying closest to the vertical meridian.

12

12.2 The analysis of variance of the results of corneal topography

Analysis of variance (two way factorial)

Corneal topography

20° Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	215.32	217.90	216.20	214.56
Corneal	214.16	214.48	215.28	214.18
Gel	210.84	211.40	211.47	210.44

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.2496	0.0832	0.39
(b) Between lenses	2	2.1715	1.0857	5.20
(c) Interaction (a) x (b)	6	0.0577	0.0096	0.04
Residual	269	60.1073	0.2087	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

15^{o} Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	203.97	206.32	204.34	204.66
Corneal	203.10	205.26	206.02	206.00
Gel	202.16	202.12	201.72	201.76

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.1299	0.0433	0.56
(b) Between lenses	2	0.9779	0.4889	6.36
(c) Interaction (a) x (b)	6	0.2329	0.0388	0.50
Residual	269	22.1346	0.0769	

Value of F from tables

Between visits ($p = 0.1$) = 2.08
Between lenses ($p = 0.1$) = 2.30
Interaction ($p = 0.1$) = 1.77

Analysis of variance (two way factorial)

Corneal topography

10^{o} Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	198.70	200.94	199.42	199.34
Corneal	198.64	199.74	201.36	200.22
Gel	198.20	198.10	196.22	197.50

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.0822	0.0274	0.50
(b) Between lenses	2	0.5875	0.2937	5.46
(c) Interaction (a) x (b)	6	0.2782	0.0464	0.86
Residual	269	15.4688	0.0537	

Value of F from tables

Between visits (p = 0.1) = 2.08

Between lenses (p = 0.1) = 2.30

Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

5° Nasal aspect of horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	196.60	197.60	197.76	198.20
Corneal	196.84	195.78	196.76	196.62
Gel	195.74	196.04	195.58	195.90

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.0193	0.0064	0.11
(b) Between lenses	2	0.3200	0.1600	2.93
(c) Interaction (a) x (b)	6	0.0690	0.0115	0.21
Residual	269	15.7185	0.054	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

0^{o} in the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	195.08	196.24	196.36	196.58
Corneal	196.20	193.62	194.72	194.64
Gel	195.12	195.32	194.48	195.02

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.0716	0.0238	0.49
(b) Between lenses	2	0.3063	0.1531	3.18
(c) Interaction (a) x (b)	6	0.1335	0.0222	0.46
Residual	269	13.8808	0.0481	

Value of F from tables

Between visits ($p = 0.1$) = 2.08

Between lenses ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.77

Analysis of variance (two way factorial)

Corneal topography

5° Temporal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	196.46	196.60	196.74	196.96
Corneal	195.94	193.36	194.86	194.64
Gel	195.60	195.50	195.98	195.44

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.1081	0.0360	0.71
(b) Between lenses	2	0.3955	0.1977	3.89
(c) Interaction (a) x (b)	6	0.0389	0.0064	0.12
Residual	269	14.6134	0.0507	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

10° Temporal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	197.66	199.22	197.42	197.32
Corneal	196.92	195.30	198.32	198.88
Gel	196.72	196.40	195.92	196.48

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.0288	0.0096	0.17
(b) Between lenses	2	0.1988	0.0994	1.77
(c) Interaction (a) x (b)	6	0.3862	0.0644	1.15
Residual	269	16.1099	0.0559	

Value of F from tables

Between visits ($p = 0.1$) = 2.08
Between lenses ($p = 0.1$) = 2.30
Interaction ($p = 0.1$) = 1.77

Analysis of variance (two way factorial)

Corneal topography

15° Temporal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	200.48	201.94	199.68	199.66
Corneal	199.28	199.86	202.52	202.20
Gel	199.38	199.06	198.82	198.96

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.0313	0.0104	0.14
(b) Between lenses	2	0.3196	0.1597	2.25
(c) Interaction (a) x (b)	6	0.4322	0.0722	1.01
Residual	269	20.4191	0.0709	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

20° Temporal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	207.08	207.32	204.68	203.99
Corneal	205.00	206.24	209.08	209.68
Gel	204.74	204.40	204.12	204.26

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.0327	0.0109	0.09.
(b) Between lenses	2	0.7819	0.3909	3.54
(c) Interaction (a) x (b)	6	1.0855	0.1809	1.64.
Residual	269	31.7398	0.1102	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.1777

Analysis of variance (two way factorial)

Corneal topography

25° Temporal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	216.76	218.82	214.04	213.60
Corneal	216.50	216.54	221.80	220.60
Gel	213.40	214.00	215.04	213.86

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.2164	0.0721	0.32
(b) Between lenses	2	2.0514	1.0257	4.58
(c) Interaction (a) x (b).	6	1.4221	0.2370	1.05
Residual	269	64.4355	0.2237	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance

Corneal topography

20^{o} Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	209.76	210.50	207.00	204.50
Corneal	207.08	206.80	208.32	206.78
Gel	206.72	206.46	206.94	205.92

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	2.9474	0.9824	3.10
(b) Between lenses	2	0.2420	0.1210	0.44
(c) Interaction (a) x (b)	6	0.5767	0.0961	0.38
Residual	269	20.5444	0.2917	

Value of F from tables

Between visits ($p = 0.1$) = 2.08

Between lenses ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.77

Analysis of variance (two way factorial)

Corneal topography

15° Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	199.76	201.26	197.90	197.04
Corneal	197.22	196.26	199.24	197.56
Gel	198.26	197.68	197.94	197.94

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.6110	0.2036	1.94
(b) Between lenses	2	0.3310	0.1655	1.51
(c) Interaction (a) x (b)	6	0.4039	0.0673	0.61
Residual	269	31.4833	0.1093	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

10^{o} Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	194.96	195.64	194.18	193.36
Corneal	193.10	190.96	195.02	193.62
Gel	194.34	193.50	193.82	194.40

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.0652	0.0217	0.33
(b) Between lenses	2	0.2282	0.1141	1.75
(c) Interaction (a) x (b)	6	0.4141	0.0690	1.05
Residual	269	18.7937	0.0652	

Value of F from tables

Between visits ($p = 0.1$) = 2.08

Between lenses ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.77

Analysis of variance (two way factorial)

Corneal topography

5° Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	193.30	194.08	192.78	192.56
Corneal	191.72	190.00	193.90	193.02
Gel	193.18	192.60	192.24	196.16

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.4651	0.1550	1.47
(b) Between lenses	2	0.2389	0.1194	1.11
(c) Interaction (a) x (b)	6	0.6253	0.1042	0.97
Residual	269	30.8957	0.1072	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

0^{o} Vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	193.00	193.22	193.28	193.18
Corneal	191.46	188.98	190.70	191.04
Gel	192.70	192.74	192.02	192.00

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.1215	0.0405	0.71
(b) Between lenses	2	0.6628	0.3314	5.88
Interaction (a) x (b)	6	0.1430	0.0238	0.42
Residual	269	16.2168	0.0563	

Value of F from tables

Between visits ($p = 0.1$) = 2.08
Between lenses ($p = 0.1$) = 2.30
Interaction ($p = 0.1$) = 1.77

Analysis of variance (two way factorial)

Corneal topography

5° Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	193.64	195.00	193.96	193.88
Corneal	192.27	191.26	194.38	195.14
Gel	193.36	193.46	192.32	193.28

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.1297	0.0432	0.83
(b) Between lenses	2	0.1727	0.0864	1.67
(c) Interaction (a) x (b)	6	0.3381	0.0563	1.09
Residual	269	14.8577	0.0515	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

10^{o} Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	195.86	197.12	196.30	195.88
Corneal	193.72	194.94	196.82	197.66
Gel	194.00	194.62	193.56	194.16

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.2449	0.0816	1.56
(b) Between lenses	2	0.5832	0.2916	5.59
(c) Interaction (a) x (b)	6	0.2025	0.0337	0.64
Residual	269	15.0092	0.0521	

Value of F from tables

Between visits ($p = 0.1$) = 2.08

Between lenses ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.77

Analysis of variance (two way factorial)

Corneal topography

15^{o} Superior aspect of the vertical meridian

Cell totals (two way factorial)

Group	Week 0	Week 4	Week 12	Week 20
Control	198.96	200.50	199.26	198.94
Corneal	197.02	198.14	198.48	199.06
Gel	197.12	196.58	195.78	196.06

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.1523	0.0507	0.85
(b) Between lenses	2	0.9009	0.4504	7.63
(c) Interaction (a) x (b)	6	0.0435	0.0072	0.12
Residual	269	16.9997	0.0590	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

20^{o} Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	204.47	205.96	204.90	204.38
Corneal	202.92	203.68	204.60	203.72
Gel	203.12	203.42	202.66	202.78

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	0.1163	0.0387	0.42
(b) Between lenses	2	0.4675	0.2337	2.54
(c) Interaction (a) x (b)	6	0.0176	0.0029	0.03
Residual	269	26.5150	0.0920	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

25° Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	212.94	218.02	215.79	216.00
Corneal	212.82	215.48	218.10	215.62
Gel	214.10	214.18	213.63	214.76

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	1.2187	0.4062	2.19
(b) Between lenses	2	0.2203	0.1101	0.59
(c) Interaction (a) x (b)	6	0.6137	0.1022	0.55
Residual	269	53.3300	0.1851	

Value of F from tables

Between visits (p = 0.1) = 2.08
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

Horizontal meridian value

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	160.00	160.00	160.00	177.00
Corneal	155.00	138.00	122.00	136.00
Gel	186.00	172.00	165.00	161.00

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	189.5424	81.5296	1.93
(b) Between lenses	2	164.9704	82.4852	2.01
(c) Interaction (a) x (b)	6	40.5924	6.7654	0.17
Residual	269	11803.8400	40.9855	

Value of F from tables

Between visits (p = 0.1) = 2.08

Between lenses (p = 0.1) = 2.30

Interaction (p = 0.1) = 1.77

Analysis of variance (two way factorial)

Corneal topography

Vertical meridian value

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Week 20
Control	229.46	225.97	229.47	230.05
Corneal	230.47	226.74	230.85	230.80
Gel	230.74	230.39	232.06	230.10

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	3	95.9231	31.9743	0.41
(b) Between lenses	2	40.5646	20.2823	0.26
(c) Interaction (a) x (b)	6	39.2269	6.5378	0.08
Residual	269	22603.9200	78.4858	

Value of F from tables

Between visits ($p = 0.1$) = 2.08

Between lenses ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.77

Discussion

The results of the analysed values of corneal topography show a general pattern:-

Horizontal meridian

With the exception of the calculated value of F at 10^{o} on the temporal aspect, the calculated values of F exceed the value of F from tables, for a probability p of 0.1 for the between lenses term. However when the level of probability is raised to 0.01 and the value of F from tables becomes 4.61 only the calculated values at 20^{o}, 15^{o} and 10^{o} on the nasal aspect remain significantly different.

Vertical meridian

The value of F for a probability p of 0.1 is exceeded by only two calculated values in the vertical meridian, those at 20^{o} on the inferior aspect and 25^{o} on the superior aspect. Both of these values are in turn exceeded when the level of probability is raised to 0.01.

Meridian axis

The calculated values of F for both meridians of the analysed results of corneal topography are exceeded by the value of F from tables for a probability p of 0.1.

Conclusion

The significant differences in the horizontal meridian suggest the possibility of shape changes in the corneal surface. However, as with the values of the spectacle refraction (page 148) it is possible that both increases and decreases are occuring which are distorting the general picture; it was therefore decided to investigate the changes in value of the corneal topography.

12.3 Tabulated Results

Changes in corneal topography

Control subjects: Initial and four week examination

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.34	+0.12	+0.04	+0.02	0.00	+0.04	+0.02	+0.02	-0.02	0.00
2	+0.02	+0.02	+0.08	+0.08	0.00	-0.02	0.00	-0.02	-0.06	+0.04
3	-0.24	-0.02	-0.06	-0.02	-0.06	+0.04	+0.04	+0.02	-0.02	-0.04
4	+0.62	0.00	-0.02	-0.04	-0.02	-0.04	-0.04	-0.02	-0.02	+0.10
5	+0.06	+0.30	+0.10	+0.06	0.00	-0.02	+0.04	-0.06	-0.10	-0.14
6	-0.22	-0.02	-0.02	-0.02	0.00	-0.04	0.00	-0.02	0.00	+0.06
7	0.00	0.00	0.00	0.00	0.00	0.00	+0.02	+0.02	+0.08	+0.04
8	-0.20	-0.28	-0.08	-0.06	+0.02	+0.08	+0.08	+0.20	+0.06	+0.06
9	+0.08	+0.02	+0.04	+0.02	-0.02	0.00	-0.02	-0.08	-0.04	-0.26
10	0.00	+0.02	+0.02	+0.02	0.00	+0.02	+0.06	+0.02	+0.02	+0.06
11	-0.08	+0.02	+0.06	+0.04	0.00	0.00	+0.02	-0.02	+0.02	+0.02
12	-0.14	-0.06	-0.08	+0.02	0.00	0.00	+0.10	+0.12	-0.04	+0.06
13	+0.24	+0.02	+0.02	-0.02	-0.04	-0.06	-0.04	-0.04	-0.06	-0.04
14	+0.14	+0.08	-0.02	-0.02	-0.02	-0.02	-0.02	0.00	0.00	+0.08
15	0.00	+0.08	-0.02	+0.04	+0.04	+0.04	+0.02	+0.02	+0.04	0.00
16	0.00	+0.02	-0.04	+0.02	-0.06	-0.02	-0.06	-0.02	-0.08	-0.04
17	0.00	+0.02	-0.02	-0.02	-0.02	-0.04	-0.02	-0.04	-0.02	+0.04
18	+0.18	+0.10	-0.06	-0.08	-0.08	-0.08	-0.04	0.00	0.00	-0.22
19	+0.16	+0.06	+0.04	-0.10	0.00	-0.06	-0.06	-0.02	-0.02	-0.34
20	+0.08	-0.02	-0.16	0.00	-0.04	-0.06	-0.08	-0.02	+0.06	+0.26
21	+0.12	+0.18	+0.04	-0.02	-0.16	+0.02	0.00	0.00	+0.04	+0.18
22	+0.14	+0.18	0.00	0.00	+0.02	+0.04	0.00	0.00	0.00	+0.04
23	-0.08	-0.08	-0.04	-0.06	-0.02	-0.04	0.00	-0.10	-0.14	+0.46
24	-0.12	-0.08	0.00	-0.02	-0.06	0.00	+0.02	-0.06	-0.10	-0.26
25	-0.06	0.00	-0.02	+0.02	-0.18	+0.02	+0.02	+0.02	-0.02	+0.12

T = Temporal aspect of the cornea

N = Nasal aspect of the cornea.

The values of the changes of the radius of curvature are measured at 5 degree intervals along each meridian.

Tabulated Results

Changes in corneal topography

Control subjects: Initial and four week examination

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.20	-0.38	-0.04	0.00	+0.10	-0.02	+0.08	-0.06	-0.02	+0.12
2	-0.18	+0.02	+0.02	+0.04	+0.02	0.00	+0.06	-0.02	+0.06	+0.04
3	-0.20	-0.04	+0.02	0.00	0.00	0.00	+0.04	0.00	-0.04	0.00
4	+0.20	+0.10	-0.04	+0.04	-0.04	0.00	-0.04	-0.04	-0.16	+0.04
5	-0.20	-0.02	-0.06	+0.22	0.00	+0.14	+0.08	-0.04	+0.06	+0.70
6	+0.12	-0.06	+0.02	+0.02	-0.02	-0.02	+0.02	-0.06	+0.08	+0.06
7	-0.20	-0.04	-0.02	-0.02	-0.02	+0.02	-0.02	+0.06	-0.04	-0.16
8	+0.26	-0.04	+0.04	-0.02	-0.04	-0.10	-0.06	+0.02	+0.08	0.00
9	+0.20	-0.02	0.00	0.00	+0.04	+0.06	0.00	-0.04	+0.04	-0.20
10	-0.02	-0.04	-0.02	+0.04	+0.02	-0.06	-0.08	-0.02	+0.02	+0.22
11	-0.02	0.00	-0.06	+0.02	-0.04	+0.02	+0.12	+0.14	+0.12	+0.12
12	-0.22	+0.08	+0.04	+0.04	0.00	+0.04	+0.04	+0.08	+0.26	+0.10
13	+0.14	+0.02	+0.02	+0.06	+0.04	+0.02	+0.06	-0.02	-0.10	-0.06
14	-0.06	+0.04	+0.06	+0.04	+0.02	+0.02	+0.04	+0.02	-0.02	-0.10
15	-0.04	+0.02	-0.04	-0.06	-0.02	+0.02	+0.04	+0.02	+0.02	+0.10
16	+0.12	0.00	-0.06	-0.02	+0.02	-0.02	+0.04	+0.16	+0.10	+0.18
17	-0.82	-0.52	+0.02	+0.04	-0.18	+0.06	0.00	-0.06	-0.12	-0.16
18	-0.22	-0.08	+0.06	+0.26	-0.08	+0.04	+0.02	+0.20	-0.02	+0.32
19	-0.02	+0.20	+0.12	+0.12	+0.10	+0.08	+0.06	-0.12	-0.22	-0.16
20	-0.22	-0.04	+0.06	-0.04	+0.10	+0.06	+0.04	0.00	-0.04	-0.10
21	-0.26	-0.02	-0.02	-0.02	-0.06	-0.04	-0.06	+0.02	0.00	-0.06
22	-0.08	-0.04	0.00	0.00	0.00	-0.02	0.00	0.00	-0.16	-0.16
23	+0.14	-0.04	+0.12	+0.04	-0.02	+0.04	+0.04	+0.02	-0.04	+0.20
24	+0.06	+0.32	+0.04	+0.10	+0.02	0.00	+0.02	-0.06	+0.06	+0.54
25	-0.12	+0.04	+0.02	+0.12	+0.14	+0.04	+0.06	+0.02	+0.02	-0.06

I = Inferior aspect of the cornea

S = Superior aspect of the cornea.

The values of the changes of the radius of curvature are measured at 5 degree intervals along each meridian.

Tabulated Results

Changes in corneal topography

Control subjects at four and twelve weeks

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.04	+0.14	+0.06	+0.06	+0.02	+0.02	0.00	+0.02	-0.02	-0.16
2	+0.08	+0.06	+0.10	+0.06	0.00	+0.02	+0.06	+0.02	-0.04	-0.02
3	-0.18	-0.04	-0.04	+0.02	+0.06	+0.02	+0.04	+0.04	+0.02	-0.14
4	-1.00	-0.14	-0.14	-0.10	-0.06	-0.04	+0.02	0.00	-0.08	+0.20
5	+0.08	+0.20	0.00	0.00	0.00	+0.04	+0.04	0.00	-0.02	-0.10
6	-0.04	+0.04	+0.02	-0.02	0.00	+0.02	+0.02	-0.04	0.00	+0.14
7	-0.02	0.00	0.00	-0.02	-0.04	0.00	-0.02	-0.02	0.00	-0.04
8	-0.30	+0.02	+0.04	0.00	+0.14	+0.06	+0.02	0.00	+0.04	-0.06
9	+0.10	0.00	+0.04	+0.02	-0.06	-0.04	-0.02	-0.02	-0.10	-0.18
10	-0.06	+0.10	+0.08	+0.06	-0.06	+0.02	+0.08	+0.10	0.00	-0.10
11	-0.52	-0.38	+0.04	+0.06	+0.06	+0.06	+0.10	+0.06	+0.08	+0.04
12	+0.08	+0.02	0.00	+0.04	0.00	0.00	+0.06	0.00	+0.06	-0.02
13	-0.30	+0.02	0.00	0.00	0.00	0.00	0.00	+0.02	-0.04	+0.10
14	-0.02	+0.02	0.00	-0.02	0.00	-0.02	0.00	+0.02	-0.04	-0.02
15	-0.44	-0.54	-0.20	-0.06	+0.04	+0.04	+0.10	+0.10	+0.22	-0.02
16	-0.04	-0.08	-0.02	+0.04	+0.02	0.00	+0.04	0.00	-0.04	+0.10
17	+0.34	-0.04	+0.02	+0.02	-0.10	-0.06	0.00	-0.04	+0.04	+0.08
18	-0.16	-0.10	-0.06	-0.02	0.00	-0.02	-0.02	+0.02	0.00	-0.14
19	+0.38	+0.18	0.00	0.00	+0.02	-0.02	-0.04	-0.06	-0.06	-0.06
20	+0.24	-0.02	-0.04	-0.02	-0.02	-0.04	-0.04	-0.02	+0.18	-0.56
21	-0.08	-0.04	0.00	0.00	-0.02	0.00	0.00	-0.02	-0.02	+0.08
22	-0.04	+0.08	0.00	-0.02	-0.02	-0.04	-0.06	+0.08	+0.06	+0.02
23	+0.10	-0.08	-0.02	-0.04	-0.06	-0.04	-0.04	-0.06	-0.14	-0.30
24	+0.10	-0.08	-0.04	+0.04	+0.04	0.00	+0.02	-0.08	-0.04	-0.36
25	-0.06	-0.02	-0.04	-0.02	+0.16	0.00	0.00	+0.02	0.00	+0.22

Tabulated Results

Changes in corneal topography

Control subjects at four and twelve weeks

	I			Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	-0.10	-0.02	+0.06	+0.08	0.00	+0.08	-0.02	+0.04	+0.16	+0.36
2	-0.18	-0.06	-0.04	-0.02	+0.02	-0.02	-0.04	0.00	-0.14	-0.04
3	-0.14	-0.08	+0.06	-0.08	-0.08	-0.02	-0.04	+0.04	-0.02	-0.04
4	-0.44	-0.16	+0.02	-0.10	+0.02	-0.06	-0.04	+0.04	-0.16	-0.14
5	+0.36	+0.10	+0.10	0.00	-0.08	-0.04	-0.04	+0.02	+0.10	-0.20
6	-0.18	0.00	-0.04	-0.04	-0.02	+0.08	+0.08	0.00	-0.04	-0.02
7	-0.10	-0.08	-0.02	-0.04	+0.02	0.00	0.00	0.00	+0.06	+0.24
8	-0.36	+0.04	-0.04	-0.08	0.00	+0.04	+0.10	+0.04	-0.04	+0.26
9	-0.48	-0.18	-0.02	0.00	-0.04	-0.02	0.00	+0.06	0.00	+0.14
10	0.00	-0.14	-0.26	-0.16	0.00	+0.12	+0.10	+0.20	+0.40	+0.44
11	-0.64	-0.16	-0.12	-0.10	-0.02	-0.08	-0.06	-0.12	-0.10	+0.12
12	+0.08	0.00	+0.02	-0.04	+0.02	0.00	+0.04	+0.02	-0.08	-0.18
13	-0.12	-0.02	-0.02	0.00	+0.04	+0.04	+0.02	+0.02	+0.06	+0.04
14	-0.14	-0.04	+0.02	+0.04	+0.02	0.00	+0.02	+0.16	+0.08	+0.08
15	-0.08	-0.06	+0.02	-0.02	+0.08	-0.02	-0.04	-0.06	0.00	-0.14
16	-0.08	-0.10	+0.02	0.00	+0.02	+0.04	+0.04	+0.12	+0.06	+0.28
17	+0.14	-0.04	0.00	+0.02	+0.12	+0.06	+0.04	+0.02	+0.10	+0.16
18	+0.04	+0.02	0.00	-0.06	-0.04	+0.02	0.00	+0.02	+0.02	-0.10
19	-0.08	-0.12	-0.04	0.00	+0.02	+0.04	+0.06	+0.10	+0.18	+0.36
20	+0.12	-0.06	-0.04	-0.04	-0.08	-0.06	-0.02	-0.04	+0.08	+0.08
21	-0.08	+0.10	+0.04	-0.02	+0.06	+0.04	+0.06	+0.02	+0.08	0.00
22	+0.12	+0.42	+0.12	+0.08	0.00	+0.10	+0.10	+0.10	+0.06	+0.24
23	-0.20	+0.10	-0.14	-0.02	-0.02	+0.02	-0.04	+0.02	+0.02	-0.32
24	-0.18	-0.24	-0.04	-0.06	+0.04	+0.02	+0.02	+0.02	-0.02	-0.42
25	+0.02	+0.06	+0.02	-0.02	-0.04	-0.04	-0.08	-0.04	0.00	+0.16

Tabulated Results

Changes in corneal topography

Corneal lens wearing subjects: twelve and twenty weeks

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.04	-0.04	0.00	-0.06	-0.04	-0.06	+0.02	+0.16	+0.38	+0.58
2	0.00	+0.02	+0.02	+0.06	+0.10	+0.16	+0.08	+0.08	+0.10	+0.12
3	-0.06	-0.16	-0.02	-0.06	+0.06	0.00	0.00	+0.12	+0.38	-0.14
4	+0.08	-0.14	+0.14	+0.08	+0.12	-0.16	-0.12	-0.22	-0.14	-0.32
5	+0.02	+0.24	+0.08	+0.04	+0.06	-0.02	-0.16	-0.08	-0.24	-0.16
6	+0.10	-0.30	-0.20	-0.14	-0.04	-0.04	-0.02	-0.08	-0.02	-0.04
7	-0.76	-0.18	-0.16	-0.20	-0.08	+0.14	0.00	+0.18	-0.04	+0.04
8	-0.16	-0.16	-0.16	-0.06	+0.02	+0.02	-0.04	+0.18	+0.18	-0.58
9	+0.14	-0.18	0.00	-0.02	+0.04	+0.04	-0.04	+0.02	+0.06	-0.14
10	+0.14	0.00	+0.04	+0.10	+0.18	-0.02	-0.06	-0.12	+0.08	+0.18
11	+0.10	-0.08	+0.04	+0.04	+0.02	+0.04	+0.06	+0.08	-0.10	-0.24
12	+0.26	-0.08	-0.04	-0.06	-0.02	-0.04	-0.04	+0.12	+0.14	-0.28
13	+0.02	+0.08	-0.04	-0.08	0.00	-0.08	+0.06	-0.02	+0.04	+0.06
14	+0.02	-0.04	+0.04	0.00	-0.02	0.00	+0.10	-0.06	+0.04	-0.08
15	-0.18	+0.16	-0.02	-0.08	+0.04	+0.10	+0.06	+0.06	-0.18	-0.32
16	-0.22	-0.06	+0.14	-0.10	0.00	-0.12	-0.30	+0.06	-0.02	-0.08
17	+0.24	+0.08	-0.06	-0.14	-0.08	+0.04	+0.06	+0.08	+0.20	+0.06
18	+0.44	-0.10	-0.16	+0.06	-0.08	-0.04	+0.10	-0.14	+0.24	+0.62
19	-0.20	-0.10	+0.08	+0.04	+0.08	+0.16	+0.18	+0.16	-0.18	+0.18
20	-0.02	-0.04	+0.08	+0.04	-0.06	-0.02	+0.02	+0.08	+0.02	-0.30
21	+0.22	+0.06	-0.08	-0.02	-0.04	-0.02	-0.04	0.00	-0.10	-0.10
22	+0.24	-0.10	-0.14	-0.12	-0.08	-0.02	-0.04	-0.10	+0.02	+0.10
23	+0.04	+0.02	-0.12	-0.06	-0.06	-0.10	-0.04	+0.02	+0.04	+0.18
24	+0.16	0.00	-0.02	-0 04	-0.08	-0.08	+0.06	+0.12	+0.04	+0.16
25	-0.02	-0.02	-0.04	+0.06	+0.10	0.00	-0.04	0.00	+0.02	+0.42

Tabulated Results

Changes in corneal topography

Corneal lens wearing subjects: twelve and twenty weeks

	I			Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.10	-0.02	+0.02	-0.02	0.00	-0.02	-0.04	-0.20	-0.04	+0.02
2	+0.08	+0.06	+0.02	-0.04	-0.02	-0.06	-0.08	-0.08	-0.06	-0.02
3	+0.10	0.02	0.00	+0.02	+0.02	-0.02	-0.02	-0.02	-0.02	+0.06
4	-0.04	-0.10	-0.08	-0.14	-0.08	+0.06	+0.16	+0.08	-0.06	-0.38
5	-0.06	+0.04	-0.10	-0.08	-0.16	0.00	+0.16	-0.08	-0.02	-0.08
6	-0.06	-0.06	+0.02	-0.06	-0.12	-0.10	-0.08	-0.06	-0.18	+0.12
7	-0.08	+0.28	0.00	-0.12	-0.12	-0.14	-0.10	0.00	+0.64	-0.22
8	-0.50	-0.14	-0.08	-0.06	0.00	+0.04	+0.02	-0.06	-0.14	-0.60
9	-0.42	-0.04	+0.02	-0.02	-0.06	+0.04	+0.02	-0.02	-0.06	+0.26
10	-0.16	-0.12	-0.04	-0.06	+0.12	+0.12	-0.02	-0.12	-0.08	+0.10
11	-0.04	0.00	+0.06	0.00	-0.02	0.00	+0.02	+0.04	+0.06	+0.08
12	0.00	-0.16	-0.04	+0.04	0.00	-0.02	+0.12	+0.04	-0.06	+0.28
13	-0.04	+0.12	+0.02	+0.02	-0.06	-0.08	-0.02	-0.04	+0.06	-0.14
14	+0.04	-0.02	-0.02	+0.20	+0.02	-0.06	-0.04	0.00	+0.10	+0.06
15	+0.16	+0.08	-0.04	+0.04	-0.08	+0.02	+0.14	+0.12	-0.06	+0.10
16	-0.10	+0.04	+0.02	-0.02	+0.06	+0.02	-0.04	+0.08	+0.08	+0.08
17	+0.06	+0.04	+0.02	+0.02	+0.12	+0.10	+0.02	-0.02	+0.04	+0.04
18	-0.02	+0.02	-0.04	-0.04	-0.10	+0.04	-0.04	-0.20	+0.08	-0.14
19	+0.06	+0.02	-0.16	-0.02	-0.04	-0.04	-0.02	+0.02	-0.06	-0.46
20	-0.30	-0.06	-0.08	+0.06	+0.06	+0.08	+0.04	0.00	-0.14	+0.26
21	+0.12	+0.08	+0.06	-0.08	-0.06	-0.10	+0.04	+0.40	+0.10	+0.16
22	-0.18	-0.04	-0.32	0.00	-0.04	+0.02	-0.06	-0.16	+0.14	-0.38
23	-0.04	-0.08	-0.08	-0.04	-0.02	-0.02	-0.04	+0.06	+0.16	+0.14
24	+0.02	+0.20	+0.04	0.00	-0.02	-0.02	-0.02	+0.04	+0.02	-0.08
25	-0.02	-0.06	-0.08	0.00	+0.04	+0.06	0.00	-0.04	+0.20	-0.24

Tabulated Results

Changes in corneal topography

Corneal lens wearing subjects: initial and four weeks

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	-0.52	-0.14	-0.12	-0.10	-0.16	-0.12	+0.08	+0.12	0.00	-0.06
2	+0.26	+0.10	0.00	-0.02	-0.04	-0.02	-0.02	-0.02	+0.18	+0.10
3	+0.34	+0.34	+0.10	-0.02	-0.10	-0.12	-0.14	-0.06	+0.02	+0.08
4	0.00	+0.10	0.00	-0.18	-0.32	-0.30	-0.18	-0.02	+0.02	-0.08
5	+0.02	-0.04	-0.10	-0.10	-0.04	0.00	+0.10	+0.06	-0.06	-0.16
6	+0.02	+0.16	+0.04	-0.06	-0.14	-0.20	-0.22	-0.04	+0.24	+0.42
7	+0.32	+0.20	-0.12	-0.06	-0.08	-0.12	-0.04	-0.08	+0.36	+0.22
8	-0.22	-0.24	-0.02	-0.02	-0.08	-0.02	+0.08	+0.02	+0.14	+0.40
9	-0.10	0.00	-0.02	-0.08	-0.14	-0.10	+0.08	0.00	+0.08	-0.16
10	+0.08	-0.02	-0.02	-0.06	-0.08	-0.10	-0.02	+0.02	+0.10	+0.16
11	+0.20	+0.02	0.00	-0.18	-0.14	-0.14	0.00	+0.12	+0.10	+0.16
12	+0.12	-0.10	0.00	-0.04	-0.10	-0.08	+0.04	-0.02	-0.38	-0.44
13	+0.08	+0.06	+0.14	+0.10	-0.08	-0.10	-0.06	-0.04	-0.38	+0.72
14	+0.10	-0.14	-0.04	0.00	0.00	-0.02	+0.02	+0.04	+0.08	+0.08
15	+0.06	+0.14	+0.02	-0.08	-0.10	-0.06	+0.04	+0.04	+0.04	0.00
16	+0.12	+0.06	+0.08	-0.02	-0.20	-0.18	-0.16	-0.02	+0.08	+0.10
17	-0.12	+0.02	+0.04	0.00	-0.20	-0.18	-0.10	+0.04	0.00	-0.02
18	+0.32	+0.22	+0.06	-0.10	-0.10	-0.20	-0.16	+0.08	+0.28	-0.02
19	+0.10	+0.02	-0.08	-0.04	-0.14	-0.16	-0.02	-0.02	-0.08	+0.16
20	-0.08	-0.04	-0.06	-0.04	-0.16	-0.18	-0.20	-0.12	-0.02	-0.20
21	+0.50	+0.02	-0.16	-0.12	-0.10	-0.16	-0.22	-0.16	+0.24	+0.50
22	-0.26	+0.04	+0.20	-0.02	-0.04	-0.02	-0.06	+0.04	+0.02	+0.24
23	+0.10	+0.12	+0.02	-0.10	-0.08	-0.06	0.00	+0.08	+0.04	+0.10
24	-0.04	-0.02	-0.06	-0.08	-0.04	-0.04	0.00	+0.14	+0.28	+0.18
25	0.00	+0.06	-0.06	-0.06	-0.12	-0.14	-0.10	+0.02	+0.08	+0.20

Tabulated Results

Changes in corneal topography

Corneal lens wearing subjects: initial and four weeks

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	-0.06	-0.06	+0.04	-0.10	-0.10	-0.12	-0.06	+0.06	0.00	-0.12
2	-0.12	-0.04	0.00	-0.08	-0.04	-0.04	-0.08	-0.02	+0.08	-0.02
3	-0.32	-0.10	-0.04	-0.14	-0.16	-0.06	+0.18	+0.16	+0.04	+0.10
4	-0.02	+0.12	-0.02	-0.20	-0.20	-0.10	-0.04	+0.10	+0.06	+0.28
5	+0.04	-0.04	-0.04	-0.06	-0.06	0.00	+0.06	+0.08	-0.10	-0.10
6	+0.18	-0.06	-0.28	-0.28	-0.20	+0.14	+0.22	+0.10	+0.12	+0.06
7	-0.16	+0.02	-0.20	-0.16	-0.14	-0.28	-0.04	+0.08	+0.36	+0.82
8	-0.08	-0.22	-0.14	-0.10	-0.02	-0.06	+0.06	-0.02	+0.18	-0.08
9	+0.02	-0.02	-0.14	-0.08	-0.10	-0.08	-0.02	+0.02	+0.08	+0.08
10	+0.02	-0.04	-0.04	-0.08	-0.10	-0.12	-0.04	-0.02	+0.02	-0.10
11	0.26	0.00	-0.12	-0.14	-0.08	-0.24	-0.10	0.00	+0.06	+0.14
12	-0.16	+0.04	-0.26	+0.06	0.00	0.00	0.00	-0.30	-0.16	-0.18
13	-0.52	-0.10	-0.02	-0.10	-0.24	-0.20	0.00	+0.10	+0.06	+0.36
14	+0.34	+0.08	-0.02	-0.12	-0.04	-0.04	+0.02	+0.08	+0.08	+0.18
15	-0.16	-0.12	-0.10	0.00	-0.12	+0.08	+0.04	+0.04	+0.20	+0.04
16	-0.16	+0.12	-0.12	-0.18	-0.24	-0.20	+0.06	-0.04	-0.02	+0.16
17	-0.40	-0.40	-0.02	+0.40	-0.02	+0.08	+0.08	+0.08	-0.06	-0.26
18	+0.30	+0.04	-0.12	-0.20	0.00	0.00	+0.18	+0.10	-0.66	+0.08
19	+0.02	+0.04	-0.10	-0.12	-0.04	+0.04	-0.02	-0.16	-0.20	+0.18
20	+0.08	-0.06	-0.18	-0.18	-0.06	-0.08	-0.04	+0.02	-0.06	-0.02
21	-0.28	-0.14	-0.28	-0.02	-0.28	-0.32	-0.14	+0.02	-0.02	+0.30
22	-0.12	-0.02	-0.08	-0.02	-0.04	+0.02	+0.04	+0.06	-0.28	-0.46
23	+0.28	+0.02	-0.04	+0.06	-0.06	-0.12	-0.14	0.00	-0.16	-0.14
24	-0.36	-0.22	-0.16	+0.06	+0.02	+0.10	+0.14	+0.06	+0.18	+0.12
25	+0.20	-0.10	-0.14	-0.16	-0.12	0.00	+0.08	+0.12	-0.02	-0.02

Tabulated Results

Changes in corneal topography

Corneal lens wearing subjects: four and twelve weeks

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.08	+0.06	+0.18	+0.02	0.00	-0.10	-0.30	-0.06	+0.10	-0.02
2	-0.28	-0.06	+0.06	+0.02	-0.04	-0.14	-0.14	-0.10	-0.02	-0.16
3	-0.52	-0.06	-0.10	-0.04	+0.08	+0.02	0.00	+0.08	+0.04	-0.02
4	+0.10	+0.08	+0.14	+0.36	+0.12	+0.30	+0.24	+0.06	-0.04	-0.40
5	+0.40	+0.06	+0.08	+0.06	-0.02	-0.2	+0.02	+0.08	+0.06	+0.08
6	0.00	-0.02	+0.12	+0.04	+0.10	+0.12	+0.06	+0.04	-0.04	-0.08
7	-0.06	-0.20	+0.04	+0.06	+0.10	+0.12	-0.02	-0.04	-0.26	-0.20
8	+1.42	-0.44	+0.02	-0.04	+0.02	0.00	-0.04	+0.04	+0.18	-0.16
9	+0.38	-0.28	-0.16	-0.22	-0.30	-0.14	-0.04	+0.08	+0.04	+0.26
10	-0.38	-0.06	-0.04	0.00	-0.08	-0.06	+0.04	+0.04	+0.04	-0.08
11	-0.14	+0.04	+0.02	+0.32	-0.26	+0.20	+0.06	-0.04	-0.08	-0.04
12	-0.10	+0.18	+0.16	0.00	+0.06	+0.08	+0.04	+0.06	-0.06	-0.14
13	+0.24	+0.12	0.00	-0.12	+0.06	+0.18	+0.08	+0.38	+0.16	+0.14
14	-0.08	-0.08	0.00	+0.02	+0.02	+0.06	0.00	+0.04	0.00	-0.06
15	-0.32	-0.18	+0.04	+0.02	+0.04	+0.08	+0.04	+0.06	-0.02	-0.10
16	+0.24	-0.16	-0.04	-0.10	-0.04	+0.06	+0.08	+0.04	-0.02	-0.06
17	+0.04	0.00	-0.04	-0.06	-0.02	-0.04	-0.06	-0.04	0.00	+0.30
18	-0.12	+0.18	+0.40	+0.56	+0.50	+0.52	+0.52	+0.54	+0.14	+0.52
19	+0.18	+0.04	-0.02	+0.02	-0.02	+0.08	+0.12	+0.18	+0.12	+0.20
20	+0.04	-0.04	-0.02	-0.04	+0.04	+0.04	+0.04	+0.02	+0.10	+0.26
21	-0.02	+0.18	+0.12	+0.08	+0.02	+0.04	+0.04	-0.02	+0.04	+0.18
22	+0.18	-0.02	+0.02	+0.02	+0.04	+0.04	+0.12	+0.26	+0.04	-0.04
23	0.00	+0.04	-0.02	-0.02	-0.02	-0.02	-0.02	+0.06	+0.08	+0.04
24	-0.20	+0.04	+0.02	0.00	0.00	+0.02	+0.08	+0.12	0.00	+0.08
25	+0.16	+0.12	+0.12	+0.04	+0.02	+0.08	+0.10	-0.04	+0.06	+0.08

Tabulated Results

Changes in corneal topography

Corneal lens wearing subjects: four and twelve weeks

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.04	+0.04	-0.06	-0.06	-0.08	+0.12	+0.10	-0.10	+0.08	-0.18
2	+0.24	0.00	+0.02	+0.06	+0.08	+0.02	+0.06	-0.06	-0.14	-0.02
3	-0.42	-0.06	-0.02	+0.12	-0.16	-0.06	-0.18	-0.24	-0.30	-0.18
4	+0.28	+0.28	+0.20	+0.30	+0.16	+0.26	+0.06	-0.14	-0.12	0.00
5	+0.36	+0.02	+0.02	+0.06	-0.02	-0.02	+0.04	0.00	+0.06	-0.02
6	+0.04	-0.16	+0.08	+0.12	+0.06	+0.06	-0.10	-0.06	-0.10	-0.18
7	+0.06	-0.10	+0.12	+0.20	+0.14	-0.04	-0.06	-0.10	-0.38	-0.64
8	+0.12	+0.14	+0.18	+0.18	+0.04	-0.22	-0.06	0.00	+0.14	-0.08
9	-0.04	+0.14	-0.04	-0.02	-0.08	-0.04	+0.16	-0.04	-0.06	-0.06
10	-0.08	+0.08	-0.08	-0.06	-0.06	+0.06	+0.12	+0.22	+0.02	-0.26
11	+0.06	+0.22	+0.26	+0.30	+0.22	-0.32	+0.16	-0.16	-0.30	-0.18
12	+0.32	-0.10	+0.34	+0.10	+0.02	+0.04	+0.14	-0.02	0.00	-0.14
13	+0.22	0.00	-0.02	+0.10	+0.04	+0.20	+0.04	+0.02	+0.02	-0.06
14	-0.12	0.00	-0.02	+0.04	+0.02	+0.06	-0.02	-0.04	-0.08	+0.02
15	-0.20	+0.06	-0.02	-0.04	+0.10	+0.14	+0.18	-0.12	-0.10	+0.18
16	-0.20	-0.26	-0.10	-0.04	+0.06	+0.10	+0.08	-0.02	+0.04	+0.18
17	+0.02	-0.02	-0.04	-0.02	-0.06	-0.02	+0.02	+0.02	+0.14	+0.08
18	+0.02	+0.26	+0.50	+0.52	+0.60	+0.60	+0.22	+0.04	+0.10	-0.22
19	-0.02	-0.04	-0.02	-0.08	+0.02	+0.02	+0.06	+0.10	+0.02	0.00
20	+0.04	+0.04	+0.02	-0.02	-0.02	-0.04	0.00	-0.06	-0.18	-0.08
21	-0.04	+0.14	+0.24	0.00	-0.02	-0.02	-0.02	+0.02	+0.06	-0.82
22	0.00	-0.04	+0.14	+0.04	+0.10	0.00	+0.08	-0.04	+0.04	+0.14
23	+0.02	-0.02	-0.06	-0.02	-0.06	-0.06	0.00	0.00	+0.02	+0.02
24	+0.08	-0.06	-0.10	-0.08	0.00	+0.02	0.00	+0.04	+0.10	+0.22
25	+0.04	+0.06	+0.18	+0.16	+0.10	+0.08	-0.04	-0.02	-0.02	-0.12

Tabulated Results

Changes in corneal topography

Control subjects: Twelve and twenty weeks

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	-0.10	+0.04	-0.12	0.00	0.00	-0.02	+0.02	+0.04	-0.04	-0.22
2	-0.02	-0.04	+0.08	0.00	0.00	0.00	0.00	0.00	+0.02	+0.06
3	-0.22	+0.04	-0.04	+0.08	+0.02	-0.02	+0.02	0.00	+0.06	-0.04
4	+0.16	+0.12	-0.06	+0.08	+0.04	-0.08	+0.08	-0.04	+0.10	+0.56
5	-0.40	-0.18	-0.10	0.00	+0.10	+0.02	+0.02	-0.04	-0.20	0.00
6	-0.20	+0.04	-0.02	-0.02	-0.02	-0.02	-0.02	+0.04	+0.06	-0.02
7	-0.12	-0.02	-0.04	0.00	-0.06	0.00	0.00	-0.02	-0.08	-0.08
8	-0.04	-0.02	-0.12	-0.14	0.00	-0.04	-0.02	-0.18	-0.06	-0.22
9	+0.14	+0.18	+0.06	+0.04	0.00	+0.02	+0.02	-0.02	0.00	+0.20
10	-0.18	-0.04	-0.06	+0.02	-0.02	+0.02	+0.04	+0.04	-0.06	+0.38
11	-0.32	-0.02	-0.02	-0.04	0.00	-0.06	-0.08	+0.02	+0.02	-0.02
12	-0.10	-0.04	-0.08	-0.06	+0.06	+0.04	+0.02	-0.02	+0.06	+0.18
13	-0.06	+0.02	0.00	-0.02	-0.06	-0.02	0.00	+0.04	+0.12	+0.18
14	+0.24	-0.02	-0.06	-0.08	-0.02	-0.02	-0.06	-0.22	-0.16	+0.04
15	+0.04	+0.02	+0.02	0.00	-0.04	-0.04	0.00	-0.07	+0.02	+0.16
16	-0.10	+0.08	0.00	0.00	-0.04	+0.04	-0.04	-0.06	-0.04	-0.20
17	-0.44	-0.02	-0.02	+0.02	+0.02	-0.02	0.00	-0.22	+0.04	+0.12
18	+0.06	+0.02	-0.02	-0.02	0.00	-0.02	+0.02	+0.06	+0.06	+0.12
19	-0.08	-0.02	-0.04	-0.06	-0.04	-0.10	-0.12	+0.18	-0.22	-0.22
20	-0.36	+0.04	-0.08	-0.04	0.00	-0.02	-0.02	+0.06	-0.10	-0.06
21	+0.22	-0.06	-0.02	+0.04	0.00	+0.02	-0.04	-0.06	-0.08	-0.02
22	-0.40	-0.16	-0.16	-0.06	0.00	-0.10	-0.08	-0.08	0.00	-0.24
23	+0.04	-0.22	+0.04	+0.04	+0.02	0.00	+0.06	0.00	+0.02	+0.30
24	-0.02	-0.10	-0.04	-0.04	-0.06	-0.04	-0.02	+0.04	-0.02	-0.08
25	+0.06	-0.14	-0.04	0.00	+0.04	+0.04	+0.12	+0.04	-0.08	-0.10

Tabulated Results

Changes in corneal topography

Control subjects: Twelve and twenty weeks

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	-0.04	-0.08	+0.04	0.00	+0.04	0.00	+0.02	0.00	-0.02	+0.02
2	-0.16	-0.04	-0.02	0.00	+0.02	+0.02	0.00	+0.06	-0.08	+0.10
3	+0.06	+0.02	-0.04	-0.04	-0.04	-0.02	0.00	0.00	-0.02	0.00
4	+0.54	+0.30	+0.18	+0.10	-0.02	+0.02	-0.02	0.00	-0.14	-0.38
5	-0.04	-0.08	+0.02	+0.02	-0.02	-0.02	-0.04	-0.04	-0.04	-0.08
6	-0.12	-0.06	0.00	+0.02	0.00	-0.02	-0.02	0.00	0.00	-0.12
7	-0.06	-0.02	+0.02	0.00	0.00	0.00	-0.02	-0.02	+0.04	0.00
8	+0.16	-0.04	-0.02	0.00	0.00	-0.02	+0.02	-0.04	-0.02	+0.10
9	0.00	-0.06	-0.08	-0.04	+0.02	0.00	+0.04	0.00	+0.08	-0.08
10	-0.08	+0.02	-0.04	-0.04	-0.02	0.00	-0.02	-0.04	+0.06	-0.14
11	-0.04	-0.02	-0.02	0.00	+0.02	-0.02	-0.04	+0.02	+0.12	+0.94
12	-0.10	-0.02	0.00	-0.02	-0.02	+0.02	-0.02	+0.02	-0.10	-0.06
13	+0.30	-0.12	-0.04	-0.02	-0.02	0.00	0.00	0.00	0.00	-0.10
14	+0.04	0.00	-0.02	-0.04	0.00	0.00	+0.04	-0.04	-0.02	-0.10
15	-0.18	-0.14	-0.02	0.00	+0.04	-0.02	-0.04	-0.02	0.00	-0.14
16	-0.06	-0.04	0.00	-0.04	+0.04	+0.02	+0.02	-0.00	-0.02	-0.06
17	+0.32	-0.12	-0.08	-0.04	+0.06	+0.04	+0.08	+0.10	+0.44	+0.72
18	+0.10	+0.06	+0.02	+0.06	+0.04	+0.02	+0.04	+0.02	+0.02	+0.22
19	-0.40	-0.12	-0.06	-0.06	0.00	0.00	0.00	+0.04	+0.02	0.00
20	-0.18	-0.02	0.00	0.00	+0.02	-0.02	0.00	-0.06	-0.18	-0.06
21	+0.18	0.00	-0.02	+0.02	+0.04	+0.04	+0.04	+0.02	+0.02	-0.02
22	+0.08	+0.24	+0.08	+0.02	0.00	0.00	+0.04	+0.08	-0.06	-0.08
23	-0.24	0.00	0.00	+0.02	0.00	+0.06	+0.02	-0.06	+0.08	+0.18
24	+0.10	+0.04	0.00	-0.04	+0.04	+0.02	+0.02	+0.06	-0.08	0.00
25	+0.04	+0.02	0.00	+0.04	0.00	+0.02	+0.02	-0.02	-0.02	-0.12

Tabulated Results

Changes in corneal topography

Gel lens wearing subjects, initial and four weeks

Pat. No.	Horizontal meridian									T
	20	15	10	5	0	5	10	15	20	25
1	+0.04	-0.06	+0.04	+0.08	+0.02	+0.06	+0.06	0.00	-0.14	-0.02
2	+0.06	+0.10	+0.08	+0.04	+0.04	+0.06	-0.04	-0.02	-0.04	+0.08
3	0.00	0.00	-0.02	+0.06	-0.02	-0.02	0.00	-0.02	0.00	0.00
4	+0.02	+0.10	+0.04	+0.08	+0.04	+0.04	+0.02	-0.02	-0.02	-0.18
5	-0.16	-0.08	0.00	0.00	-0.08	+0.08	+0.02	+0.12	-0.02	-0.30
6	+0.10	0.00	-0.02	+0.06	+0.02	+0.02	+0.04	0.00	+0.02	-0.08
7	+0.12	-0.02	+0.02	+0.04	+0.02	+0.04	+0.04	0.00	+0.04	+0.04
8	-0.36	-0.14	-0.02	-0.08	-0.08	-0.02	+0.02	+0.10	+0.04	+0.12
9	-0.06	-0.08	-0.02	-0.02	-0.04	-0.04	+0.02	-0.06	-0.04	+0.04
10	+0.14	+0.02	-0.02	-0.02	+0.02	0.00	+0.00	+0.02	+0.08	+0.12
11	+0.16	-0.04	+0.06	+0.04	+0.04	+0.04	-0.02	+0.04	-0.02	0.00
12	+0.04	+0.10	+0.04	0.00	-0.04	-0.04	-0.04	-0.06	0.00	+0.02
13	+0.02	0.00	-0.04	-0.04	-0.04	-0.00	+0.02	+0.06	-0.02	-0.26
14	-0.10	+0.02	0.00	0.00	+0.02	-0.02	0.00	+0.02	+0.14	0.00
15	+0.18	+0.04	+0.02	+0.02	0.00	0.00	+0.04	+0.04	+0.04	-0.02
16	0.00	+0.06	-0.02	0.00	+0.04	+0.02	+0.06	+0.06	+0.04	-0.28
17	+0.02	-0.04	+0.02	0.00	0.00	+0.02	+0.04	0.00	-0.04	-0.04
18	-0.16	+0.28	+0.04	0.00	+0.02	0.00	+0.04	+0.02	+0.04	-0.06
19	+0.16	0.00	-0.04	0.00	-0.10	-0.08	-0.02	+0.02	+0.04	-0.10
20	-0.14	-0.18	-0.08	+0.02	+0.02	+0.02	-0.04	-0.02	0.00	+0.02
21	+0.12	-0.10	+0.02	-0.14	-0.10	-0.04	+0.04	+0.04	+0.08	-0.10
22	-0.26	-0.04	+0.04	-0.02	+0.02	+0.02	0.00	-0.02	-0.02	-0.02
23	-0.10	+0.06	+0.04	+0.06	+0.04	+0.02	+0.04	+0.04	-0.04	0.00
24	+0.04	+0.12	-0.04	-0.02	-0.02	0.00	-0.02	+0.04	+0.04	+0.10
25	-0.12	-0.02	-0.06	-0.04	-0.06	-0.10	-0.08	-0.08	+0.04	+0.04

Tabulated Results

Changes in corneal topography

Gel lens wearing subjects, initial and four weeks

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	+0.08	+0.04	+0.02	-0.02	+0.02	0.00	-0.02	+0.12	-0.04	+0.14
2	-0.20	-0.10	+0.06	+0.06	+0.14	+0.12	+0.06	+0.02	-0.08	+0.02
3	0.00	0.00	0.00	+0.02	-0.02	0.00	+0.02	-0.02	0.00	0.00
4	-0.40	-0.14	+0.08	+0.08	+0.08	+0.08	0.00	-0.04	-0.08	+0.12
5	+0.12	+0.02	0.00	+0.02	+0.02	0.00	0.00	+0.02	-0.10	+0.08
6	-0.12	+0.14	+0.14	+0.10	+0.04	0.00	-0.02	+0.04	+0.08	-0.06
7	-0.04	-0.08	+0.40	-0.02	0.00	-0.04	-0.04	0.00	0.00	-0.22
8	-0.56	-0.02	-0.16	-0.04	-0.10	-0.02	-0.02	0.00	+0.02	-0.06
9	0.00	0.00	-0.02	+0.08	+0.04	0.00	-0.02	-0.02	-0.04	+0.22
10	-0.06	+0.02	0.00	+0.02	0.00	+0.04	-0.04	+0.06	+0.14	-0.04
11	+0.22	+0.06	+0.14	+0.12	+0.06	+0.02	0.00	-0.04	-0.24	-0.04
12	0.00	+0.06	+0.02	-0.02	-0.02	-0.04	-0.04	+0.04	-0.02	+0.02
13	+0.06	+0.04	+0.04	+0.02	-0.06	-0.40	-0.02	+0.12	-0.14	-0.30
14	-0.18	+0.02	+0.06	0.00	-0.06	0.00	+0.02	-0.06	-0.20	0.00
15	+0.46	+0.04	+0.12	0.00	-0.04	+0.02	-0.02	+0.14	+0.20	+0.14
16	+0.06	+0.14	+0.18	+0.04	-0.02	-0.04	-0.04	+0.04	+0.16	+0.04
17	+0.06	+0.14	0.00	-0½02	+0.04	+0.02	+0.08	+0.10	-0.08	+0.02
18	+0.46	+0.04	-0.02	-0.04	-0.10	-0.04	0.00	-0.02	-0.04	+0.08
19	0.00	+0.24	+0.04	+0.06	-0.04	-0.04	+0.02	0.00	+0.02	-0.24
20	-0.16	-0.18	+0.02	-0.04	-0.06	-0.06	0.00	+0.06	+0.06	+0.20
21	-0.02	-0.08	+0.02	+0.10	+0.04	-0.06	-0.06	-0.06	+0.40	+0.14
22	0.00	+0.02	-0.08	0.00	+0.02	-0.02	+0.02	+0.02	-0.04	-0.02
23	+0.06	+0.10	+0.02	0.00	-0.02	-0.02	+0.04	+0.10	-0.18	-0.20
24	-0.18	-0.12	-0.04	+0.06	-0.04	+0.04	0.00	0.00	+0.06	-0.18
25	+0.30	-0.02	+0.04	0.00	-0.02	-0.02	-0.06	-0.10	+0.04	-0.02

Tabulated Results

Changes in corneal topography

Gel lens wearing subjects four and twelve weeks

Pat. No.	N 20	15	10	5	0	Horizontal meridian 5	10	15	20	T 25
1	-0.02	+0.02	0.00	+0.02	-0.02	0.00	-0.02	+0.08	+0.12	+0.04
2	-0.06	+0.04	0.00	+0.06	-0.04	-0.12	-0.02	-0.06	-0.06	-0.28
3	-0.02	-0.04	+0.04	0.00	+0.04	+0.06	+0.04	+0.10	+0.06	-0.12
4	+0.04	-0.02	+0.04	+0.06	+0.10	0.00	+0.02	+0.02	-0.06	+0.14
5	+0.06	+0.10	+0.06	+0.06	+0.04	+0.02	+0.04	-0.02	-0.04	+0.28
6	-0.08	-0.12	0.00	-0.06	-0.06	+0.02	+0.02	+0.10	+0.02	-0.18
7	-0.10	-0.04	0.00	-0.04	-0.02	-0.02	0.00	-0.02	-0.22	-0.02
8	0.00	+0.02	+0.02	-0.02	+0.08	0.00	-0.02	-0.10	-0.04	0.00
9	0.00	+0.10	+0.10	+0.02	0.00	-0.02	-0.02	+0.06	-0.10	-0.26
10	-0.22	0.00	-0.02	0.00	-0.02	+0.02	+0.04	+0.04	-0.10	-0.12
11	-0.04	+0.02	-0.06	-0.08	-0.04	-0.02	+0.06	+0.04	-0.08	0.00
12	-0.02	+0.06	-0.04	+0.10	0.00	+0.04	+0.02	+0.02	+0.04	-0.14
13	-0.06	+0.06	+0.02	+0.02	+0.08	+0.06	+0.04	+0.02	+0.08	+0.08
14	+0.02	-0.16	-0.06	-0.08	-0.10	0.00	+0.06	+0.30	+0.78	0.00
15	-0.14	-0.08	-0.04	0.00	-0.02	-0.02	-0.02	-0.04	-0.08	+0.10
16	-0.04	-0.04	0.00	0.00	+0.04	-0.06	-0.04	0.00	0.00	+0.18
17	0.00	-0.04	-0.04	-0.04	+0.02	+0.02	-0.06	+0.02	+0.10	-0.10
18	+0.12	+0.24	+0.40	+0.38	+0.46	+0.36	+0.30	+0.20	+0.08	-0.34
19	-0.04	+0.06	+0.02	-0.08	+0.02	+0.02	-0.06	-0.16	-0.28	-0.40
20	+0.20	+0.20	+0.12	+0.04	-0.02	+0.02	+0.04	+0.02	-0.02	+0.12
21	-0.12	+0.06	-0.02	+0.02	-0.02	-0.02	-0.02	0.00	-0.06	+0.28
22	+0.20	+0.06	0.00	+0.08	+0.14	+0.08	+0.04	-0.08	-0.04	-0.10
23	-0.04	-0.04	-0.04	-0.04	+0.10	+0.02	-0.02	-0.04	-0.06	0.00
24	+0.12	+0.04	+0.06	+0.04	-0.02	0.00	+0.04	+0.08	+0.12	-0.26
25	-0.10	-0.06	+0.04	+0.04	+0.08	+0.06	+0.04	+0.08	0.00	+0.10

Tabulated Results

Changes in corneal topography

Gel lens wearing subjects four and twelve weeks

	I				Vertical meridian					S
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	0.00	0.00	-0.06	-0.04	0.00	+0.06	+0.12	-0.24	-0.04	-0.06
2	0.00	+0.22	-0.14	+0.08	-0.02	-0.08	+0.02	+0.24	+0.42	-0.38
3	-0.10	-0.04	+0.14	+0.04	+0.10	+0.08	+0.16	+0.10	-0.18	-0.06
4	-0.04	0.00	-0.02	0.00	-0.12	+0.10	+0.18	+0.16	+0.08	-0.08
5	0.00	+0.04	0.00	+0.06	+0.02	+0.02	+0.10	-0.06	+0.12	+0.08
6	-0.10	-0.06	0.00	+0.02	+0.06	+0.06	0.00	-0.04	+0.06	+0.32
7	+0.04	-0.04	0.00	+0.04	+0.04	+0.10	-0.02	+0.04	+0.06	+0.04
8	0.00	0.00	0.00	0.00	0.00	+0.02	-0.02	0.00	-0.02	-0.06
9	-0.16	-0.12	-0.10	-0.06	0.00	+0.02	+0.04	+0.06	+0.02	-0.02
10	0.00	-0.10	-0.02	-0.04	-0.04	-0.04	+0.14	-0.02	-0.10	+0.12
11	-0.18	0.00	-0.20	-0.10	0.00	+0.06	-0.08	-0.02	+0.24	-0.04
12	-0.06	+0.04	-0.08	+0.20	+0.10	+0.04	+0.14	0.00	-0.08	+0.02
13	-0.32	0.00	+0.04	+0.40	+0.06	+0.02	0.00	-0.04	+0.10	+0.06
14	+0.18	-0.08	-0.10	-0.12	-0.08	+0.02	-0.04	-0.12	+0.34	+0.48
15	-0.34	-0.04	0.00	-0.06	-0.06	-0.02	+0.02	-0.06	0.00	+0.08
16	+0.02	-0.22	-0.16	-0.04	+0.02	+0.06	+0.10	-0.10	-0.20	+0.06
17	-0.10	-0.22	0.00	+0.04	+0.02	+0.02	-0.10	-0.10	+0.26	-0.16
18	+0.30	+0.42	+0.42	+0.42	+0.38	+0.40	+0.32	+0.24	+0.12	-0.30
19	+0.28	-0.08	0.00	-0.02	+0.10	+0.04	-0.06	-0.06	-0.36	-0.10
20	+0.04	0.00	0.00	+0.08	+0.08	+0.08	+0.08	+0.12	+0.16	-0.12
21	+0.14	+0.02	-0.04	-0.08	-0.04	+0.04	+0.06	+0.06	0.00	-0.04
22	+0.14	+0.12	+0.10	+0.24	+0.12	+0.20	0.00	+0.02	+0.18	+0.16
23	-0.12	-0.06	0.00	0.00	+0.02	0.00	0.00	0.00	+0.12	-0.10
24	-0.12	-0.02	+0.04	-0.02	+0.02	0.00	-0.06	+0.10	-0.02	-0.16
25	-0.04	+0.10	-0.04	-0.04	-0.02	0.00	+0.10	+0.12	+0.06	+0.10

Tabulated Results

Changes in corneal topography

Gel lens wearing subjects twelve and twenty weeks

	N				Horizontal meridian					T
Pat. No.	20	15	10	5	0	5	10	15	20	25
1	-0.54	-0.18	-0.06	+0.04	+0.02	+0.04	+0.02	-0.08	-0.16	-0.08
2	-0.18	+0.12	+0.08	+0.12	0.00	-0.04	-0.04	-0.02	+0.02	-0.42
3	-0.04	-0.10	-0.08	-0.08	-0.06	-0.02	0.00	0.00	-0.04	-0.06
4	-0.02	0.00	+0.08	+0.16	+0.20	+0.10	+0.08	-0.04	-0.16	-0.04
5	-0.04	0.00	-0.12	-0.02	0.00	+0.08	+0.04	+0.04	-0.02	+0.12
6	-0.32	-0.22	-0.08	-0.10	+0.02	+0.04	+0.06	+0.06	-0.08	-0.08
7	+0.12	+0.04	+0.04	0.00	0.00	0.00	-0.02	-0.04	-0.18	+0.12
8	-0.20	-0.06	0.00	-0.04	+0.06	-0.02	+0.02	0.00	0.00	-0.04
9	-0.16	0.00	0.00	-0.02	0.00	-0.06	+0.02	+0.02	-0.14	-0.06
10	-0.12	-0.02	-0.04	-0.08	-0.04	0.00	+0.02	-0.02	+0.12	-0.12
11	-0.36	-0.04	-0.10	+0.16	+0.28	-0.20	-0.16	-0.24	-0.38	-0.10
12	+0.06	-0.06	-0.02	+0.08	+0.02	+0.04	-0.04	+0.04	+0.10	-0.06
13	+0.24	+0.02	0.00	0.00	+0.06	+0.08	+0.08	-0.08	+0.08	+0.04
14	+0.06	-0.16	-0.12	-0.06	-0.10	-0.06	-0.02	+0.30	-0.22	+0.66
15	+0.08	-0.02	-0.02	+0.04	0.00	0.00	+0.02	+0.04	-0.02	-0.14
16	+0.28	-0.04	0.00	0.00	-0.02	-0.02	-0.02	+0.04	+0.04	+0.06
17	-0.04	-0.14	-0.04	-0.08	-0.02	0.00	-0.08	0.00	+0.02	-0.20
18	-0.20	+0.54	+0.46	+0.38	+0.42	+0.28	+0.34	+0.30	+0.12	-0.06
19	-0.04	+0.06	0.00	-0.10	-0.04	-0.04	-0.06	-0.14	-0.24	+0.36
20	+0.12	+0.08	-0.02	+0.06	+0.02	+0.06	+0.02	-0.04	-0.06	+0.20
21	+0.06	+0.04	-0.02	+0.04	-0.06	0.00	+0.04	-0.06	+0.02	+0.16
22	-0.04	+0.04	0.00	+0.04	+0.14	+0.10	+0.06	-0.06	-0.04	+0.16
23	+0.36	+0.06	0.00	+0.08	+0.20	+0.06	-0.04	-0.02	-0.04	-0.08
24	+0.20	+0.18	-0.08	0.00	-0.06	-0.02	0.00	+0.10	+0.20	-0.18
25	-0.02	+0.04	+0.04	+0.02	+0.04	+0.04	-0.02	+0.02	-0.08	0.00

Tabulated Results

Changes in corneal topography

Gel lens wearing subjects twelve and twenty weeks

	I			Vertical meridian					S
	20	15	10	5	0	5	10	15	20	25
1	-0.22	-0.02	+0.08	+0.04	-0.02	-0.02	0.00	-0.16	+0.04	+0.04
2	-0.26	-0.12	-0.02	+0.04	+0.18	+0.08	+0.02	-0.06	+0.10	+0.24
3	+0.06	+0.08	-0.04	0.00	+0.04	+0.04	-0.02	0.00	-0.30	-0.02
4	-0.20	-0.28	-0.10	0.00	-0.06	+0.24	+0.30	+0.20	+0.18	+0.36
5	+0.16	-0.04	0.00	+0.06	0.00	0.00	-0.02	-0.04	0.00	-0.06
6	-0.24	+0.08	+0.20	-0.06	-0.06	-0.10	-0.04	+0.02	+0.24	+0.24
7	0.00	-0.08	-0.02	-0.02	+0.04	-0.06	0.00	+0.02	+0.08	+0.14
8	-0.44	-0.20	-0.24	-0.04	+0.02	-0.06	+0.06	+0.08	+0.10	+0.14
9	-0.24	-0.06	-0.14	+0.10	+0.08	-0.02	-0.16	-0.24	-0.08	+0.04
10	-0.02	-0.20	0.00	0.00	-0.06	-0.04	-0.04	+0.02	+0.12	+0.28
11	+0.20	+0.30	+0.18	+0.16	+0.16	+0.10	-0.04	-0.10	-0.26	-0.48
12	+0.10	+0.02	0.00	0.00	+0.08	0.00	+0.02	-0.04	-0.14	+0.10
13	-0.02	+0.02	+0.10	+0.06	-0.02	-0.04	-0.04	+0.02	-0.12	-0.20
14	+0.06	-0.08	0.00	-0.10	-0.16	-0.06	-0.06	+0.04	+0.26	-0.08
15	+0.02	+0.02	+0.08	-0.02	-0.06	0.00	+0.02	+0.02	+0.30	+0.18
16	0.00	0.00	0.00	+0.04	+0.02	+0.02	0.00	-0.10	-0.14	+0.12
17	-0.14	-0.22	-0.04	-0.02	-0.08	-0.02	-0.10	-0.10	-0.28	-0.18
18	+0.30	+0.46	+0.38	+0.34	+0.42	+0.42	+0.38	+0.30	0.00	-0.06
19	+0.32	+0.02	+0.02	+0.02	-0.10	-0.02	-0.02	-0.14	-0.38	+0.34
20	-0.10	-0.24	-0.06	+0.02	-0.02	-0.02	+0.06	+0.26	+0.24	-0.04
21	-0.04	-0.04	+0.04	+0.02	0.00	+0.02	+0.02	-0.02	0.00	+0.20
22	+0.10	+0.08	+0.08	+0.08	+0.14	+0.20	+0.06	-0.02	+0.22	+0.50
23	+0.20	+0.04	+0.04	0.00	0.00	0.00	+0.04	+0.10	-0.04	-0.24
24	-0.32	-0.24	+0.02	+0.06	0.00	+0.02	+0.06	+0.10	+0.16	+0.10
25	+0.12	+0.20	-0.10	-0.02	-0.10	0.00	+0.08	+0.08	-0.20	+0.22

Tabulated Results

Changes in meridians of corneal topography

Meridians in degrees

Patient No.	CONTROL						CORNEAL						GEL					
	0-4 weeks		4-12 weeks		12-20 weeks		0-4 weeks		4-12 weeks		12-20 weeks		0-4 weeks		4-12 weeks		12-20 weeks	
	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V
1	+2	+4	+6	-4	+2	+6	+1	+3	-1	-2	+1	+2	-3	-5	-5	-1	+5	+2
2	-1	+4	-1	-14	+12	+23	-19	-3	+7	+3	-5	-1	-2	0	+2	-4	-4	+1
3	+3	0	-10	-2	+1	-2	-2	-2	+1	+1	+1	0	-2	+2	-2	+3	+4	-5
4	+2	0	-4	-2	+5	+1	-4	-2	0	0	-1	-2	+4	+4	+5	+10	-1	-4
5	-1	-1	0	-3	+3	+4	+4	+9	-4	-2	+2	+1	+1	-1	0	+3	0	0
6	-4	+8	+1	+4	+3	-3	+1	-1	-6	+11	+1	-2	-3	+1	+4	+5	-3	-5
7	+2	+7	+1	-3	-2	+3	+2	+1	-1	+1	+1	-2	+4	-1	-2	+5	+4	-3
8	0	+3	+10	+8	-15	-14	-2	+4	-2	+2	-1	+4	-13	-2	+4	-5	-1	+7
9	-12	-5	+4	+2	+7	+8	-6	-2	+4	+2	-2	-3	+7	+2	-9	-5	+1	+5
10	-2	-2	-1	-4	0	+4	+2	0	-7	+9	+4	+6	-8	+2	+12	-4	-7	+7
11	+12	-16	-7	-14	-3	-16	+1	+2	+7	+5	-4	-1	0	-2	-2	+3	+4	-2
12	+2	0	+2	-5	-1	-4	0	+1	+4	+5	0	0	+1	-7	-7	-6	+4	+4
13	+1	+1	-2	-2	+3	+2	+2	0	0	-5	-2	+1	0	+1	+1	-1	0	0
14	-4	-8	+6	+3	-3	+1	-5	+3	+4	+6	-2	-3	-2	+3	+3	+2	-5	-3
15	+1	0	-3	-4	0	-1	+14	+8	-20	-12	+3	+4	-7	+1	+1	0	+4	+4
16	+4	+5	+2	-1	-7	-5	-3	0	+1	0	-2	-3	+3	-1	-1	+4	-2	-2
17	-4	+6	-1	-1	+4	-7	+1	+10	-2	-3	+1	+2	-6	+1	+1	+2	+2	-2
18	-1	-3	-2	+2	-3	-1	-5	-3	-1	-2	-1	-1	0	0	0	0	+2	-1
19	0	-2	-4	0	-4	+6	-3	-1	-8	+4	+2	0	+4	-3	-3	-2	0	0
20	+4	+4	-2	-4	-2	-1	0	+3	-4	-7	-2	+3	+2	-4	-4	+7	+3	-9
21	+2	0	+3	+3	+5	+3	-1	-1	+3	0	-3	+3	+1	-1	-1	+5	-2	-2
22	-3	+1	-5	0	-1	-1	0	-13	+2	+2	-2	-1	0	+2	+2	-1	0	+2
23	-1	-2	-2	+2	+4	+2	+2	+1	-2	-2	-1	+2	+1	-1	-1	+1	-3	+2
24	0	0	+7	+2	+1	0	0	+2	+7	+4	-4	-2	+7	-2	-2	-2	-7	+9
25	-4	-2	+2	+6	0	-5	+7	-13	+3	+10	-6	-5	0	+3	+3	-1	-5	-4

H = Axis lying closest to the horizontal meridian

V = Axis lying closest to the vertical meridian

12.4 The analysis of variance of the results of the changes in corneal topography

Analysis of Variance (Two way factorial)

Changes in corneal topography

20° Temperal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	3.32	4.80	3.35
Corneal	3.44	5.68	2.80
Gel	2.67	1.86	3.90

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F Ratio
(a) Between visits	2	0.0626	0.0313	1.03
(b) Between lenses	2	0.0961	0.0480	1.58
(c) Interaction (a) x (b)	4	0.2619	0.0654	2.16
Residual	216	6.5466	0.0303	

Value of F from tables

Between visits	(p = 0.1)	= 2.30
	(p = 0.01)	= 4.61
Between lenses	(p = 0.1)	= 2.30
	(p = 0.01)	= 4.61
Interaction	(p = 0.1)	= 1.94

Analysis of Variance (Two way factorial)

Changes in Corneal Topography

15^{o} Temperal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	1.80	2.44	1.68
Corneal	2.42	2.76	1.93
Gel	1.70	1.72	2.26

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0092	0.0046	0.60
(b) Between lenses	2	0.0161	0.0080	1.05
(c) Interaction (a) x (b)	4	0.0267	0.0066	0.86
Residual	216	1.6529	0.0076	

Value of F from tables

Between visits ($p = 0.1$) = 2.30

Between lenses ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.94

Analysis of variance (Two way factorial)

Changes in corneal topography

10^{o} Temporal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20	Row Total
Control	1.08	1.00	0.82	2.90
Corneal	1.56	2.02	1.46	5.04
Gel	0.84	1.24	1.50	3.58

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0040	0.0020	0.52
(b) Between lenses	2	0.0314	0.0157	4.13
(c) Interaction (a) x (b)	4	0.0139	0.0034	0.89
Residual	216	0.8409	0.0038	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	2.90	5.04	3.58			
Comparison and number						
Control vs. Gel	+1	0	-1	-0.68	0.0031	0.81
Control vs. Corneal	+1	-1	0	-2.14	0.0322	8.04

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
Orthogonal comparisons	(p = 0.01)	= 6.63

Analysis of variance (Two way factorial)

Changes in corneal topography

5° Temporal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	0.82	0.76	0.68
Corneal	1.68	2.28	1.20
Gel	0.88	1.38	1.80

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0073	0.0036	0.87
(b) Between lenses	2	0.0572	0.0286	6.97
(c) Interaction (a) x (b)	4	0.0337	0.0084	2.04
Residual	216	0.9036	0.0041	

Value of F from tables

Between visits (p = 0.1) = 2.30

Between lenses (p = 0.1) = 2.30

Interaction (p = 0.1) = 1.94

Analysis of variance (Two way factorial)

Changes in corneal topography

0^{o} in the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	0.86	1.02	0.52	2.40
Corneal	2.78	2.02	2.70	7.50
Gel	0.94	1.58	1.88	4.40

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0026	0.0013	0.15
(b) Between lenses	2	0.1766	0.0883	10.63
(c) Interaction (a) x (b)	4	0.0353	0.0088	1.06
Residual	216	1.8107	0.0083	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	2.40	7.50	4.40			
Comparison and number						
Control vs. Gel	+1	0	-1	-5.10	0.1732	21.46
Control vs. Corneal	+1	-1	0	-2.00	0.0276	3.24

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.1)	= 2.71

Analysis of variance (Two way factorial)

Changes in corneal topography

5^{o} Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	0.80	0.66	0.42	1.88
Corneal	2.82	2.56	1.28	6.66
Gel	0.78	1.08	1.36	3.22

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0148	0.0074	2.24
(b) Between lenses	2	0.1630	0.0815	24.69
(c) Interaction (a) x (b)	4	0.0489	0.0122	3.69
Residual	216	0.7304	0.0033	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	1.88	6.66	3.22			
Comparison and number						
Control vs. Gel	+1	-0	-1	-4.78	0.1521	47.21
Control vs. Corneal	+1	-1	0	-1.34	0.0116	5.21

Value of F from tables

Between visits ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.94

Orthogonal comparisons ($p = 0.01$) = 6.63

($p = 0.05$) = 3.84

Analysis of variance (Two way factorial)

Changes in corneal topography

10^{o} Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20	Row Total
Control	0.82	0.84	0.62	2.28
Corneal	2.14	2.30	1.36	5.80
Gel	0.76	1.10	1.32	3.18

Variance

Source	Degrees of freedom	Sum of squares	Variance estimates	F ratio
(a) Between visits	2	0.0062	0.0031	0.93
(b) Between lenses	2	0.0894	0.0447	13.54
(c) Interaction (a) x (b)	4	0.0218	0.0054	1.63
Residual	216	0.7248	0.0033	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	2.28	5.80	3.18			
Comparison and number						
Control vs. Gel	+1	0	-1	-0.90	0.0054	1.68
Control vs. Corneal	+1	-1	0	-3.52	0.8273	25.06

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.1)	= 2.71

Analysis of variance (two way factorial)

Changes in corneal topography

15° Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	0.99	0.86	0.76	2.51
Corneal	1.42	2.52	1.98	5.92
Gel	0.92	1.70	1.80	4.42

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0247	0.0123	2.73
(b) Between lenses	2	0.0744	0.0372	8.26
(c) Interaction (a) x (b)	4	0.0217	0.0054	1.20
Residual	216	0.9872	0.0045	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment total	2.51	5.92	4.42			
Comparison and number						
Control vs. Gel	+1	0	-1	-1.91	0.2425	5.78
Control vs. Corneal	+1	-1	0	-2.41	0.3858	8.58

Value of F from tables

Between visits	(p = 0.1)	= 2.30
	(p = 0.05)	= 3.00
Interaction	(p = 0.1)	= 1.94
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.05)	= 3.84

Analysis of variance (Two way factorial)

Changes in corneal topography

20^{o} Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	1.06	1.34	1.68	4.08
Corneal	3.30	1.74	2.66	7.70
Gel	1.04	2.04	2.58	5.66

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0243	0.0121	1.80
(b) Between lenses	2	0.0870	0.0435	6.49
(c) Interaction (a) x (b)	4	0.0824	0.0206	3.07
Residual	216	1.4507	0.0067	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	4.08	7.70	5.66			
Comparison and number						
Control vs. Gel	+1	0	-1	1.58	0.01572	2.28
Control vs. Corneal	+1	-1	0	3.62	0.0808	12.04

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.01)	= 3.32
	(p = 0.05)	= 2.60
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.1)	= 2.71

Analysis of variance (Two way factorial)

Changes in corneal topography

25° Nasal aspect of the horizontal meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20	Row Total
Control	2.96	3.26	3.82	10.04
Corneal	4.96	4.70	4.50	14.16
Gel	2.40	4.14	3.60	10.14

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0255	0.0127	0.45
(b) Between lenses	2	0.1474	0.0737	2.64
(c) Interaction (a) x (b)	4	0.0582	0.0145	0.51
Residual	216	6.0331	0.0279	

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Between lenses	(p = 0.1)	= 2.30
	(p = 0.05)	= 3.00
Interaction	(p = 0.1)	= 1.94

Analysis of variance (Two way factorial)

Changes in corneal topography

20° Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12
Control	4.32	4.46	4.30
Corneal	4.66	3.08	3.88
Gel	3.80	2.82	3.88

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0417	0.0208	1.06
(b) Between lenses	2	0.0458	0.0229	1.16
(c) Interaction (a) x (b)	4	0.0364	0.0091	0.46
Residual	216	4.2505	0.0196	

Value of F from tables

Between visits $(p = 0.1) = 2.30$

Between lenses $(p = 0.1) = 2.30$

Interaction $(p = 0.1) = 1.94$

Analysis of variance (Two way factorial)

Changes in corneal topography

15^{o} Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	2.22	2.40	1.70
Corneal	2.22	2.34	2.44
Gel	1.83	2.04	3.14

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0070	0.0035	0.41
(b) Between lenses	2	0.0049	0.0024	0.28
(c) Interaction (a) x (b)	4	0.0442	0.0110	1.30
Residual	216	1.8355	0.0084	

Value of F from tables

Between visits (p = 0.1) = 2.30

Between lenses (p = 0.1) = 2.30

Interaction (p = 0.1) = 1.94

Analysis of variance (Two way factorial)

Changes in corneal topography

10° Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	1.02	1.32	1.34	3.68
Corneal	2.70	2.88	1.92	7.50
Gel	1.72	1.70	1.98	5.40

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0036	0.0018	0.29
(b) Between lenses	2	0.0989	0.0494	8.09
(c) Interaction (a) x (b)	4	0.0220	0.0055	0.90
Residual	216	1.3277	0.0061	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	3.68	7.50	5.40			
Comparison and number						
Control vs. Gel	+1	0	-1	-1.72	0.0197	3.21
Control vs. Corneal	+1	-1	0	-3.82	0.0981	16.54

Value of F from tables

Between visits	($p = 0.1$)	= 2.30
Interaction	($p = 0.1$)	= 1.94
Orthogonal comparisons	($p = 0.01$)	= 6.63
	($p = 0.1$)	= 2.71

Analysis of variance (Two way factorial)

Changes in corneal topography

5^{o} Inferior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	1.38	1.12	0.90	3.40
Corneal	2.74	2.77	1.79	7.30
Gel	0.98	2.24	1.32	4.54

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0297	0.0148	2.79
(b) Between lenses	2	0.1072	0.0536	10.11
(c) Interaction (a) x (b)	4	0.0340	0.0085	1.60
Residual	216	1.1598	0.0053	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	3.40	7.30	4.54			
Comparison and number						
Control vs. Gel	+1	0	-1	1.14	0.0087	1.67
Control vs. Corneal	+1	-1	0	3.90	0.1236	19.23

Value of F from tables

Between visits	(p = 0.1)	= 2.30
	(p = 0.05)	= 3.00
Interaction	(p = 0.1)	= 1.94
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.1)	= 2.71

Analysis of variance (Two way factorial)

Changes in corneal topography

0^{o} in the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	1.14	0.90	0.66	2.70
Corneal	2.49	2.32	1.50	6.31
Gel	1.10	1.52	1.92	4.54

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0036	0.0018	0.40
(b) Between lenses	2	0.0867	0.0433	9.62
(c) Interaction (a) x (b)	4	0.0373	0.0093	2.06
Residual	216	0.9840	0.0045	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment total	2.70	6.31	4.54			
Comparison and number						
Control vs. Gel	+1	0	-1	1.84	0.0226	5.03
Control vs. Corneal	+1	-1	0	3.61	0.0967	19.23

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
	(p = 0.05)	= 2.37
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.05)	= 3.84

Analysis of variance (Two way factorial)

Changes in corneal topography

5^{o} Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0	Week 4	Week 12	Row Total
Control	0.94	1.06	0.82	2.82
Corneal	2.52	2.42	1.52	6.46
Gel	1.14	1.58	1.60	4.32

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0108	0.0054	0.91
(b) Between lenses	2	0.0906	0.0453	7.67
(c) Interaction (a) x (b)	4	0.0218	0.0054	0.91
Residual	216	1.2831	0.0059	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	2.82	6.46	4.32			
Comparison and number						
Control vs. Gel	+1	0	-1	1.50	0.0142	2.54
Control vs. Corneal	+1	-1	0	3.64	0.0892	14.86

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.1)	= 2.71

Analysis of Variance (Two way factorial)

Changes in corneal topography

10° Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20	Row Total
Control	1.12	1.10	0.92	3.24
Corneal	1.88	2.10	1.74	5.72
Gel	1.66	1.96	1.66	5.28

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F Ratio
(a) Between visits	2	0.0127	0.0062	1.10
(b) Between lenses	2	0.0912	0.0412	7.48
(c) Interaction (a) x (b)	4	0.0310	0.0067	1.15
Residual	216	1.0132	0.0052	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	3.24	5.72	5.28			
Comparison and number						
Control vs. Gel	+1	0	-1	2.04	0.0166	3.19
Control vs. Corneal	+1	-1	0	2.48	0.0486	9.36

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
	(p = 0.05)	= 2.37
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.05)	= 3.84

Analysis of variance (two way factorial)

Changes in corneal topography

15^{o} Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20	Row Total
Control	1.30	1.32	1.54	4.16
Corneal	1.84	1.68	2.34	5.86
Gel	1.24	2.12	2.28	5.64

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0167	0.0083	2.12
(b) Between lenses	2	0.0226	0.0113	2.89
(c) Interaction (a) x (b)	4	0.0153	0.0038	0.97
Residual	216	0.8606	0.0039	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	4.16	5.86	5.64			
Comparison and number						
Control vs. Gel	+1	0	-1	1.48	0.0145	3.72
Control vs. Corneal	+1	-1	0	1.50	0.0150	3.85

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
	(p = 0.05)	= 2.37
Orthogonal comparsions	(p = 0.01)	= 6.63
	(p = 0.05)	= 3.84

Analysis of variance (two way factorial)

Changes in corneal topography

20^{o} Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20	Row Total
Control	1.89	2.06	1.72	5.67
Corneal	2.66	2.62	3.00	8.28
Gel	2.10	3.34	3.98	9.42

Variance

Source	Degrees of freedom	Mean square	Variance estimate	F ratio
(a) Between visits	2	0.0459	0.0229	2.8987
(b) Between lenses	2	0.1000	0.0500	6.39
(c) Interaction (a) x (b)	4	0.0470	0.0117	1.4810
Residual	216	1.7246	0.0079	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Mean square	F ratio
Treatment totals	5.67	8.28	9.42			
Comparison and number						
Control vs. Gel	+1	0	-1	3.75	0.0938	11.7
Control vs. Corneal	+1	-1	0	2.61	0.0479	6.2

Value of F from tables

Between visits	(p = 0.1)	= 2.30
Interaction	(p = 0.1)	= 1.94
	(p = 0.05)	= 2.37
Orthogonal comparisons	(p = 0.01)	= 6.63
	(p = 0.05)	= 3.84

Analysis of variance (two way factorial)

Changes in corneal topography

25^{o} Superior aspect of the vertical meridian

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	3.96	4.56	3.76
Corneal	4.40	3.28	5.48
Gel	2.60	3.20	4.52

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	0.0675	0.0337	1.72
(b) Between lenses	2	0.0502	0.0281	1.44
(c) Interaction (a) x (b)	4	0.1217	0.0304	1.55
Residual	216	4.2260	0.0195	

Value of F from tables

Between visits (p = 0.1) = 2.30
Between lenses (p = 0.1) = 2.30
Interaction (p = 0.1) = 1.94

Analysis of variance (two way factorial)

Changes in corneal topography

Horizontal meridian value

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	72	88	91
Corneal	87	101	54
Gel	81	77	73

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	15.4196	7.7098	0.76
(b) Between lenses	2	2.6990	1.3495	0.13
(c) Interaction (a) x (b)	4	40.8266	10.2066	1.01
Residual	216	2181.44	10.0992	

Value of F from tables

Between visits (p = 0.1) = 2.30

Between lenses (p = 0.1) = 2.30

Interaction (p = 0.1) = 1.94

Analysis of variance (two way factorial)

Changes in corneal topography

Vertical meridian value

Cell totals (sum of 25 values)

Group	Week 0 and 4	Week 4 and 12	Week 12 and 20
Control	84	95	117
Corneal	83	100	58
Gel	52	82	88

Variance

Source	Degrees of freedom	Sum of squares	Variance estimate	F ratio
(a) Between visits	2	24.4252	12.2126	1.11
(b) Between lenses	2	39.3842	19.6921	1.79
(c) Interaction (a) x (b)	4	63.6559	15.9139	1.44
Residual	216	2371.2000	10.9777	

Value of F from tables

Between visits ($p = 0.1$) = 2.30

Between lenses ($p = 0.1$) = 2.30

Interaction ($p = 0.1$) = 1.94

Discussion

The analysed results of the changes in corneal topography conform to a general pattern.

1) Corneal lens wearing subjects

The changes in corneal topography for the more peripheral regions of the cornea are shown to be statistically indistinguishable from those of the control patients: the relevant F ratios are summarised below:-

	Temporal		Inferior		Superior
Meridian and angle	20°	15°	20°	15°	25°
Calculated value of F	1.58	1.05	1.16	0.28	1.44
Value of F from tables ($p = 0.1$)	2.30	2.30	2.30	2.30	2.30

The changes in the more central regions of the cornea show a significantly different pattern: the calculated values of F exceeding the values of F from tables:-

	Temporal			Nasal			
Meridian and angle	10°	5°	0°	5°	10°	15°	20°
Calculated value of F	8.04	6.97	21.46	47.21	25.06	8.58	12.04
Value of F from tables	6.63	6.63	6.63	6.63	6.63	6.63	6.63

	Inferior				Superior	
Meridian and angle	10°	5°	0°	5°	10°	20°
Calculated value of F	16.54	19.23	19.23	14.86	9.36	11.78
Value of F from tables	6.63	6.63	6.63	6.63	6.63	6.63

2) Gel lens wearing subjects

Among gel lens wearing subjects a significant difference was also found to exist when compared to the control group. This difference was only demonstrated for certain regions of the cornea, and at certain levels of probability:-

	Horizon.	Nasal		Infer.	Vert.	Superior		
Meridian and angle	0^o	5^o	15^o	10^o	0^o	10^o	15^o	20^o
Calculated value of F	21.46	5.21	5.78	3.21	5.03	3.19	3.72	6.29
Value of F from tables	6.63	3.84	3.84	2.71	3.84	2.71	2.71	3.84
Level of probability	0.01	0.05	0.05	0.1	0.05	0.1	0.1	0.05

In the remaining regions of the cornea a comparison of the gel and control groups was found to be statistically insignificant by analysis of variance.

3) Changes in the meridian values

The calculated values of F for the meridians of the keratometric reading are both exceeded by the appropriate value of F from tables. Hence no change has been demonstrated for these criteria of the topographic readings.

Conclusion

1) Corneal lens wearing subjects

The significant changes in corneal topography among corneal lens wearing subjects was an anticipated aspect of this group. Shape changes expressed in terms of the central keratometric value have been reported on a number of occasions in the past [83,84,85]. The absence of a statistically discernible change in the peripheral topographic values does not necessarily imply that this region is unaffected in corneal lens wear. The manufacturers of the topographic keratometer state that the instrument is less accurate in the "peripheral zones". This claim is supported by an examination of the variance estimates: the values being greater at the periphery, than at the centre. It is therefore possible

that the statistically insignificant results arise from a lack of instrument accuracy rather than from a lack of response to corneal lens wear.

It is not possible from the present information to state whether the changes in corneal topography in corneal lens wear are regular or irregular. However, the changes in refraction and the reductions in visual acuity for this group would imply a general shape change in the corneas of those patients wearing corneal lenses coupled with some irregularity and consequent loss of optical quality of the anterior surface of the cornea.

2) Gel Lens wearing subjects

The statistically significant changes in corneal topography found among gel lens wearers is the only ocular response to these lenses found in the present study. The level of significance (0.05) is not as high as that found among corneal lens wearing subjects. The presence of more than one statistically significant different group, however, does suggest that the differences found are not caused by extreme random effects; thus implying a real response to gel lens wear in terms of corneal topography. Further replication in the experimental design would be necessary to confirm this hypothesis.

The incidence of the changes in corneal topography among gel lens wearing patients represents the first demonstrable response by the eye to gel lens wear and conforms to the similar changes found by Bonnet and El Hage [86]. The changes in the topography of gel lens wearing patients presents some interesting conclusions.. Among gel lens wearing patients the factors of visual acuity after lens wear, and the incidence

of "spectacle blur" (page 116) are statistically indifferent to analysis of variance techniques. This would suggest that the changes in ocular contour did not give rise to changes in the ocular refraction or produce changes in the visual acuity as a result of irregularity in the eye surface. These two conclusions are, however, a contradiction of one another: if the changes in the corneal topography were of a regular nature a change in the spectacle refraction should have resulted since the ocular prescription is a direct function of the shape of the anterior surface of the cornea. Conversely, if the changes in the shape of the cornea were irregular, a loss in visual acuity would have resulted as a product of the reduced optical quality of the corneal surface. The answer to this paradox is unfortunately not available from the present results, which are recorded only in terms of individual changes at regular points over the corneal surface. It therefore remains for a further detailed study of corneal shape in gel lens wear to examine this question further.

Section 13

13.1 Tabulated Results

Visual stability at twenty weeks

Results recorded in terms of visual acuity

Control

Time in seconds	30	60	90	120	150	180	Total Change
1	0.8	0.8	0.8	0.8	0.8	0.8	0.0
2	0.7	0.7	0.7	0.7	0.7	0.7	0.0
3	0.7	0.7	0.7	0.7	0.7	0.7	0.0
4	1.0	1.0	1.0	1.0	1.0	1.0	0.0
5	0.7	0.7	0.7	0.7	0.7	0.7	0.0
6	0.7	0.7	0.7	0.7	0.7	0.7	0.0
7	0.7	0.7	0.7	0.7	0.8	0.7	0.2
8	0.7	0.8	0.7	0.7	0.8	0.8	0.3
9	1.0	1.0	1.0	1.0	1.0	1.0	0.0
10	0.7	0.7	0.7	0.7	0.7	0.7	0.0
11	0.7	0.7	0.7	0.7	0.7	0.7	0.0
12	0.8	0.8	0.8	0.8	0.8	1.0	0.2
13	0.7	0.7	0.7	0.7	0.7	0.7	0.0
14	0.7	0.7	0.7	0.7	0.7	0.7	0.0
15	1.0	0.8	0.8	0.8	0.8	0.8	0.2
16	0.7	0.7	0.7	0.7	0.7	0.7	0.0
17	0.8	0.8	0.8	0.8	0.8	0.8	0.0
18	0.7	0.7	0.7	0.7	0.7	0.7	0.0
19	0.7	0.7	0.7	0.7	0.7	0.7	0.0
20	0.8	0.7	0.8	0.7	0.7	0.7	0.3
21	0.7	0.7	0.7	0.7	0.7	0.7	0.0
22	0.7	0.7	0.7	0.7	0.7	0.7	0.0
23	0.7	0.7	0.7	0.7	0.7	0.7	0.0
24	0.7	0.7	0.7	0.7	0.7	0.7	0.0
25	0.7	0.7	0.7	0.7	0.7	0.7	0.0

Visual stability at twenty weeks

Results recorded in terms of visual acuity

	Corneal						
Time in seconds	30	60	90	120	150	180	Total Change
1	0.7	0.7	0.8	0.7	0.8	0.7	0.4
2	0.7	0.8	0.7	0.7	0.7	0.7	0.2
3	0.7	0.7	0.7	0.7	0.7	0.8	0.1
4	0.7	0.8	0.8	0.8	0.8	0.8	0.1
5	0.7	0.7	0.7	0.7	0.7	0.7	0.0
6	0.8	0.8	0.8	0.8	0.8	0.7	0.1
7	0.8	0.8	0.7	0.8	0.8	1.0	0.4
8	0.7	0.7	0.8	0.7	0.8	0.7	0.3
9	0.7	0.8	0.8	0.7	0.7	0.7	0.2
10	0.8	0.8	0.8	0.7	0.7	0.8	0.2
11	0.7	0.7	0.7	0.7	0.7	0.7	0.0
12	0.8	1.2	1.2	0.8	1.0	0.8	0.2
13	0.7	0.7	0.8	1.0	1.0	1.0	0.3
14	0.7	0.7	0.7	0.7	0.7	0.7	0.0
15	0.7	0.7	0.7	0.7	0.7	0.7	0.0
16	0.8	0.8	0.8	0.8	0.8	1.0	0.2
17	0.8	1.0	0.8	0.8	0.8	1.0	0.6
18	0.7	0.7	0.7	0.7	0.7	0.7	0.0
19	1.0	1.0	1.0	1.2	1.0	1.0	0.4
20	0.8	1.0	0.8	0.8	0.8	0.8	0.4
21	0.7	0.7	0.7	0.8	0.8	0.7	0.3
22	1.5	1.2	1.5	1.2	1.0	1.0	1.1
23	0.7	0.7	0.7	0.8	0.8	0.8	0.1
24	0.7	0.7	0.7	0.7	0.7	0.7	0.0
25	0.7	0.7	0.7	0.7	0.7	0.7	0.0

Visual stability at twenty weeks

Results recorded in terms of visual acuity

	Gel						
Time in seconds	30	60	90	120	150	180	Total Change
1	1.2	1.0	1.0	1.0	1.2	1.2	0.6
2	3.0	3.0	3.0	2.0	2.0	3.0	2.0
3	0.7	0.7	0.7	0.7	0.7	0.7	0.0
4	1.5	0.8	1.2	1.2	2.0	1.0	2.9
5	0.8	0.8	0.8	1.0	0.8	0.8	0.2
6	1.0	1.0	0.8	1.0	1.5	1.0	0.7
7	3.0	0.8	1.2	1.2	3.0	1.5	5.9
8	1.2	2.0	1.0	1.0	1.0	1.5	2.3
9	0.7	0.7	0.8	1.5	1.0	0.7	1.6
10	1.2	2.0	2.0	3.0	2.0	2.0	2.8
11	2.0	1.5	2.0	1.2	1.2	1.2	1.8
12	1.2	1.0	1.2	1.0	1.0	1.0	0.6
13	1.5	1.0	1.0	1.0	0.8	1.0	0.9
14	1.0	1.0	0.8	0.8	1.0	1.0	0.2
15	0.8	1.0	1.0	1.0	1.2	0.8	0.8
16	1.2	1.0	1.2	1.5	1.2	1.2	1.0
17	1.0	0.8	1.0	1.0	1.0	1.0	0.4
18	0.8	0.8	1.0	1.0	1.0	0.8	0.4
19	1.0	1.0	1.0	1.2	2.0	1.2	1.8
20	2.0	1.5	1.2	1.0	1.5	1.2	1.8
21	1.5	1.2	1.2	1.2	1.2	1.5	0.6
22	1.0	1.0	0.8	0.8	0.8	1.0	0.4
23	1.2	1.2	1.0	1.2	1.0	1.2	0.8
24	1.2	1.2	1.2	1.0	0.8	1.0	0.6
25	0.8	1.0	0.8	0.8	0.8	0.8	0.4

13.2 Analysis of Variance (Multiple One Way)

Visual stability expressed in terms of visual acuity

Analysis

Source of variance	Degrees of freedom	Sum of squares	Variance estimate	F ratio
Between groups	2	20.3703	10.1851	17.44
Residual	72	42.0437	0.5839	

Orthogonal comparisons

Treatment	Control	Corneal	Gel	Treatment difference	Variance estimate	F Ratio
Treatment totals	1.2	6.2	31.5			
Comparison and number						
Gel vs. Control	+1	0	-1	31.3	19.4	33.30
Corneal vs. Control	+1	-1	0	5.0	0.5	0.87

Value of F from tables

F (for a probability p = 0.01) = 7.08

(for a probability p = 0.1) = 2.79

Discussion

The calculated value of F is exceeded by the value of F for the orthogonal comparison of the gel and control groups, by 25.22 (for a probability p of 0.01). This indicates a significant increase in visual variability for gel lens wearing patients.

The appropriate value of F for the corneal / control comparisons is exceeded by the calculated value, by 1.92 (for a probability p of 0.1). The lack of a significant difference between the two groups implies that no increase in the variability of vision has been demonstrated for those patients wearing corneal lenses.

Conclusion

The demonstration of an increased variability of vision among gel lens wearing patients confirms the subjective symptoms recorded by these subjects. At the completion of twenty weeks of wear 16 of the group of twenty five patients reported their vision to "vary or fluctuate". This instability in vision was a troublesome factor in gel lens wear and 13 patients reported that they were "not satisfied" with their level of vision for close work and 10 were "not satisfied" with their level of distance vision.

The confirmation of the experimental results by the patients subjective symptoms presents a prohibition on the use of these lenses, in their present form, in normal opthalmic practice.

Section 14

14.1 Tabulated Results

The Incidence of the Objective Signs of Corneal Oedema

a) The corneal periphery

	Presence of oedema	Absence of oedema
Control	24	1
Gel	25	0
Corneal	25	0

Chi squared analysis

Value of x^2 for control/gel comparison = 1.02

Value of x^2 for control/corneal comparison = 0.00

b) The central corneal region

	Presence of oedema	Absence of oedema
Control	1	24
Gel	2	23
Corneal	13	12

Chi squared analysis

Value of x^2 for control/gel comparison = 0.3545

Value of x^2 for control/corneal comparison = 14.2857

Value of F from tables for one degree of freedom at a probability of 0.005 = 7.88

Conclusion

The value of x^2 from tables for a probability of 0.05 is exceeded by only one calculated value: that of the control/corneal comparison for the central region of the cornea. Hence it is only for this group and area that a significant difference between groups has been established.

Discussion

The significant increase in epithelial oedema of the central corneal region of corneal lens wearing subjects is greater than is shown by an examination of the symptoms of corneal oedema for this group (page 117). At twenty weeks no patient reported the symptoms of corneal oedema at the time of examination although a total of seven patients had reported symptoms on previous visits. This would suggest that whilst a proportion of corneal lens wearing subjects show objective evidence of an oedematous state of the cornea, few if any patients are aware of this condition.

Among gel lens wearing subjects no significant difference has been established with respect to the control group, and no patient reported any symptoms of oedema at twenty weeks. This lack of ocular response conforms to the general pattern of the other measured factors for this group of patients.

Section 15

Conclusion

The discussion and conclusions of the analysed results of each individual factor suggest a general conclusion for the overall ocular response of the two forms of contact lenses. With the probable exception of the changes in corneal topography no discernible change has been demonstrated in the ocular parameters of those patients wearing gel contact lenses. Among those patients wearing corneal lenses, each of the observed parameters has undergone a change which conforms to the previous clinical experience of these lenses.

One factor, however, has marred the apparent improvement in gel lenses; that of the quality of vision. The lower visual acuity and visual instability among gel lens wearing patients is a shortcoming, which at present precludes the use of these lenses in general Ophthalmic practice. In considering the ways in which the quality of vision with gel lenses might further be improved, it may be of interest to examine the steps in lens design already taken.

The isolation and study of the three design parameters referred to in Section 3 provided a lens of apparently improved optical performance. However, in general terms, the design of gel lenses still remains unsophisticated; the question of the topographical shape of the front and rear lens surface remains uninvestigated as does the relationship of the one to the other. The overall physical properties of the material from which gel lenses are made has also not been exhaustively examined from the point of view of contact lens performance. A search of the available literature has failed to reveal a reference to studies

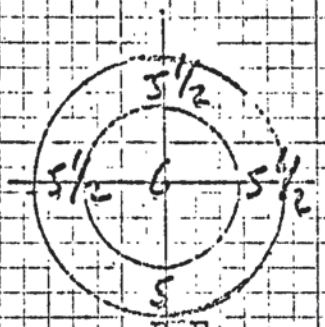
of the surface hardness or flexibility characteristics of hydrophilic gel lenses. It would therefore seem reasonable that before gel lenses can be rejected on the grounds of poor optical properties, a more sophisticated analysis of the design of this new form of contact lens could be carried out. Certainly the very much improved ocular response of gel lenses as compared to traditional corneal lenses would provide a strong motivation for further work.

Should further work be carried out on the design of gel lenses, it may yet be possible that the original concept of the Czech workers of a mass produced, mass fitted contact lens could be realised.

Appendix

An Example of a Patient's Complete Clinical Record

CORNEAL SENSITIVITY



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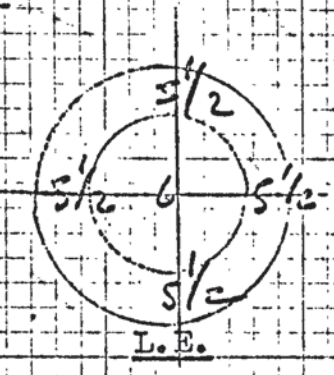

L.E.

CORNEAL STAINING

CLASIFICATION

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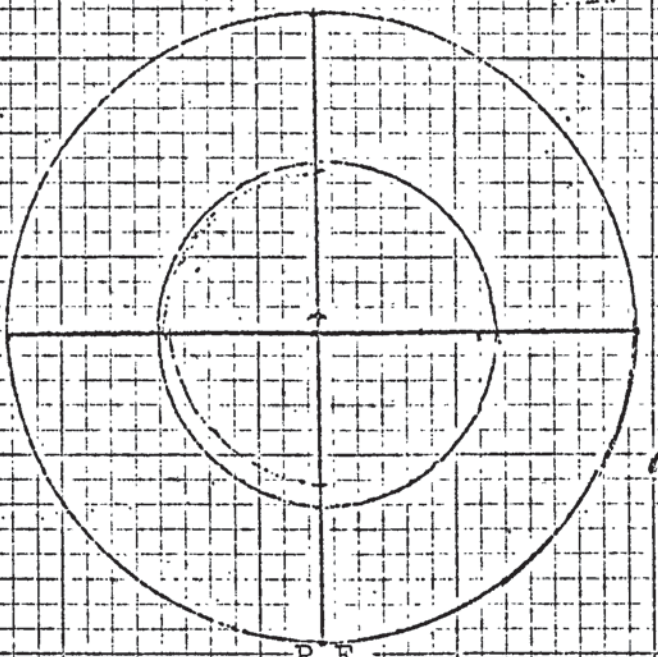

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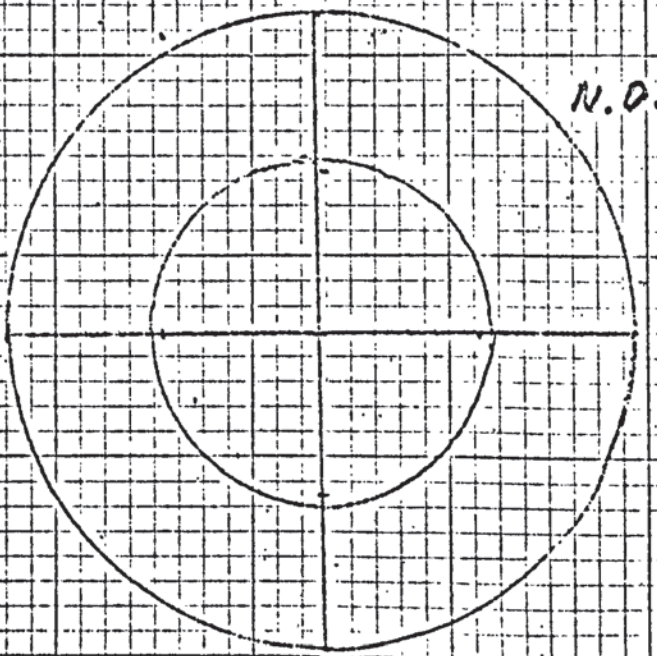
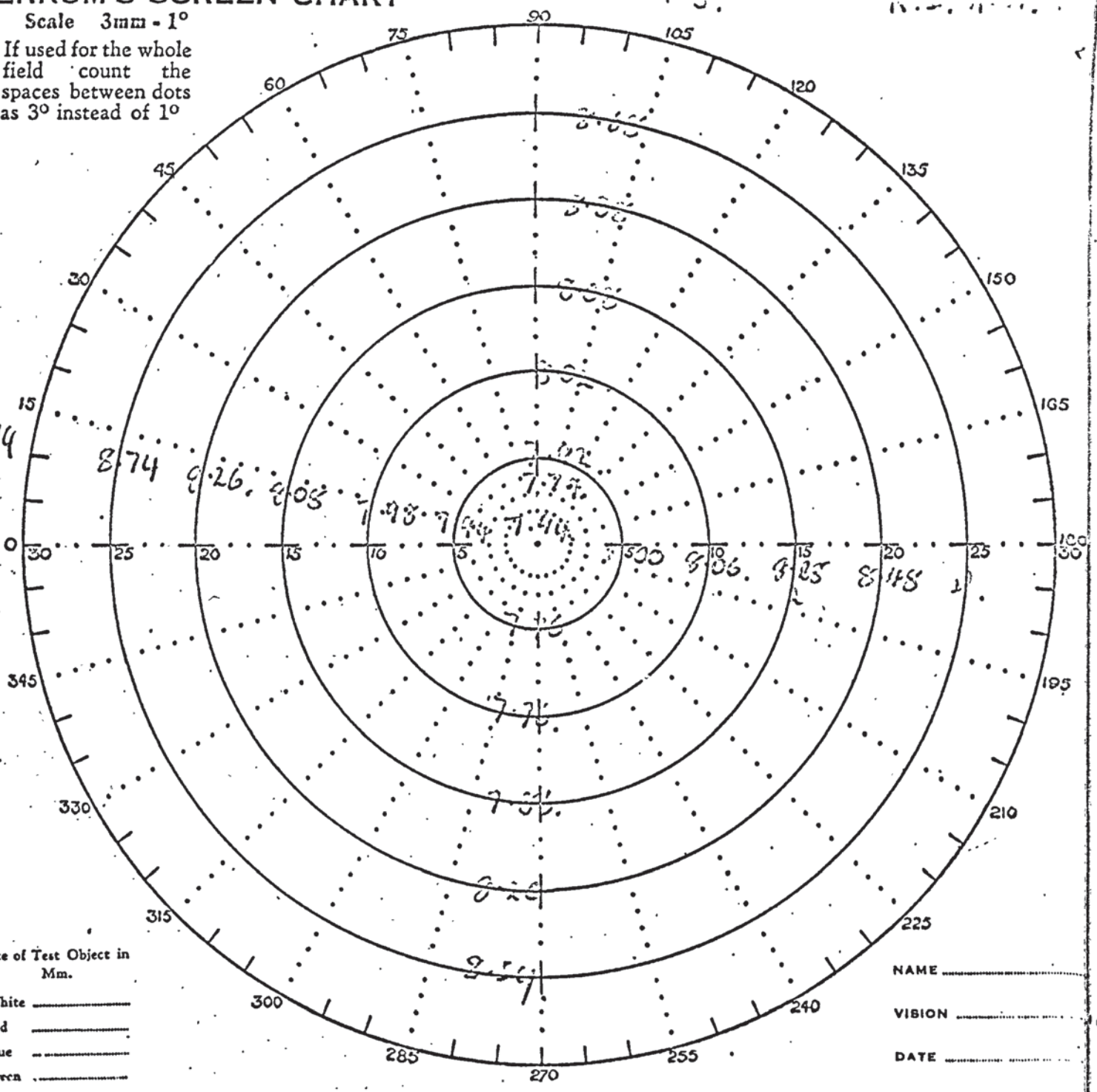


L.E.

BJERRUM'S SCREEN CHART

Scale 3mm - 1°

If used for the whole field count the spaces between dots as 3° instead of 1°



Size of Test Object in Mm.

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NAME _____

VISION _____

DATE _____

BJERRUM'S SCREEN CHART

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Scale 3mm - 1°

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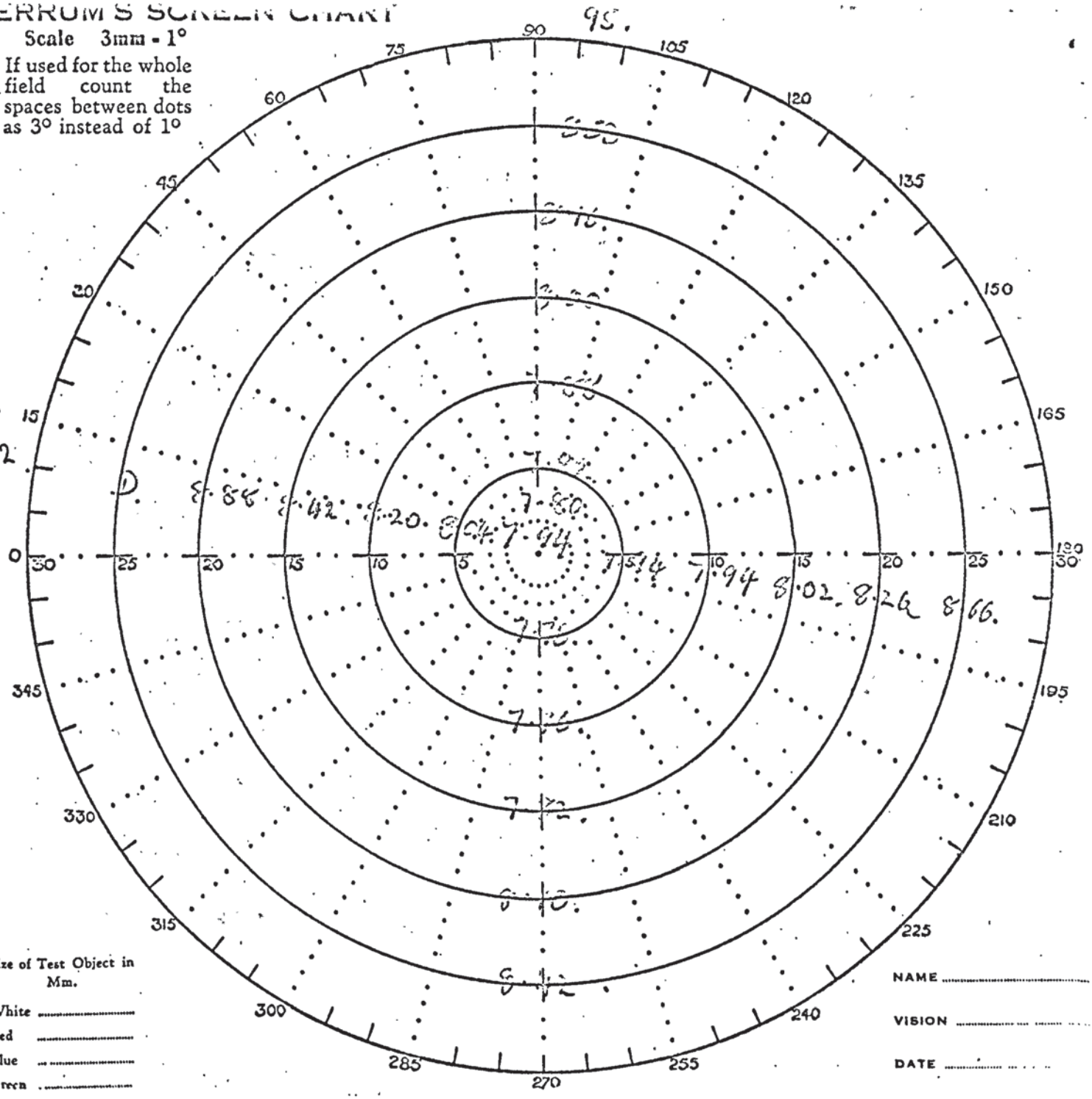

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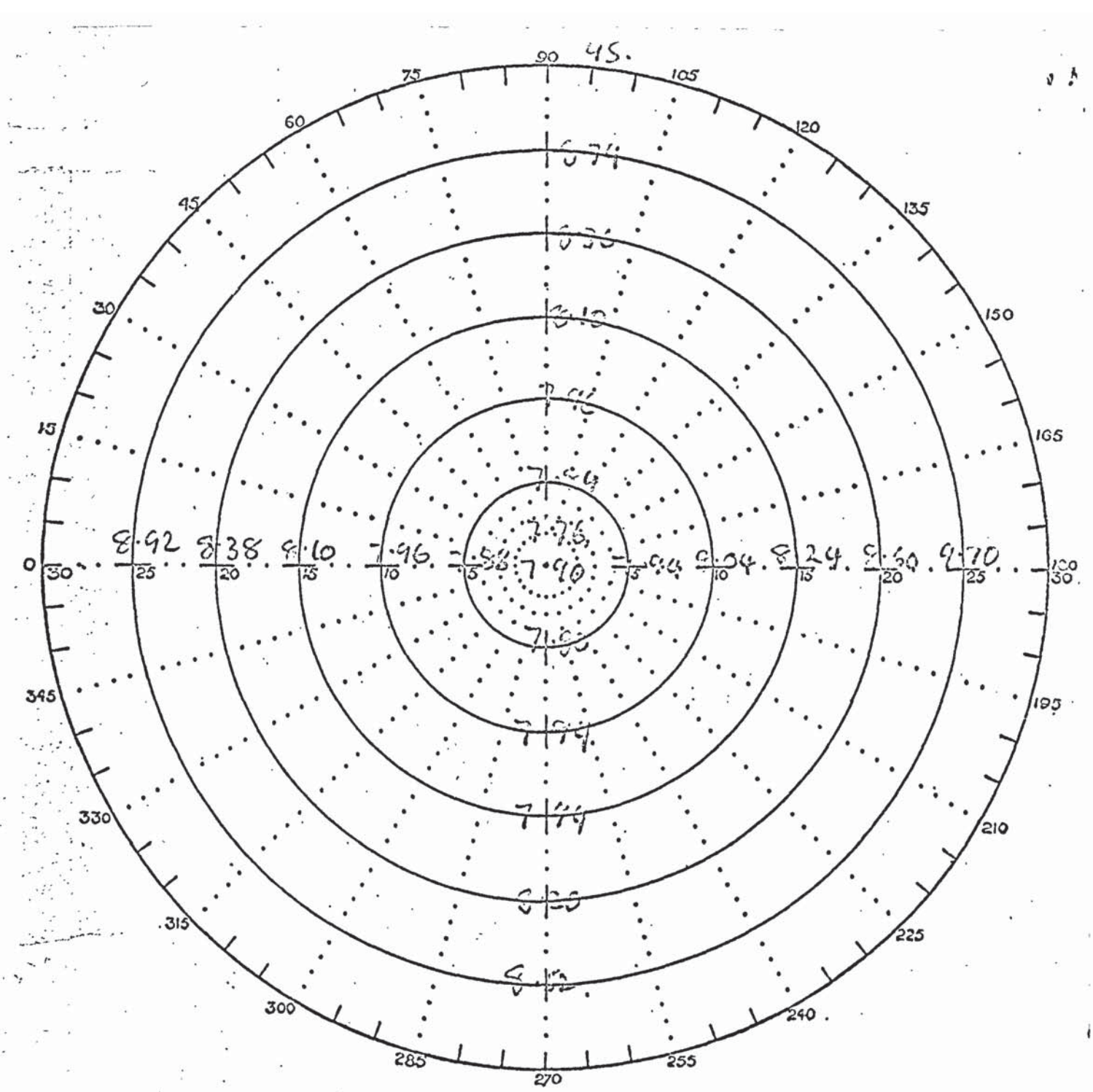
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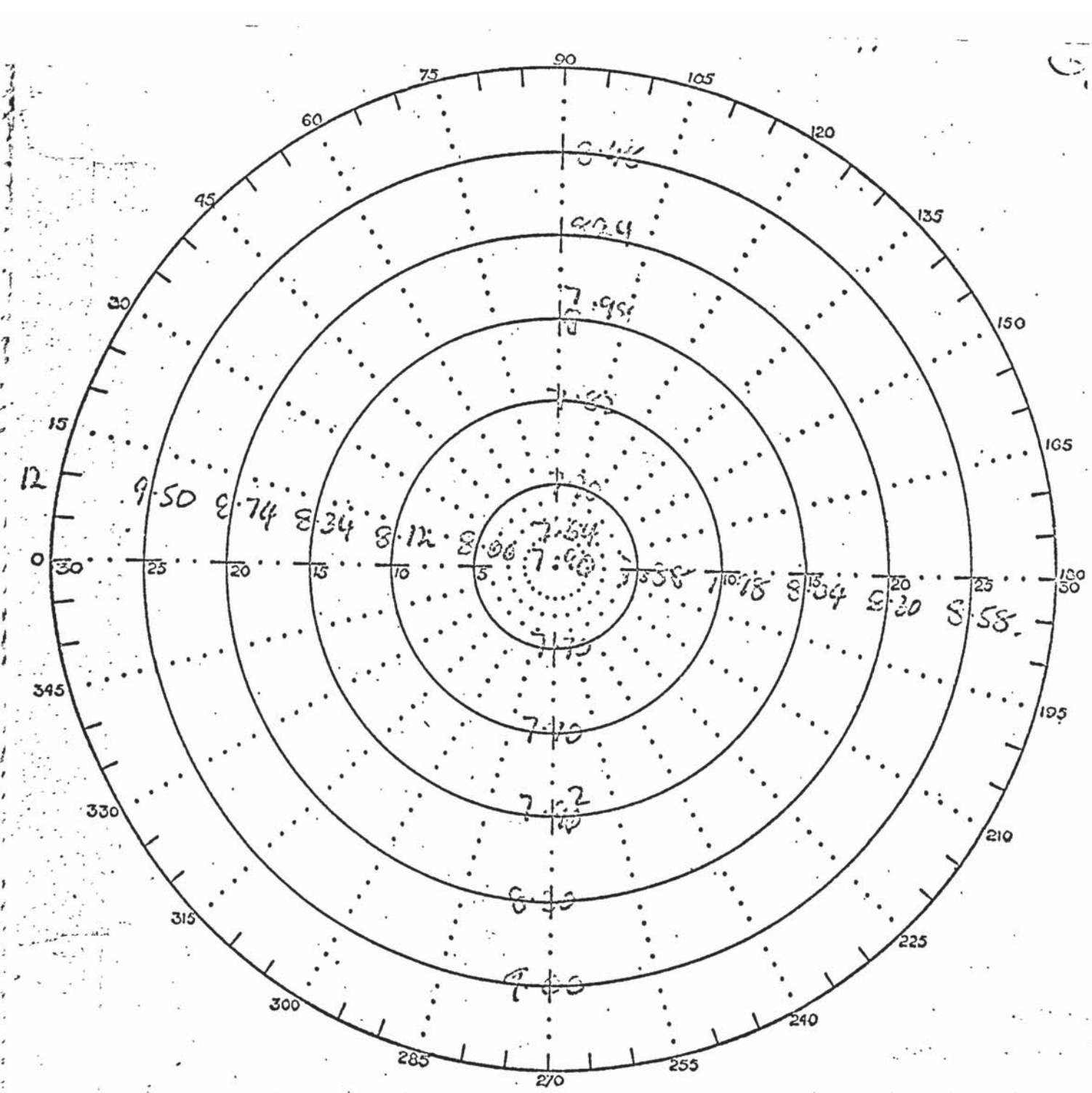
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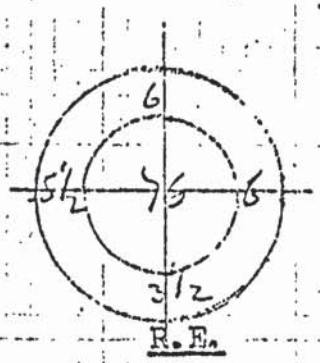
CORNEAL SENSITIVITY



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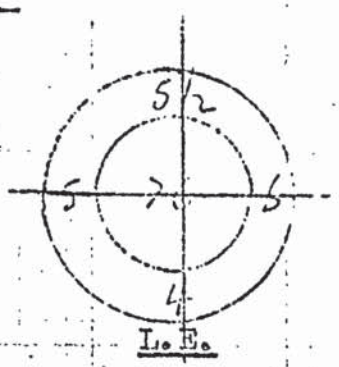

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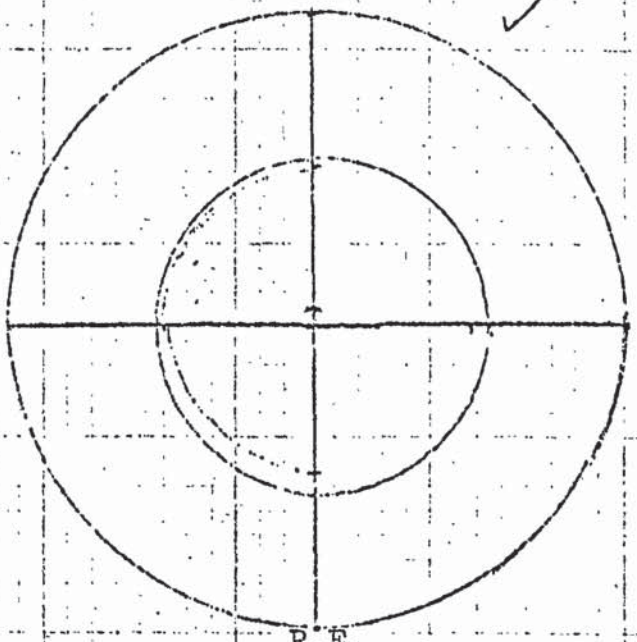
CORNEAL STAINING



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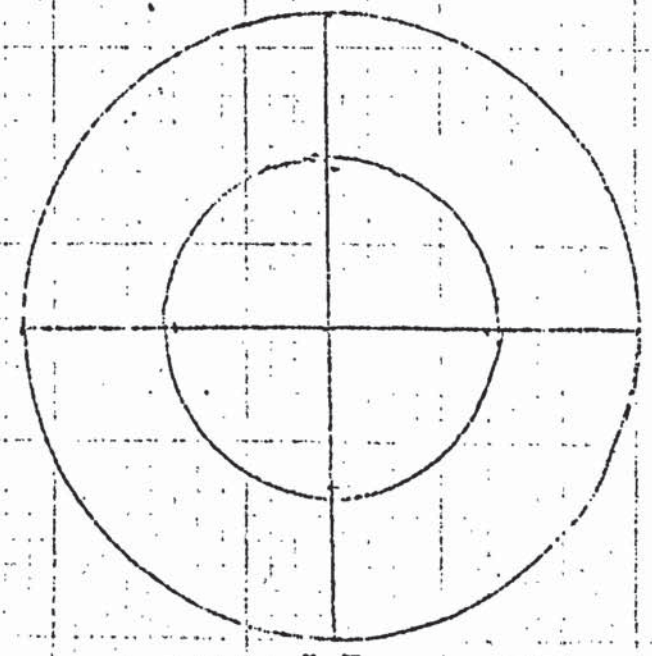

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CLASIFICATION

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AFTER CARE

REPORT NO:.2.. DATE.16/5/68 4.30.

EXAMINATION AFTER ..9½..HRS WEAR.

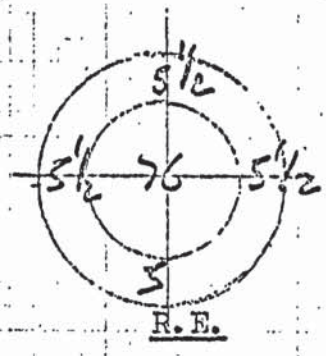
	R.E.	L.E.	
RIDING POSITION.			
VISION.	6/6+2.	6/6-1	B 6/5-2.
Rx(with lenses)	0.00/-0.25 D 165	-1.00/-0.50 D 90	
VISUAL ACUITY.	6/6+2	6/5+4	B 6/4-1
OEDEMA(subjective)	NEGATIVE.		

LENSES REMOVED

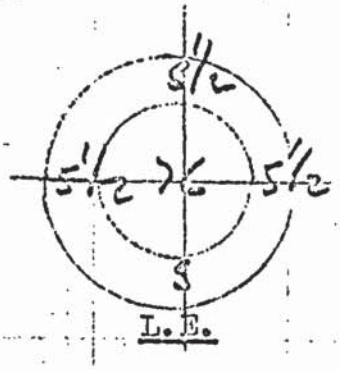
Rx	-3.00/0.5 D	-4.00/-0.50 115.	
VISUAL ACUITY	6/5+4.	6/5+3	B 6/5+4
OEDEMA (subjective)	NEGATIVE.		

COMMENTS

CORNEAL SENSITIVITY

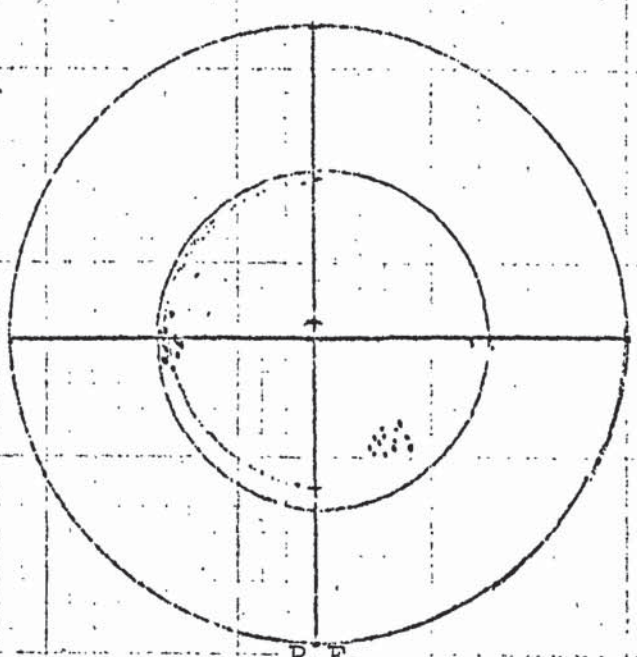


R.E.



L.E.

CORNEAL STAINING



R.E.

CLASIFICATION

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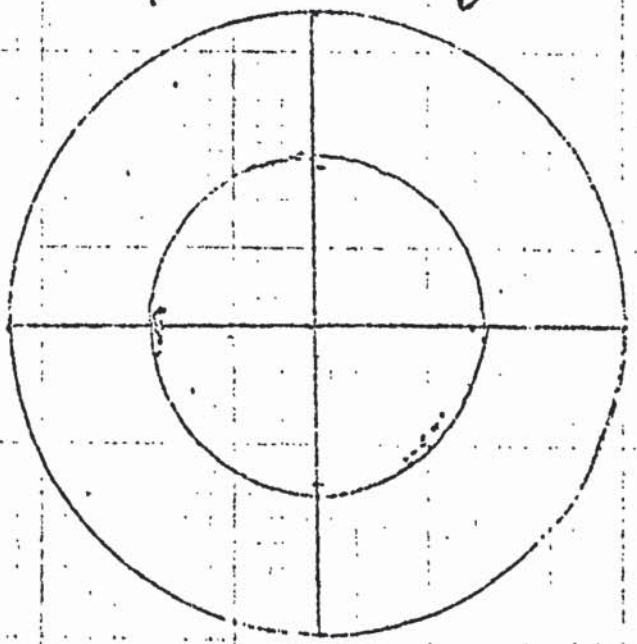

L.E.

CLASIFICATION

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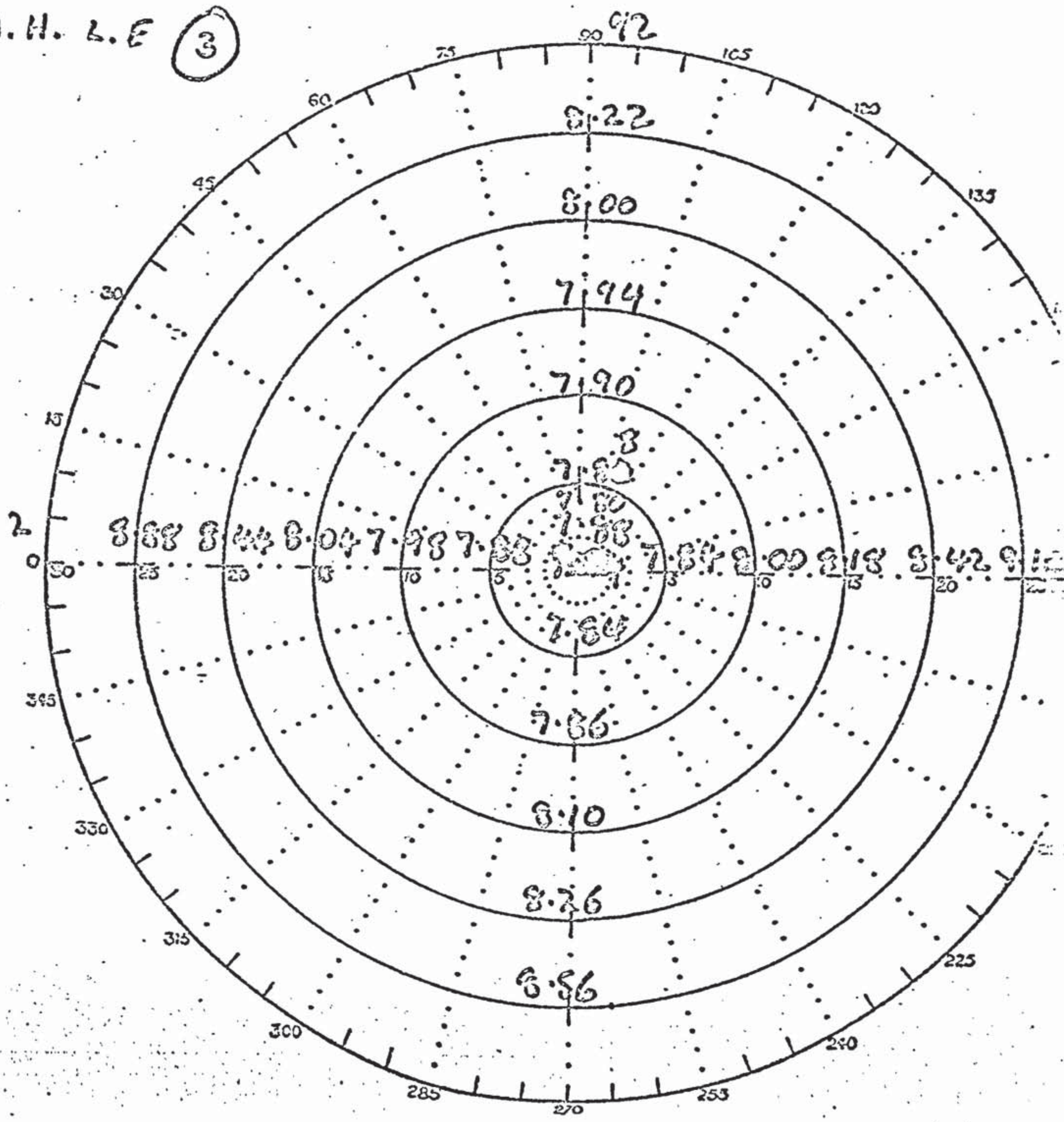
R.A.H. L.E (3)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300
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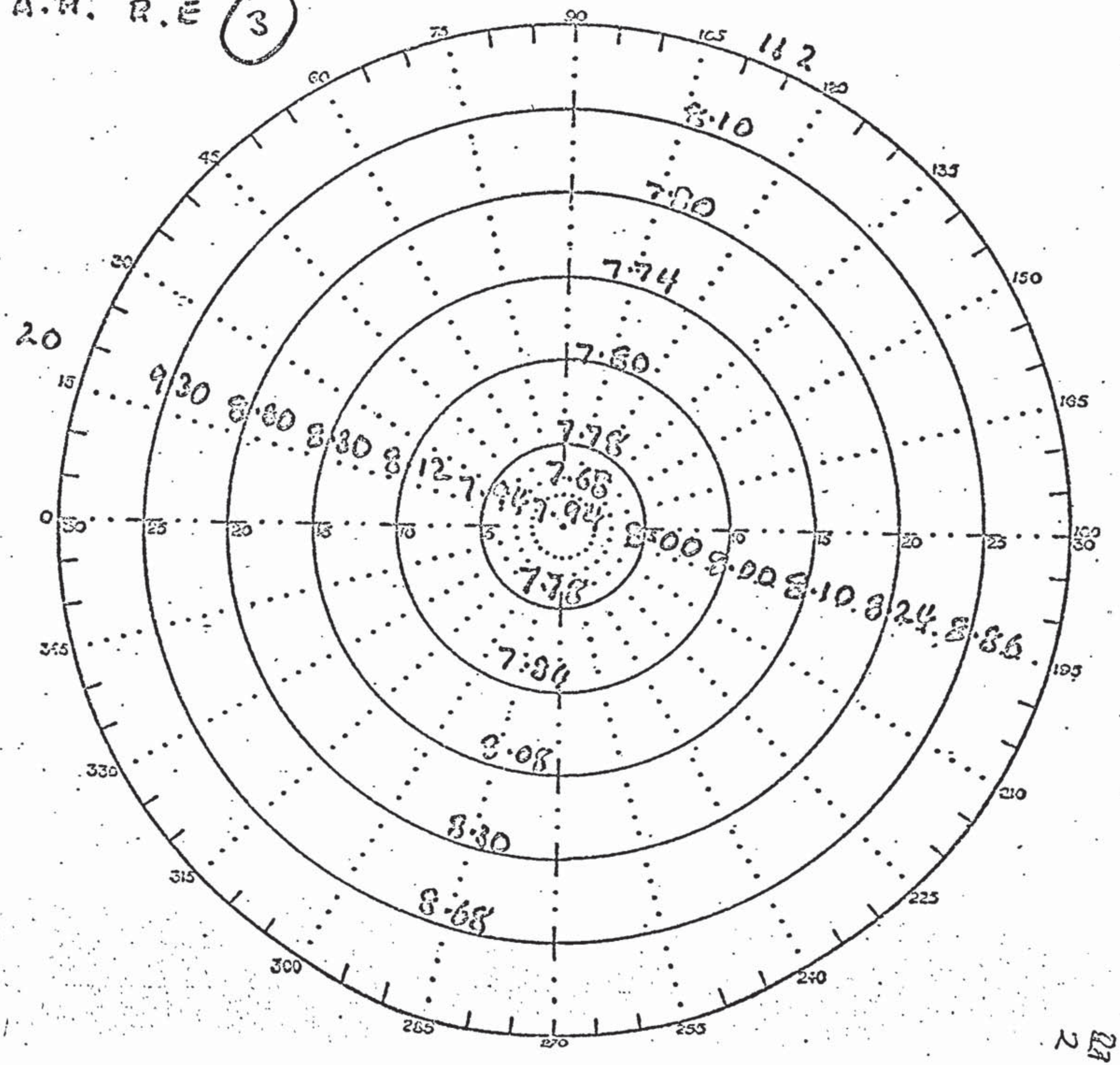
R. A.M. R.E (3)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7·78
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8·08
8·30
8·68

AFTER CARE

REPORT NO: 3 DATE. 23/ 7/68

EXAMINATION AFTER 5½ HRS WEAR.

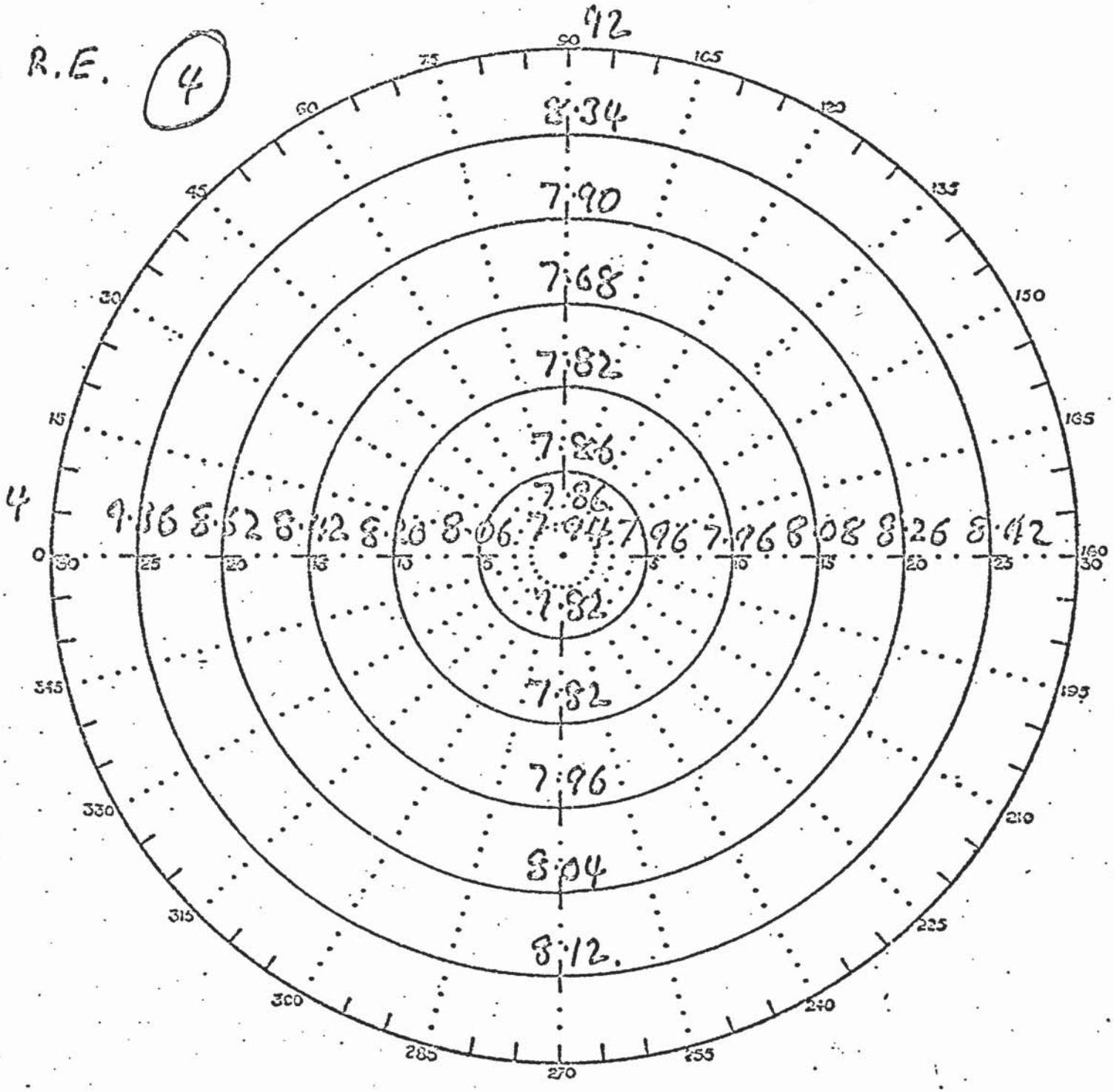
	R.E.	L.E.
RIDING POSITION.		
VISION.	6/5+3.	6/9-1, 6/5+3
Rx(with lenses)	+0.50/-0.DS.10	+0.25/-0.DS. 120.
VISUAL ACUITY.	6/9-1	6/9-1. 6/9.
OEDEMA(subjective)	NEGATIVE.	

LENSES REMOVED

Rx	-2.00/-0.CD.180	-3.00/-1.CD 120
VISUAL ACUITY	6/9-1	6/9-1, 6/9-1
OEDEMA (subjective)	NEGATIVE.	

COMMENTS

R.A.H. R.E. (4)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7.96
8.04
8.12
4
9.16 8.52 8.12 8.20 8.06 7.94 7.96 7.96 8.08 8.26 8.42
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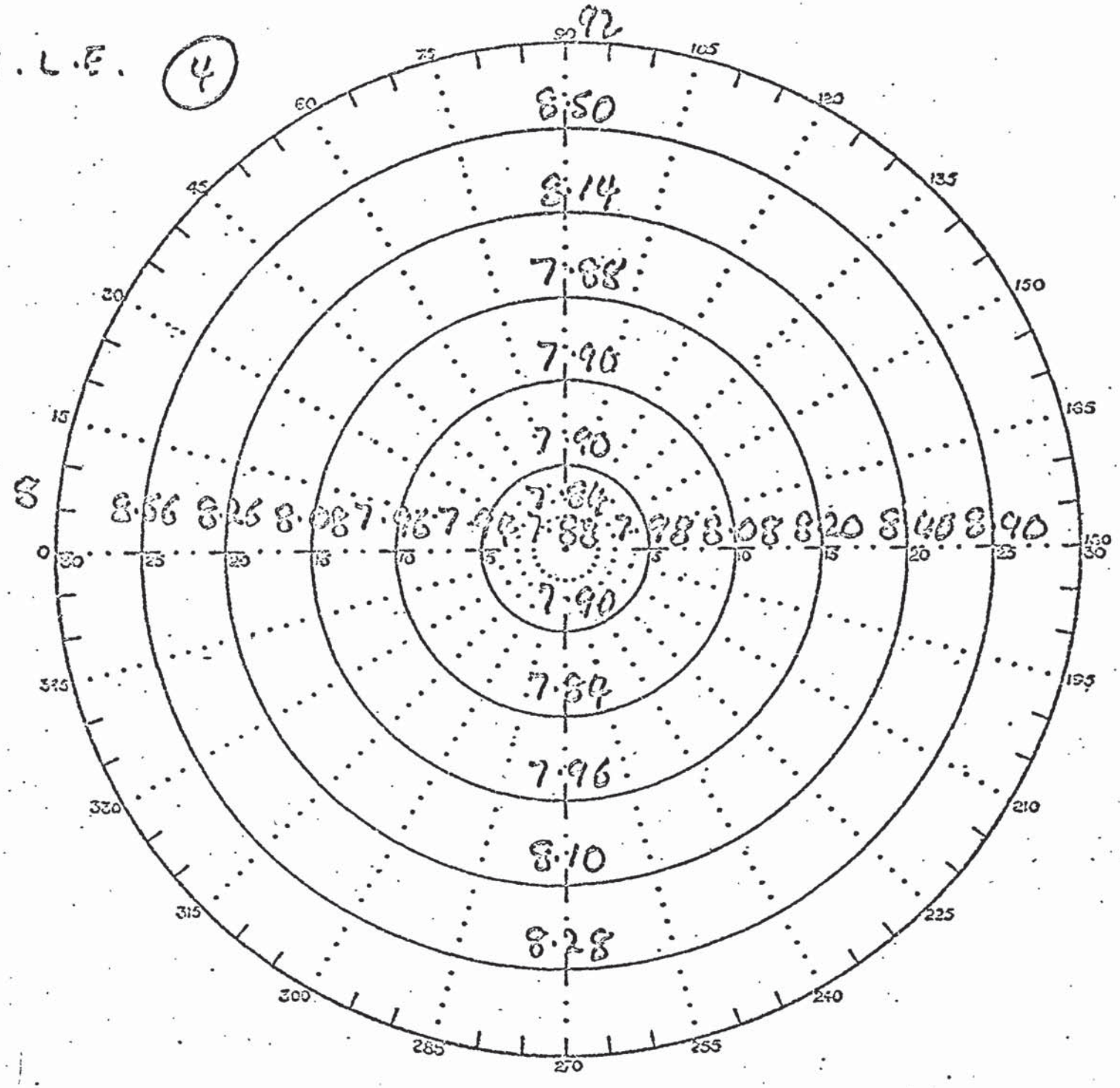
R. A-H. L.E. (4)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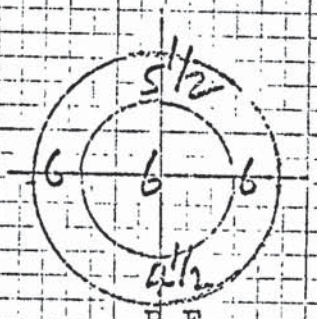
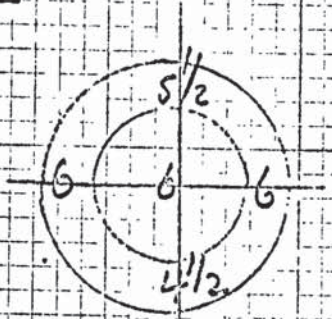
CORNEAL SENSITIVITY

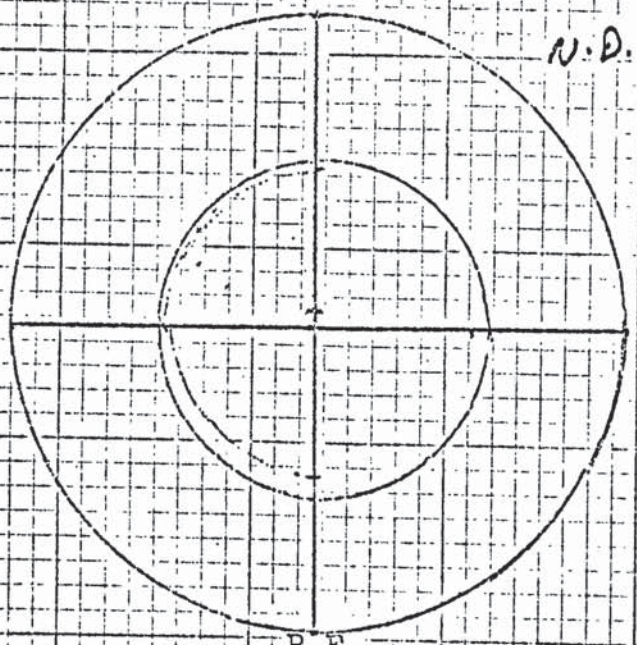


R.E.



L.E.

CORNEAL STAINING



N.D.S.

CLASIFICATION

1.
2.
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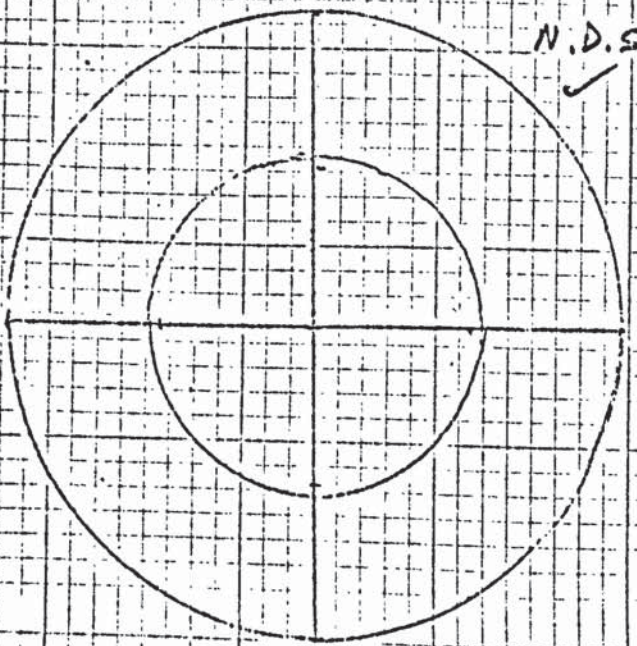
4.
5.
6.
7.

R.E.



N.D.S.

CLASIFICATION

1.
2.
3.
4.
5.
6.
7.

L.E.

The Department of Ophthalmic Optics

Supplementary Questionnair

1) When you first started wearing your contact lenses did your vision, vary or fluctuate? Yes ✓ No .....

2) If yes to question 1) how many days/weeks passed before your vision settled down? 6 days ..... weeks

3) If your vision has not settled down tick the appropriate space — right eye ..... left eye .....

4. Are you satisfied with the level of vision achieved with your contact lenses:

   1) For close work — Yes ✓ No .....
   2) For distance vision — Yes ✓ No .....

5) When you have been wearing your contact lenses have you ever noticed coloured haloes round lights? Yes ..... No ✓

6) If yes to question 5) did the haloes cease after the first few weeks of lens wear? Yes ..... No .....

7) If no to question 6) do you notice haloes occasionally or almost every day? Occasionally ..... No .....

8) If almost every day, after approximately how many hours wear do you first notice haloes (average) ..... hours

9) During your period of contact lens wear has your vision ever appeared double?

   For near work — Yes ..... No ✓
   For distance vision — Yes ..... No ✓

10) If yes to question 9) is your vision double

   Very occasionally .....
   Occasionally :::::
   On most occasions .....
   On all occasions .....

The Department of Ophthalmic Optics

Supplementary Sheet

White Light

'Bedewing'

	R.	L.
1)	✓	✓
2)		
3)		
4)		
5)		

Near V.A.

R.E. N. 5.

L.E. N. 5. B. N. 5.

V.A. Variability

	0.	30 20sec	60 40sec	90 60sec	120 80sec	150 100sec
R.E.	6/~~12~~ 18	6/7.5.	6/6	6/6-1	6/6-2.	6/07.5.
L.E.	6/12 9	6/6	6/6	6/7.5-1	6/6	6/018

	180 120sec
R.E.	6/7.5-2
L.E.	6/7.5.

Bibliography

1) Panas. P. Presentation of of instruments and apparatus. Pt. 4. Bull. Acad. Med. Ser. 3. (19). 400 - 401. 1888

2) Fick. A.E. Eine Contactbrille. Arch. f. Augenheilk. 18. 279-289. 1888.

3) Mann. I. History of contact lenses. Trans. Ophthal. Soc. U.K. 58. (1). 109 - 136. 1938.

4) Graham. A. The corneal lens - A progress report. Amer. J. Optom. 26.. (75). 77. 1949.

5) Busch. H. The corneal lens of Wohlk. Der Augenoptiker. 19. (2). 10. 1964.

6) Obrig. T. Contact Lenses. 3rd ed. New York. Obrig Laboratories. 188. 1957.

7) De Carle. J. Corneal Flange Contact Lenses. Opt. (Eng.). 125. 616-617. 1953.

8) Dunn. G.M. Independent Curve corneal Fitting. Opt. (Eng.). 138. 501-503. 1959.

9) Huang. D.T. Bicurve and Tricurve Contact Lenses. Optom. wkly. 50. 2453-2457. 2518-2520. 1959.

10) Dickenson. F. Multicurve microlens. Contracto. 8. 4. 1964.

11) Moss. H.L. A Review of small corneal lenses and the corneal relationship. Amer. J. Optom. 41. 609. 1964.

12) Nissel. G. Offset corneal contact lenses alias parabolic lenses and suchlike. Oph. Opt. 6. (17). 857-860. 1966.

13) Berens. C. Corneal contact lenses: a clinical investigation. Trans. Amer. Ophthal. 50. 55-75. 1952.

14) Chen. D.K. Smelser. G.K. Physiological changes in cornea induced by contact lenses. Arch. Ophthal. (Chicago). 53. 676-679. 1955.

15) Black. C.J. Ocular anatomical and physiological changes due to contact lenses. Illinois Med. J. 118. 279-281. 1960.

16) Dixon. J.M. Pathology of the eye due to contact lens wear. Trans. Pacif. Cst.Oto.Ophthal.Soc. 44. 103-121. 1963.

17) Rengstroff. R.H. Corneal curvature and astigmatic changes subsequent to contact lens wear. J. Amer. Optom Ass. 36. 996-1000. 1965.

18) Rengstroff. R.H. Contact lenses and after effects: Some temporal factors which influence myopia and astigmatic variations Am. J.of Optom. 45 (6) 364-373. 1968.

19) Cochet. P. Bonnet. R. Epithelial reactions to contact glasses. Bull. Soc. Ophthal. Fr. No 1. 20-27. 1959.

20) Shulman. P.F. Clinical pathology caused by contact lenses. Opt.Wkly. 57.(28). 37-42. 1966.

21) Wichterle. O. Lim. D. United States Patent No. 2,976,576. March 28th 1961.

22) Wichterle. O. Lim. D. United States Patent No.3,220,960. March 28th 1961.

23) Wichterle. O. Lim. D. Dreifus M. A contribution to the problem of contact lenses. Csl.Ofthal 17. 70-75. 1961.

24) Dreifus. M. Wichterle. O. Clinical experience with hydrophilic contact lenses. Cs. Ofthal. 20. (5). 393-399. 1964.

25) Driefus. M. Personal communication 1968.

26) Hart. R.S. An interesting experience with hydrophilic lenses. Opt.(Eng). 150. 291. 1965.

27) Anon. Studies with hydrophilic lenses. Opt.(Eng). 150 (3892) 453. 1965.

28) Morrison. R.J. Hydrophilic contact lenses. J. of the Am.Optom.Ass. 37. (13). 211. 1966.

29) Author. An optical assessment of hydrophilic gel contact lenses. Dissertation for the degree of Bachelor of Science. University of Aston in Birmingham. 1966.

30) Hart. R.S. An interesting experience with hydrophilic lenses Opt.(Eng). 150. 291. 1965.

31) Blackstone. M. Hydrophilic gel lenses. Opt. (Eng). 150 (3889). 388. 1965.

32) Bier. N. Contact lenses routine and practice 2nd ed. London. Butterworth. 6. 191. 1959.

33) Author. An optical assessment of hydrophilic gel contact lenses. Dissertation for the degree of Bachelor of Science. University of Aston in Birmingham. 1966.

34) Sellars. F.J. Fenestration first not last Contacto. 8. (2). 17. 1964.

35) Rogers.G.L.Personal communication. Reader in Physics. The University of Aston in Birmingham. 1966.

36) Conn. W.M. Zs.f.Angewadte.Physik. 7. 539. 1955.

37) Rogers. G.L. Personal communication. Reader in Physics. The University of Aston in Birmingham. 1969.

38) Fick. A.E. Eine Haftglas. Arch.f.Augenheilk. 18. 279. 1888.

39) Smelser. G.K. Ozanics V. Importance of atmospheric oxygen for maintenance of the optical properties of the human cornea. Science·115. 140. 1952.

40) Wichterle. O. Personal communication. Professor The Institute of Macromolecular Chemistry Prague.

41) Duane. T.D. Metabolism of the cornea. Arch.Ophth. 41 (June) 736. 1949.

42) Hill. R.M. Respiratory Profiles of the Corneal Epithelium. Amer.J.Optom 43. 233-237. 1966

43) Wichterle. O. Personal communication. Professor The Institute of Macromolecular Chemistry.Prague.

44) Fatt. I. Hill. R.M. Tashakanti. Physical properties of hydrophilic gel contact lenses. Brit.Med.J. 1. (142). 2. 1966.

45) Hill. R.M. Effects of hydrophilic plastic lenses on corneal respiration. J. of the Amer.Optom.Ass. 38. 181. 1967.

46) Hill. R.M. Oxygen Transmissivity of Membranes in contact with the cornea. Brit. J. Physiol.Opt.24(3) 206-216. 1967.

47) Sattler. C.H. Erhahrungen uber den ausgleigh von brechun gsfehlern des auges durch haftglaser. Deuch.Med.52.312.1931

48) Smelser. G.K. Relation of factors involved in the maintenance of the optical properties of cornea to contact lens wear. Amer.Arch.Ophthal. 47 (March) 328. 1952.

49) Kaplan. M. Optical considerations of hydrophilic contact lenses. Opt. Wkly. 57. (14). 29-39. 1966.

50) Wichterle. O. Mechanical and optical aspects of soft lens fitting. Cont.lens symp.Munich-Feldating. Aug. 133-138. 1966.

69) Enoch. J.M. McGraw. J.L. Contact lenses: some aspects of visual acuity and photophobia Amer J. Optom. 31 (2). 78-87 1954.

70) Girard. L.J. Corneal Contact Lenses. 1st Ed. C.V. Mosby. St. Louis. 244. 1964.

71) Rengstorff. R.H. The Fort Dix report - a longitudinal study of the effects of contact lenses. Amer J. Optom Arch. Amer. Acad. Optom. 42 (3). 153-163. 1965.

72) Hamano. Hibaru. Topical and systemic influences of wearing contact lenses. Contacto. 4 (2). 41-48. 1960.

73) Schirmer. K.E. Corneal sensitivity and contact lenses. Brit. J. Ophth. 47 (8) 493-495. 1963.

74) Bryon. H.M. Wesley. A.C. Clinical investigations of corneal contact lenses Am. J. Ophth. 51 (4). 675-694. 1961.

75) Cochet. P. Bonnet. R. Epithelial reactions to contact glasses. Bull. Soc. Ophthal. Fr. No 1 20-27. 1959.

76) Shulman. P.F. Clinical pathology caused by contact lenses Opt. Wkly. 57(28). 37-42. 1966.

77) Duke - Elder. S. System of Ophthalmology H.K. Kimpton. London. Vol VIII. pt 2. 5. 1965.

78) Sorsby. A. Modern Ophthalmology. Butterworths. London. 1st Ed 4 (1). 1963.

79) Doggart. J.H. Diseases of Childrens' Eyes. H. Kimpton. London. 2nd Ed. 240. 1950.

80) Mandell. R.B. Contact Lens Practice. Basic and Advanced. 1st. Ed. C.C. Thomas. Illinois 229-232. 1965.

81) Rengstorff. R.H. The Fort Dix report - a longitudinal study of the effects of contact lenses. Amer. J. Optom. and Arch. Amer. Acad. Optom. 42(3). 153-163. 1965.

82) Hodd. F.A.B. Changes in corneal shape induced by the use of alignement fitted corneal lenses. Contacto. 9. (3). 18. 196

83) Black. C.J. Ocular anatomical and physiological changes due to contact lenses. Illinois. med. J. 118. 279-281. 1960.

84) Harris. B. Sarvar. M. Corneal lenses and spectacle blur. Amer. J. Optom. 44. 316-318. 1967.

85) Miller. D. Contact lens induced corneal curvature and thickness changes. Arch. Ophth. 80(4) 430-434. 1968.

86) Bonnet. R. El Hage. S.G. Deformations of the cornea by wearing hard and gel contact lenses. Amer. J. Optom. 45 309-321

51) Girard. L.J. Corneal Contact Lenses. C.V Mosby. St. Louis. 1st Ed. 125. 1964.

52) Boberg Ans J. Experience in clinical examination of corneal sensitivity Brit. J. Ophth. 39(12). 705-726. 1955.

53) Wolffe M. Personal communication. Lecturer Ophthalmic Optics Dept University of Aston in Birmingham 1967.

54) Emsley. H.H. Visual Optics Halton Press London. 2nd Ed. 507. 1939.

55) Cochet. P. Problemes medicaux poses par l'adaption et le port des verres de contact. Amn.Oculist. (Paris) 190. 401-406 1957.

56) Boberg Ans J. Experience in clinical examination of corneal sensitivity Brit. J. Ophth 39(12). 705-726. 1955.

57) Miller. D. Contact lens induced corneal curvature and thickness changes Arch.Ophth. 80(4). 430-434. 1968.

58) Sawar. M.D. Corneal veiling Brit. J. Physiol. Opt. 11(3) 167-169. 1954.

59) Mandell. R.B. Contact Lens Practice: Basic and Advanced C.C. Thomas. Illinois. 1st Ed. 215. 1965.

60) Cochet. P. Bonnet. R. L'esthesic corneene su mesure clinique ses variations physioligiques et pathologiques. La clinique. Ophth. 4. 1. 1960

61) Bonnet. R. Cochet. P. New method of topographical keratometry. Bull.Soc.franc.Ophthal.73.688-716.1960.

62) Sabell. A.G. Contact lens after care questionnaire. The contact lens clinic. The University of Aston in Birmingham.

63) Doggart. J.H. Ocular signs in slit-lamp microscopy. 1st Ed. H. Kingston. 24. 1948.

64) Davis. O.L. Design and Analysis of Industrial Experiments Oliver and Boyd. Appendix 6.B. 235. 1967.

65) Mandell. R.B. Contact lens Practice: Basic and Advanced 1st Ed. C.C. Thomas. Illinois. 107. 1965.

66) Girard. L.J. Corneal contact lenses. 1st Ed. C.V. Mosby 198. 1964.

67) Sarvar. M.D. The effect of contact lens tilt upon residual astigmatism Amer. J. Optom 40(12) 730-744. 1963.

68) Bailey. N.J. Residual astigmatism with contact lenses Part 2. Predictibility Opt.J Rev Optom 98 (2). 40-45. 1961.

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