CHAPTER XXIII

The Glass Corneo-scleral Shells in Other Countries throughout the World (1920-1942)

1 - The Glass Corneo-scleral Shells in the United Kingdom

1.1 - The Awakening of Interest in Contact Lenses (1920-1930)

Eye healthcare professionals in the United Kingdom followed the developments and publications from Germany in regard to glass contact shells with considerable interest, especially when Zeiss opened branch offices there and promoted them actively. Thus, various initiatives from the optical companies and their employees became apparent. In 1920, *Edmond Tomkins*, a technician at the *Zeiss* branch office in London, wore contact shells and tolerated them for up to four hours a day. In 1927, *Hamblin*'s Opticians, and in particular *Wingate*, their manager and his technician *Dick Smellie*, were encouraged by the ophthalmic surgeons to import *Zeiss* contact shells; thus, *Smellie* did his first fit in October 1929. In 1931, *Hamblin*'s catalogue featured a trial set of *Zeiss* contact shells and, following the order of the surgeon *Andrew Rugg-Gunn*, *C.W. Dixey* Co. and their manager, *Harry Birchall*, were selling *Zeiss* contact lenses. The optician, *Dunscombe* (Bristol), who, in 1932, had visited *Zeiss* in Jena, had fit contact shells and his colleagues knew him by his attendance at conferences. [1] *George Paxton*, an ophthalmologist, complained, however, that "*from the available literature of the maker of these lenses, no guidance is given on the method of fitting*". He proposed a method for eliminating air bubbles when the contact shells were placed in the eye. [2]

1.2 - Zeiss-Heine Contact Shells in the United Kingdom (1930-1935)

Consequent to the renewal of interest in contact lenses following the publications of *Heine*, the optometrist *Joseph I. Pascal,* drew the attention of his colleagues in The Optician to the new contact glasses that *Heine* described which risked, according to him, displacing regular eye glasses from their market supremacy. Several months later, *Pascal* insisted once again on the necessity for the profession to take the fitting of contact lenses in hand. [3]

1.2.1 - Rugg-Gunn (1930)

Pascal's article was followed, in the same journal, by a detailed summary of the article that *Rugg-Gunn* had just published in The Lancet. This ophthalmologist had, in fact, entrusted a publication to this prestigious journal, in which he summarized the essentials of the communications of *Heine* and *Hartinger*. A traditional photograph of the four *Zeiss* contact shells illustrated this. [4] He made a somewhat reserved comment as follows: "*Good vision depends entirely on corneal curvature, but comfort depends on scleral curvature, and every effort must be made to get this right*."

He acknowledges, however, that his experience is too limited to give any definitive advice:

"*While the use of contact glasses and their possibilities cannot yet be said to have been fully explored, my brief experience has already convinced me that they have come to stay.*"

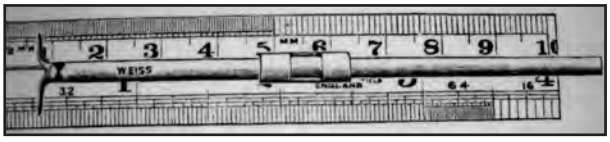


Figure 23-1
The Rugg-Gunn vertex-measuring gauge (1931).
Measurement gauge for the measurement of the distance between the vertex of the contact glass in situ and the back of the sphere in the trial frame. The measuring instrument consists of a stainless steel ruler graduated along one side in millimeters, on the other in half-millimeters. A slot is cut in the scale to take a sleeve through which slides a fine metal rod. The rod can be made to project beyond the end of the rule and its other end is bifurcated to form two pointers, one of which registers millimeters, the other half-millimeters. To take the measurement: the end of the rule is placed against the diaphragm and the rod pushed through the pinhole until it touches the contact glass. The degree of projection recorded by the pointers is read off the scale after the manner of a depth gauge.
(Rugg-Gunn A., 1931a)

1.2.2 - Heine's Reply to Rugg-Gunn (1931)

In the following year, in 1931, one is aware of an impressive unveiling of publications. Starting in the month of March, The Lancet is to publish an article by *Heine* in contradiction to *Rugg-Gunn*'s article:

"*There are several points on which I do not agree with him. (...) I presume that he has only one set of contact lenses, for he only speaks of one, but in my opinion the minimum for uniocular examination is a set [with*

radii of curvature] of 5-11 mm, each varying from the other by about 1 mm. (...) For high corrections, therefore, it is better to work with a second set in which the radius varies by 0.5 mm. (...) Best of all, however, is to have a set of glasses progressing by 0.25 mm."

For lens insertion and removal, *Heine* recommends using a suction device and *Ringer*'s solution. *Ringer*'s solution had not yet been introduced into the U.K.:

"*In removing the glass, the physician must not use an ivory spatula or even a finger nail, (…) the glass must be put in and out with a small rubber sucker. (...) Physiological saline (Ringer's solution) is better than sugar solution*."

Heine explains past published fitting failures as being most likely caused by using standard scleral radii of 12.00, 11.00 and 13.00 mm, whereas intermediate curvatures would also be mandatory:

"*All the writers on contact glasses in the past have used a fixed scleral radius of 12 mm and that is the reason why experiments on this form of correction have hitherto all failed*."

To conclude, he cites ten clinical cases, some unpublished. These include one male patient affected by color-blindness who was 'corrected' by a colored contact glass, a sailor who was able to go back to sea and a presbyopic orchestral conductor. (5)

In the same year (1931), *Rugg-Gunn* is to present two other important papers. The first of these was actually published in the British Journal of Ophthalmology and was 26 pages in length. It contains a historical synthesis of the current state of optical and technical knowledge. He makes reference, to *Hartinger*, *von Rohr* and *Erggelet* for the optics portion to all of whom he has submitted his paper for review. He proposes to measure the distance between the eye and the contact lens with a '*Wessely keratometer*' specially modified for this purpose:

"*The measuring instrument consists of a stainless steel rules graduated along one side in millimeters, on the other side in half-millimeters. A slot is cut in the scale to take a sleeve through which slides a fine metal rod. The rod can be made to project beyond the end of the rule and its other end is bifurcated to form two pointers, one of which registers millimeters, the other half millimeters. To take the measurement: the end of the rules is placed against the diaphragm and the rod pushed through the pinhole until it touches the contact glass*." (6)

In the second communication (presented at the Oxford Ophthalmology Congress), *Rugg-Gunn* recalls the difficulties, amongst others that he encountered because of the limited selection of parameters available for the *Zeiss* contact shells: "*the optical correction by contact glasses is not very difficult. I cannot say the same about scleral fitting." As far as tolerance is concerned, he estimates that "nobody knew whether a patient could tolerate [contact] glasses or not. Some could not wear them more than three or four hours at a time*." (7)

In the same year (1931), *Affleck R. Greves* (Middlesex Hospital) publishes the case of a female patient in The Lancet. She was affected by bilateral keratoconus, did not tolerate contact shells and ran into difficulties with insertion. He describes a technique for insertion that seemed to him to be the most suitable for avoiding air bubbles. (8) Meanwhile, *J.H. Beaumont* presents his experience of correcting high astigmatism with a *Zeiss* contact glass, following a corneal scar due to a perforating wound. He recalls that, while on a trip to Vienna, he had seen similar patients fit. He will reconsider the subject with the same patient who "has now been wearing the contact glass for five hours" in several months time. (9) In Dublin, *Joyce R. Dwyer* gave several practical indications for the fitting of keratoconus patients. (10)

1.2.3 - Rugg-Gunn, Rycroft and Wright (1932)

In 1932, *Rugg-Gunn* returns to his difficulties in fitting contact lenses on the occasion of a new presentation to the Royal Society of Medicine. Fitting is not always as simple as described (11):

"*Looked at superficially, the technique of fitting contact-glasses seems fairly simple, and fortunately, in many cases it is so. There is, however, a considerable residuum of cases in which there is difficulty in acquiring tolerance*."

He describes the difficulties experienced in fitting *Zeiss* contact glasses on protuberant corneas in myopes. Other fitters, including *Dallos*, also experience these difficulties:

"*In Budapest they are now actually manufacturing contact glasses which have an intermediate zone between the corneal crown and the scleral rim. By some such method (...) this serious difficulty will ultimately be met. At present, however, the uncertainty (...) constitutes a very real obstacle towards attaining adequate comfort. (...) Of all eyes the high myope is the most difficult to fit*."

After numerous interesting considerations drawn from his recent experiences, *Rugg-Gunn* classifies his patients into two groups:
- The first group consisted of "*those of small curvature which come into contact with the cornea only at the margin of the crown, i.e. in the position of the rim which separates the corneal crown and the scleral rim*". This group tolerated contact shells very well.
- The second group, "*those of larger curvature, which come into contact with the cornea in the neighborhood of its centre*". This group is intolerant of every type of contact glass fitting.

As a good clinician, he had observed and described the 'overwearing syndrome': "*I have seen corneal edema and cases in which patients have complaint, after a few hours' wear, of dimness of vision and haloes around lights.*" he noted that his fitting technique "*is practically identical with that employed in Budapest where there is a very active centre of contact glass experimentation independent of Jena*".

For the measurement of the distance between the summit of the contact shell and the additional lens, he recommends naturally the gauge that he had described a year earlier. Aside from considerations regarding to fitting and tolerance, *Rugg-Gunn* describes several economic problems:

Figure 23-2
The Hamblin apparatus for insertion of a contact glass (1932).
The apparatus for insertion of a contact lens consists of a cup-shaped rubber sucker supported on an upright standard which is fixed into a base-block. A small glass tube of narrow bore is fitted into the lower end of the sucker; to the other end of the glass tube is attached a small pressure bulb. Halfway up the standard is fixed a plane mirror, which may be rotated to left or right.
(Rycroft B.W., 1932)

"*Many opticians now possess sets of trial contact-glasses. (...) At the present, a full set of Zeiss contact lenses must cost somewhere about £ 260 and can hardly bee considered an essential part of an ophthalmic surgeon's equipment. The actual fitting should be in the hand of the surgeon*." (12)

In the same year, *Benjamin W. Rycroft* presented a 12-page exhaustive in-depth assessment of the history and technical aspects of contact lenses. This included the most recent publications and did not conceal the difficulties encountered by the majority of fitters nor the causes that they put forward. (13) His enthusiasm from the first had been restrained, nevertheless he considered that contact glasses had their indications, but "*the contact glass is not the ophthalmological panacea some would have us believe*". He had, however, a set of 53 *Zeiss* contact shells at his disposition. For insertion, he had *Hamblin*'s construct a device inspired by *O'Rourke*'s device, which reduced the number of air bubbles:

"*Messrs. Hamblin has constructed an apparatus which has proved to be most useful, especially for the rapid interchange of glasses. This apparatus is very simple and consists of a cup-shaped rubber sucker supported on an upright standard, which is fixed into a base-block. A small glass tube of narrow bore is fitted into the lower end of the sucker; to the other end of the glass tube is attached a small pressure bulb. Halfway up the standard is fixed a plane mirror, which may be rotated to left or right*."

Also in 1932, *R.E. Wright* described a therapeutic use of contact lenses. In his description, a contact glass was left in the patient's eye for seven days in order to maintain a conjunctival graft used to cover a pre-pupillary fistula resulting from a corneal ulcer. (14)

1.2.4 - Rycroft, Williamson-Noble and Other Fitters (1933 - 1935)

In the year to follow, *Rycroft* published in The Lancet a decidedly more optimistic article that ended with the description of two clinical cases, that of a keratoconus patient perfectly corrected and another of a young physician with severe myopia who wore contact shells even for aquatic sports. (15)

In 1934, *F.A. Williamson-Noble* presented a case of a myopic patient wearing a contact lens for a year. [16] In the following year (1935), *Rugg-Gunn* described the successful correction of acute corneal ectasias in bilateral keratoconus. [17] There he revealed the difficulties of this correction He used the tholometer and the new contact shell with super-elevation of the corneal part of *Zeiss-Dallos*. He highlighted the merits of *Dallos*: "*I am glad to have this opportunity of paying a tribute to the work of Dallos. He has done work with respect to the clinical application of contact glasses ranking in importance with that of Hartinger on optical theory*."

In the course of the discussion, *J. Gray Clegg* reported on the recent visit of several British ophthalmologists to Budapest:

"*Recently with members of the North of England Ophthalmological Society, we saw in Budapest a demonstration of the method of Dallos. (...) Dallos said that each case had to be done individually; it was of no use to order a glass from Zeiss of any particular measurement. One material was used for making the negative mold, and a different type of material was employed for making the positive, and on this he moulded the eyes himself*." [18]

In the same discussion, *A.G. Paling* called attention to the 'milky serous exudates', which typically occurs after several hours of wear. [19] *Rugg-Gunn* responded that, even when they were giving no discomfort, contact shells should always be removed after 4 hours of wearing time:

"*He always advised his patients to take them off every four hours, at the most, and, generally, he found that those who wore contact lenses chose meal-times for resting from them*."

As if echoing these discussions, The Optician also drew attention to *Dallos*' contributions:

"*Dr. Dallos has discovered a new process for the preparation of contact lenses. (...) He has taken as his example the method of the dentist, who, when preparing a dental plate, takes an impression of the shape of the patient's own teeth on which to work. (...) It has been found that contact lenses made in this way can be worn in comfort for eight or ten consecutive hours, and in many cases, for the entire day.*" [20]

1.3 - Dallos' Influence (1936-1954)

At this stage in history, British contact lens fitters had reached a relative impasse. After their initial enthusiasm, they had to admit that fitting the available contact shells, essentially those of *Zeiss* or their locally produced imitations, was not simple. The difficulties in choosing corneal and, above all, haptic curvatures, plus the limitation of wearing time without a break to a few hours represented for many an insurmountable obstacle. In addition, there was the rapid appearance of visual blurring. Convinced that their fitting was accurate, some fitters attributed all their problems to the inadequacy of the solutions recommended for insertion:"*Most practitioners concentrated their efforts to find the right liquid to be used in conjunction with contact lenses. The buffer solution was thought to be responsible for veiling with its limitation in tolerance*."

1.3.1 - The Hamblin-Dallos Contact Lenses

This conviction was radically opposed to the initiatives of *Dallos* and his arrival in Great Britain was going to create significant re-evaluation on the part of both manufacturers and fitters of contact lenses. After his arrival in London, *Joseph Dallos* was invited to share premise with the firm *Theodore Hamblin*'s Ltd (Opticians) where he was given the opportunity to develop both molded contact shells as well as a semi-standardized series that would avoid the painstaking ocular moldings, as in the '*New Hamblin-Dallos Contact Lens*' then currently being marketed. [21] These more or less standardized contact shells had an aspheric haptic, but their shape, size and diameter (also the height of the arrow in each case) varied as indicated. [22] Overall diameter extended from 24.00 to 28.00 mm for an optic zone of 12.00 mm. According to witnesses from this period, *Dallos* had developed an exceptional eye for lens selection and this, added to his enormous experience allowed him to find the appropriate lens quickly most of the time. It was only after a possible failure of the trial contact shells that he envisaged molding. The model selected as his first choice was subsequently modified by successive adjustments. That procedure took two weeks or more. Starting with the

definitive model, the technician manufactures a metallic mold on which is molded a plaque of heat-softened glass. After the optical grinding finishing and polishing is completed, the contact shell is delivered.

1.3.2 - The Individual Fitting of Contact Glasses (1937)

In 1937, *Joseph Dallos* presented his first communication in English: '*The individual fitting of contact glasses*'. In that talk, he points out that a contact shell that corresponds with the ocular molding is well tolerated and does not cause irritation for many hours at a time: "*The only means of avoiding irritation (...) is to give the inner surface of the contact glass exactly the same curvature as those of the eyeball, in every case*." [23]

Types of contact lens	*Medical indications*
P	Corneal scar after pemphigus and trachoma
G	Keratitis and Complications
C	Keratoconus
M	Moderate myopia (less than -10 D), aphakia, keratitis
AM	Myopia with significant scleral astigmatism
M2	Myopia between -10 and -20 diopters
M3	Severe myopias (higher than -20 diopters)
H	Hyperopias
AH	Hyperopias with significant scleral astigmatism
A	Extreme scleral astigmatism
A1	Inverse scleral astigmatism
S	Diameter less than 24 mm
L	Diameter greater than 28 mm

Notes
- All trial contact glasses are afocal.
- With the exception of types S and L, all of the contact glasses have total diameters between 24.50 mm and 27.50 mm.
- The heights of the arrows (measurements between the limbus and the level of the scleral border) are between 2,7 and 4,3 mm.
- The diameter of the optical part is 12 mm.

Table 23-1
Table summarizing the different types of Hamblin-Dallos contact lenses as a function of their indications.

He describes the procedure of molding with Negocoll, from which is poured a positive cast in Hominit. A reproduction in metal is taken from this and the contact glass is molded on it. A conforming contact lens must be almost 'fluidless' and barely touch the corneal summit. It should rest without pressure on the sclera. A slight clearance at the limbus and at the corneal edge is required. Trial fittings take about two weeks and do not last longer than an hour a day in order to avoid irritations. After that, the optical center of the lens is marked and the trial lens is given to the technician who makes an exact copy of it in glass. The glass is then polished and ground to the correct refractive power. The definitive shell still requires a period of clinical observation in order to detect possible edema, neovascularisation and irritative symptoms. *Dallos* emphasized the need for humility and circumspection on the part of the fitter:

"*I wish to point out that the individual fitting is not a panacea for contact glasses in the same way that contact glasses are not a panacea for diminished vision. (...) The individual fitting gives you the acme of what contact glasses may give: both the best possible correction and the best possible wear.*"

While this communication was being discussed, *Williamson-Noble*, *Ida Mann* and *Rugg-Gunn* congratulated *Dallos* and paid tribute to his ability, steadfastness and indeed passion in making contact lenses suitable for clinical practice. *Mann* referred to the pemphigus patient described by *Whiting* and the use of a minus power contact lens and a positive spherical spectacle lens in a patient with congenital macular degeneration. *Rugg-Gunn* indicated the importance of the new concept presented and of understanding "*the technique of fitting the glasses to the eye to achieve a complete and extremely light contact of almost aerial delicacy between the two surfaces, the glass and the conjunctiva*." [24]

1.3.3 -Emulation in London

All of these happenings in the U.K. produced a wave of emulation in London and a stimulus to other manufacturers of optical appliances, notably *Charles Keeler* and *Clement Clarke* to set up their own laboratories both for the manufacture contact lenses and the products required for molding contact lenses. Taking into account the fact that *Dallos* had not divulged his techniques or the type of materials used, his competitors had to invent their own procedures. Thus it was that, in 1937, *Charles Richard Keeler* visited the newly commissioned contact lens manufacturing laboratories of *Weve* and *Thier* at the Utrecht Ophthalmology Clinic. Accompanied by his technician *Leen Rutter*, *C.R. Keeler* was to participate for six months, starting at the end of 1937, in an apprenticeship to learn the techniques of manufacture and fitting, as well as a pro-

fitable reciprocal exchange to clarify these techniques and improve the machines required. [25]
In 1938, *Keeler* opened his own Contact Lens Fitting Centre in London. This was called 'Charles Davis Keeler Contact Lenses Ltd' at 47 Wigmore Street. *L. Rutter*, assisted by three technicians, was in charge of the manufacturing laboratory on the first floor and fitting by *Charles Keeler*, assisted by *Arthur Poole*, was guaranteed on the ground floor. It is reported that *Prince Bernard* of the Netherlands was one of the first patients to be fit with contact lenses by *Keeler*'s.
Because of dissatisfaction with Negocoll which had to be heated up and then left a certain time to cool and solidify, the three manufacturers *C. Davis Keeler*, *Clement Clarke* and *Theodore Hamblin* developed in 1938 a new product for molding called Zelex (in conjunction with the Amalgamated Dental Company). This could be used at room temperature and was clearly successful throughout the British Commonwealth and the Americas. [26]

With the guaranteed collaboration of *Dallos*, *Ida Mann* opened a specialized consultation service for contact lens fittings in London at Moorfields Eye Hospital, City Road. In the same year, in 1937, *M.H. Whiting* presented a communication from this clinic in which he described fitting contact lenses in a patient with conjunctival pemphigus. Healing was accelerated by the use of liquid paraffin and a buccal mucosa graft was maintained in position by the contact glass [27]:

"*It seems that the use of contact glasses with liquid paraffin provides a valuable method of treating these otherwise hopeless cases. (...) The mucous membrane graft not only made the application of a contact glass possible but also seemed to improve the general condition of the eye.*"

In the following year (1938), *Ida Mann* published the first historical publication on contact glasses in English and summarized the progress achieved and the evolution of ideas on this subject. She emphasizes that afocal contact glasses with refractive correction by tear meniscus are outdated and are now replaced by lenses with a ground optical part separated from the cornea by a fluid bed of capillary thickness. [28] She reviewed more contemporary research at great length, notably papers by *Gualdi* and especially by *Dallos*. The number of patients for whom contact lenses can be advocated inevitably become larger because of these advances. These new indications include keratoconus and irregular astigmatism patients of every kind, high myopia and aphakia, high anisometropia and lagophthalmos. Professional and esthetic considerations must be added to this list.
At the end of 1938, she described the first three fittings at the Contact Lens Unit of the Royal London Ophthalmic Hospital at Moorfields. These included a patient of -24 diopters of myopia, another with anisometropia due to unilateral aphakia and the patient with conjunctival pemphigus, previously described by *Whiting*. [29]

In the same year, 1938, *Williamson-Noble* highlighted the recent development of contact lenses and the new indications for these, thanks to the molded contact shells according to *Dallos*. In comparing molded shells with ground shells as used previously, he explained the causes of the failures that he had seen and described during the era. He presented a small statistical study of his first results, of which some were managed in the Moorfields Contact Lens Department: of 18 myopes, 11 wore contact shells more than 6 hours; the majority of the keratoconus patients and mustard gas keratitis patients wore their lenses for more than 8 hours.

1.3.4 - The Contact Lens Centre

In 1938, *A. Rugg-Gunn* presented and published an assessment of the Contact Lens Center (18, Cavendish Square) that he had founded along with *Ida Mann* and *Williamson-Noble*. [30] He recalled that, after their visit to *Dallos* at Budapest, they were convinced that his molding method was superior and they wanted to introduce it to London:

« *Mr. Dallos independently approached Messrs. Hamblin and ultimately transferred himself and a skilled mechanic to London and organized for Messrs. Hamblin a special department for the manufacture of contact lenses*. »

With the intention of taking account of the ethical guarantees that *Rugg-Gunn* had detailed in his publication, they decided to rethink the structure of *Hamblin-Dallos* and recreate there a teaching and research facility open to all ophthalmologists that would take account not only of teaching and research but would provide a contact lens fitting center as well:

"*Thus we decided to rent, staff, furnish and equip a centre entirely at our own expense. (…) It is essential for the smooth working of a Contact Lens Center that the manufacture of the lenses should take place in immediate proximity to the surgeon who is fitting them. During the fitting of a single patient, or indeed of a single eye, as many as half a dozen plaster casts may be made, each slightly modified from its predecessor, and from these half a dozen new glasses are mouded to constitute a fresh point for departure in arriving at a perfect fit*."

His ophthalmological colleagues as well as the opticians criticized the closeness to *Hamblin*'s, but *Rugg-Gunn* justified it as follows:

"*Accordingly, when Messrs. Hamblin took over 18, Cavendish Square for their new department the Executive Committee rented the ground floor for the work of the Centre. For these premises – adapted, decorated, furnished, and equipped with grinding and other apparatus at the expense of the members of the committee – the latter pay the ordinary rent – namely, £500 per annum. In addition to being our opticians, therefore, Messrs Hamblin are our landlord, and further, by the terms of another agreement with the committee, the services of Dr. Dallos are, on certain conditions, available to the staff as technical adviser to the Center.*"

Rugg-Gunn concluded:

"*We are confident that the method adopted in the Contact Lens Centre – namely, that of Dr. Dallos – does give the best results by far, and that, in establishing the Centre, we have made England the seat of the best contact lens work in the world. (…) The last words on contact lens technique have not yet been said, but such as it is we introduce the Dallos technique to the notice of ophthalmic surgeons as the most promising basis of any for further research*."

In another connection, *McKie A. Reid* describes the use of tinted *Zeiss* contact shells with diaphragm to correct congenital aniridia [(31)] and *S.K. Mukerjee* the development of an esthetic contact shell for an eye with a large leucoma and a corneal staphyloma. [(32)]
The following year (1939), several other publications drew attention to or described a number of individual successes. In that year, *W.H. Davis* presented the case of a young woman whose unilateral keratoconus had been successfully fit with a *Zeiss* contact shell. [(33)] The report by *T.J. Phillips* describing the first fittings at the Moorfields Contact Lens Clinic, covered seven medical indications, namely conjunctival pemphigus, spastic entropion, high myopia, corneal scarring, keratitis from mustard gas. [(34)]

In 1940, *Williamson-Noble*, *Dallos* and *Mann* published a preliminary note on the fitting of *Dallos* moulded contact shells with sphero-cylindrical optic on patients who could not be corrected by means of a spherical optic. Lenticular astigmatism was also a factor in these patients. Using a sphero-cylindrical optic, the authors gave a full refractive correction to 4 patients in whom such residual astigmatism persisted. [(35)]
Also in 1940, *James A. Flynn* (Australia) described his experience using *Dallos* contact shells distributed by *Theodore Hamblin Ltd*. He reported that, in London, *Dallos* and *Hamblin* had a major collection of contact shells of every shape in their Contact Lens Center. In most patients, an ocular molding is not required and they can often fit the patient at the time of the first appointment. This procedure is not however practical at a great distance (e.g. Australia) where the fitter is obliged to undertake a molding and forward contact shells to London numerous times for adjustments. [(36)]

In 1943, *M. Klein* reported the fitting of molded shells according to *Dallos* at the Central London Eye Hospital (Judd Street) to two patients affected by neuroparalytic keratitis, one with facial paralysis and the other with a lesion of the trigeminal nerve. The contact lenses allowed the opening of the tarsorhaphy in the patient with facial paralysis and gave favorable results in both patients. [(37)]

In the Moorfields Contact Lens Clinic, *Ida Mann* had to treat numerous patients with keratitis secondary to chemical burns acquired during World War I from mustard gas poisoning (dichlorodiethylsulphide). All of these patients had a typical corneal degeneration with deposition of lipid and cholesterol, conjunctival verrucosities and corneal neovascularisation. The appearance of sequelae was of late onset and consisted of recurrent ulceration, leaving scars with resulting astigmatism and progressive visual deterioration. She proceeded first to rabbit experimentation [(38)]:

"*The work falls into two sections, firstly, experiments on rabbits carried out at the Imperial Cancer Research Fund Laboratory and, secondly, the correlation of the results of animal experiments with cases studies at the Royal London Ophthalmic (Moorfields) Hospital.*"

Mann entrusted fitting to *Dallos* and published the results in 1944:

"*84 cases passed through the Contact Lens Clinic at Moorfields fitted by Dallos. The diagnosis was made on the history and on the findings of typical mustard gas scars with corneal degeneration (fat and cholesterin), varicose conjunctival and corneal vessels and avascular scars on the interpalpebral conjunctiva. (…) Usually the only complaint is of altering refraction, this often characterized by the appearance of and increase in a horizontal plus cylinder, due to slow alteration in curvature of the transverse scar in the cornea. A history with long intervals, repeated attacks and fluctuating but slowly deteriorating visual acuity, relieved by wearing contact lenses is typical. (…) The first cases were fitted in 1937. (…) Improvement in visual acuity from contact lenses was present in all but two of the cases. (…) In 39 cases, the lenses are worn with comfort during the working. (…) The relapses tend to be less frequent, since the glass protects the insensible cornea from small injuries*." (39)

1.3.5 - Description of the Sattler's Veil by Dallos (1946)

In 1946, *J. Dallos* published an article entitled 'Sattler's Veil', highlighting the evolution of contact glasses during his epoch. Starting with his observation of the visual veil that appeared after contact lenses had been worn for several hours, he recounted how he had recommended as long ago as 1934, that the best tolerance of these was after 'fluidless' fitting:

"*When a lens fits firmly over large areas in the upper-inner and lower-outer quadrants, not with edges, but surface to surface, and has, apart from these primarily fitting areas, a secondary touch, i.e. contact without pressure, spreading over the middle of the cornea; the centre part of the lens should have a radius somewhat flatter than the cornea so that an air bubble can freely circulate around the limbus and escape in the lacrymal meridian which is made comparatively loose, thus allowing a certain amount of breathing. (...) In the following years evenness and steadiness of fit gained in importance*." (40)

In 1937, he had recommended a flat but meticulous fit:

"*The loss through grinding out a capillary layer of glass in the centre raising it by 50 mμ should completely sever contact with the cornea; (...) Scleral sectors must not only touch evenly, but also help their neighbors and their counterparts in the opposite half of the same meridian to keep an equal, even proximity to the surface of the eye.*"

In the course of his last ten years at the Contact Lens Centre, *Dallos* fitted more than 2,000 patients very successfully according to this principle. These included the most difficult cases due to scarring as well as both corneal and scleroconjunctival irregularities. However, he admitted that with the contact lenses presently on the market, there may "*develop a corneal haze very similar to that accompanying a mild attack of glaucoma*". This phenomenon had been described by *August Müller* in 1889 in his own eyes, (41) but took on great importance with the marketing of *Zeiss-Heine* contact lenses. In 1935 *Sattler* described the condition in detail and *Dallos* proposed that it be called 'Sattler's Veil'. (42) After removal of the lenses, the veil disappeared in 20 to 30 minutes. Epithelial vesicles with the risk of permanent damage can appear in some very severe cases. *Dallos* presents some interesting comments in his discussion on the cause of the veil:

"*One school stressed internal suffocation, interference with the blood circulation, strangulation of the limbal mesh that provides the nutritional fluids for the cornea and of the small veins of the ciliary region that help to carry away toxic products of metabolism. Other stressed an outer suffocation and thought that, at least some extraocular factors like stoppage of the tear circulation, prevention of the constant massage of the eye by blinking and occlusion of the cornea from the air are of greater importance*."

Dallos noted: "*There are many arguments against the outer suffocation theory*", because the appearance of the veil is very variable according to different patients and the intervals between appearances can lengthen when the contact lenses are worn regularly. Other findings show that the presence of a large space filled with tears as in the first *Zeiss* lenses accelerated the formation of the veil in contrast to those lenses with a reduced precorneal space. Furthermore, the early appearance of the veil is associated with a sensation of discomfort at the time of insertion: "*The fact that a loosely worn, comfortable contact lens allows a longer span of clarity, that insensitive or hypo-aesthetic corneas hardly veil and that increasing use makes for decreasing veiling, all point to the tension of the eyelids as playing an important role in pressing the lens so tightly on to the surface of the eye as to interfere seriously with some of its physiological functions*."

Dallos conducted experiments with contact lenses placed in his own eyes. Starting "*with a 14 mm opening in the middle*" that did not produce any veil, he progressively reduced this opening in order to eliminate contact little by little and the palpebral pressure until the veil reappeared.
"*However, by careful adjustment the lenses were finally made to fit so as to keep air circulation through one or more active perforations and yet remain in constant contact over the pupillary area. (...) This was reached by making the inside curvature grossly flatter than that of the cornea, thus providing ample air space around the limbus where the lens is subsequently perforated*."

In addition, *Dallos* observed:

"*Apart from the absence of veiling, there is another striking feature, i.e. the absence of the initial irritation. (...) It was generally assumed that the cause of the phenomenon was mechanical irritation through suction precipitated and aggravated by the tension of untrained eyelids. It now appears that this irritation was not mechanical at all, but chemical probably due to the gradual rise of the pH as the CO2 concentration increased.*"

He concludes:

"*The new type of fitting is by no means without additional difficulties. (...) However, once there is a working principle, I am confident that ways will be found, perhaps through a combination of air pockets and channels, and holes to overcome this last minor trouble with contact lenses*."

This publication rejects the principle of a vast area of captive precorneal tears under a spherical shell and partly closes the debate on the quality of the tears: pH, osmotic pressure, of which disturbances are recognized to be one of the consequences of tear enclavement. *Dallos* opens new practical perspectives: favor the circulation of tears with a fitted haptic, create perforations and channels to promote lachrymal circulation and fit a flatter corneal part that is flatter than the flattest corneal radius of curvature.
This publication also closes the era of glass contact shells within the British Isles. Shells made from plastic materials will now replace these. *Dallos* alone remains loyal to glass scleral shells, which, in his opinion, remain the best option for the eye pathology in his clientele. He is estimated to have fit six to seven thousand patients with glass contact shells.

1.3.6 - Further Evidences from Dallos

Apart from the publications emanating from Moorfields Contact Lens Clinic, loyal users of *Dallos* glass contact shells in difficult cases, we have further testimonies from other users. *Robert Tuner* who had worked with *Dallos* at 18 Cavendish Square from 1948 to 1954 gives us the following evidence:

"*Dallos was not enthusiastic about the use of plastic for contact lenses. He felt that it was not stable enough for the type of fitting he was doing. (...) During that time we were talking about 3,800 patients with glass lenses, as it was a very busy clinic. We regularly had 40 patients per day to fit and adjust.*
The fitting department was in two sections. On the ground floor, where I worked mainly, there was a staff of 6 including Dallos and office staff and a further two or three staff fitting on the first floor. There were 8 to 10 technicians on the top floor of the building producing the lenses. (...) Patients came from various parts of Europe but the majority came from Moorfields Eye Hospital." [(43)]

In 1946, *Charles Scheepens*, having previously attended the *Dallos* Contact Lens Clinic in war-time London and assisted him with his contact lens fittings, reports [(44)]:

"*Joseph Dallos is the father the manufacturing process for contact glasses by individual molding and I was able to observe him at work in London over a period of several years. I remember how, seven or eight years ago, he was a strong partisan for contact glasses made from plastic material. At present time, he makes almost all of his prostheses from glass. The reason that he gives is that plastic material goes out of shape with use and scratches very quickly. It seems to me that molding the eye by means of a plastic substance of Negocoll type has lost its significance. The molding studio possesses a large collection of contact glasses grouped in families. When a new patient arrives, he is tried with a contact glass from the collection. One determines thus which contact glass most closely meets that patient's requirements and makes a plastic copy of that. This copy is then modified in such a way that it adapts perfectly. In this instance, plastic is used because it is easier to work on than glass. The final prosthesis is made from glass. Twelve to eighteen fitting sessions*

are necessary. The glass is worn for one or two hours a day only to begin with, even if the patient can tolerate it for longer. It's only after about a year that the patient wears the contact glass for eight, twelve or even 16 hours a day in favorable cases." [45]

In 1949, *A.G. Cross* performed a large statistical analysis on contact lens patients' satisfaction. A number of these had been fit in glass by *Dallos* while he was with *Theodore Hamblin*'s Ltd. [46] Unfortunately *Cross* gave no details of the replies in relation to the materials used. His questionnaire was to be reused in 1954 by *D.P. Choyce* for a statistical evaluation of ventilated glass contact lenses that were fit by *Dallos* at the Hamblin's Contact Lens Centre, which he compared with the non-ventilated series of *Cross*. His conclusions were that ventilation, be it by fenestration, perforation and channeling represented an advance in the fitting of scleral contact shells: "*This comparison reveals an overwhelming preference for ventilated lenses, because they produce less veiling and are more comfortable to wear. However, they have still far to go and improvement is needed in certain respects, such as the number of fittings required and the discomfort experienced in hot, stuffy surroundings, or under intense illumination*."

In 1949, *H. Treisman*, in his comment on *Sattler*'s veil:

'*Some observations on the causation and elimination of Sattler's Veil' recalls how he collaborated with Dallos in 18 unilateral aphakia cases and practiced the technique over a ten year period. These explanations of the Sattler's veil are "1. Embarrassment of the limbal circulation; 2. Unsuitability of the buffer solution used; 3. Interference with gaseous exchange at the cornea*." [47]

During the following year (1950), *Hirtenstein* also reports *Dallos*'s fitting of 18 patients with unilateral aphakia during the previous two years: 16 of these recovered full binocular vision thanks to well-conducted orthoptic training. [48] When *Bier* inaugurated new modality of contact lens fenestration, *Dallos* clarified that issue in 1954 by pointing out that he was the first to perform these. Also he completed and rectified *Choyce*'s publication. [49]

2 – The Glass Corneo-scleral Shells in Utrecht (1932-1939)

Ophthalmologists in the Netherlands were among the first to comment on *Heine*'s presentation at the Amsterdam Congress of Ophthalmology. Thus, from 1930, *W.P.C. Zeeman* and de *F. Wibaut* are enthusiastic. [50] Then, in 1932, *Henricus Jacobus Maria Weve*, director of the Utrecht Ophthalmology Clinic, asks *Zeiss* to grind a corneal-diameter contact glass for protection of the cornea and elimination of corneal astigmatism in order to facilitate the observation of the fundus during treatment by diathermy for retinal detachment [51]:

"*The examination of the fundus is much facilitated by the placement of a small Zeiss corneal contact lens. Placement is not difficult. It is easy to replace the small shells on the cornea without air bubbles after an eventual displacement. The cornea remains clear and no irregular corneal astigmatism occurs as a result of desiccation. It must also be pointed out that this small shell is very useful for identifying the meridian and thus avoiding localization errors consequent on astigmatism*." [52]

2.1 - Weve and Thier's Interest

In 1934, *Weve* delivered a communication to the Netherlands Society of Ophthalmology in which he described his recent problem in choosing between glasses and sclero-corneal contact lenses. [53] He described his present interest in the new *Zeiss-Heine* ground-glass contact shells and in the *Müller*'s blown-glass shells. The latter were evidently better tolerated. *Weve* described his experience in two clinical cases, emphasizing the risk of complications that he had observed. These were a visual veil and corneal edema. In spite of these drawbacks, he concluded that, with certain precisely defined indications, contact lenses had an advantage over glasses. After *Dallos*'s publications, *Weve* sent his Chief Clinical Assistant *Petrus Franciscus Xaverius Thier* to visit the Budapest laboratory. On his return, *Thier* reported to the Netherlands Society of Ophthalmology that the *Dallos* contact glasses were as good optically as those of *Zeiss*, but their tolerance was definitely superior and extended to eight hours because of the manufacture of their molded haptic from an ocular impression. [54] When his communication was discussed, a speaker suggested that a contact lens fitting center for be set up

in Utrecht to which Netherlands physicians could refer their patients. This actually happened, because in May 1936, *Thier* announced that he had successfully fit keratoconus patients with contact shells manufactured by *Dallos* and made from Negocoll moldings at the Utrecht Eye Clinic, of which the Hominit cast had been previously sent to Budapest. (55)
When *Dallos* had left Budapest, the Utrecht Ophthalmology Clinic found itself deprived of his Hungarian supplier. *Weve* installed his own workshop for contact shell manufacture using molded haptics. He entrusted this to *Thier* and a technician assistant. After numerous attempts, *Thier* succeeded in undertaking haptic and optic fittings using shells manufactured on site following a new and original procedure. This occurred because *Dallos* had delivered neither the trade secrets nor the manipulation advice necessary for their execution. (56)

2.2. - The Utrecht Clinical Laboratory

When the *Haas* report on contact glasses was being discussed in Paris, in 1937, *Weve* informed his audience that his Clinic was already interested in contact lenses before knowing about *Dallos*'s research. (57) When he had realized that the *Dallos* molding technique was superior, he had sent *Thier* to Budapest in order that the latter could be initiated into the new technology. He vigorously denied the rumor that *Dallos* had visited Utrecht, because *Dallos* had never divulged his manufacturing secrets for contact glasses. When *Donders* founded the Utrecht facility as a 'Non-profit Research Foundation', *Thier* had to invent his own manufacturing procedure. He made use of standard shells as imprint-holders in order to produce the most exact and rigorous Negocoll imprints possible. In the previous year (1936), *Thier* had thus produced 41 shells for 23 patients affected by keratoconus. Of these, 37 lenses were tolerated for more than 8 hours. 14 were made for unilateral aphakia, 5 for astigmatism, 5 for high myopia and 10 for cosmetic indications. The aesthetic indications were generally not retained and are therefore not discussed further. (58)
In 1938, *Thier* published a new report, this time dealing with the first two years of activity in the Utrecht Clinical Laboratory. During this period of time, he had produced 76 contact lenses that were well tolerated by patients and provided good vision. Moldings were carried out with Negocoll. During the discussion, the possibility of using Plexiglass, a product newly arrived on the market, was suggested. (59)
In June of the same year, *Weve* published a remarkable in-depth report regarding the current evolution of contact glasses, in which he confirmed that, in parallel with the contact lenses of the three major industrial manufacturers *Zeiss*, *Müller Brothers* and *Müller-Welt*, the Utrecht Clinic were using the Dallos manufacturing principle very successfully. Contact shells with molded haptics were tolerated up to 8 hours a day. This was the case with 37 eyes affected by keratoconus out of 41 eyes fitted with molded contact shells. The use of contact glasses for reasons of comfort or for cosmetic purposes could not be considered for the time being because of the excessive costs of manufacture. The future did not lie in mass production, but with contact glasses that were fit individually. However, at the actual time, the manufacture of a well-tolerated contact lens was still delicate and difficult, therefore onerous:

"*The problem of the haptic is the most important aspect. For a contact glass to be well tolerated without discomfort for eight hours a day, fitting must be extremely exact. That is why the future does not rest with mass production, but with individually fitted contact glasses*." (60)

When plastic materials first became available, *Thier* reported, in 1938, his recent experiments with Plexiglass. According to his publication, the polished ground optic part is perfectly transparent and should not be deformed by eyelid pressure, whereas the haptic portion would had a certain suppleness that would adapt to the shape of the sclera. Contact shells made from synthetic material are twice as light as those manufactured from glass. Furthermore they are unbreakable, easy to manufacture and make adjustments on. (61)
The invasion of the Netherlands by the German army brutally interrupted the encouraging prospects of the Utrecht Clinic's research. *Thier* published his final two papers in English. The first of these concerned molding using *Dallos*'s method on phthisical eyes. For ocular prosthesis manufacture, the posterior surface corresponded to the geometry of the ocular imprint. The second article summarized the results in the 106 fittings of molded contact shells that were manufactured and fit between January 1937 and June 1938 at the Utrecht University Eye Clinic. (62)

3 - The Glass Corneo-scleral Shells in Italy

From the time of their presentation by *Heine*, the new *Zeiss* contact shells were known in Italy through a translation by *Oscar Oblath* (Trieste) Then in the following year *Lodovico Mamoli* (Venice) published a summarized review, that included a historical section, a review of the literature, and a detailed description of the new *Zeiss* shells. [63]

3.1 - Vincenzo Gualdi (1931-1935)

Figure 23-4
Young man wearing glasses and also wearing contact lenses fit by Oblath (1930).
The publication by Oscar Oblath in 1930 was mostly inspired by the research work carried out by Heine. It represented the first basic Italian research project on contact lenses. (Oblath O., 1930)

Then, *Vincenzo Gualdi*, Clinical Assistant at the Ophthalmology Clinic in Florence translated and commented on *Hartinger*'s optical theories with a series of tables and curvatures. [64] However, using the same formulae as *Hartinger*, he proposed other spacing of the corneal radii of the trial lenses: 0.25 diopters for refractive errors between 0.25 to 5.00 diopters, 0.50 diopters for refractive errors between 5.00 to 8.00 diopters, and 1.00 diopter for refractive errors between 8.00 to 15.00 diopters. He also asked that the choice of scleral curvatures be increased. This change would require at least 233 trial contact shells. A little time after that, *Gualdi* completed his publication with a new compilation of German publications on *Zeiss* ground contact glasses, with a new presentation of *Hartinger*'s theories including a historical survey of the recent *Heine*'s publications, of which he made significant criticism. [65] In his practice, he had observed numerous cases of intolerance that he attributed to poor design and insufficiency of finish of the *Zeiss* contact shells. This concerned particularly the edge profile. His arguments are illustrated by microphotographic shots of the edge profiles showing significant differences between individual *Zeiss* contact glasses with unfavorable effects on their tolerance. The majority of the ground contact lenses showed excessive weight and thickness in addition to internal tensions. The total diameter as indicated by the manufacturer corresponded only rarely to the actual diameter. For handling the lenses, *Gualdi* recommended a suction device resembling a dropper with a widened opening. He illustrated his presentation with clinical observations: 10 myopias, 3 hypermetropias, 2 aphakias, 2 keratoconus and two patients with irregular astigmatism. The fitting of the scleral part is controlled by instillations of methylene blue or fluorescein. After having verified the intraocular tensions both before and after wearing the contact glasses, he put an end to *Heine*'s hypothesis, often quoted, that contact glasses would have a beneficial effect on glaucoma or ocular hypertension. Considering that the excessive price of the *Zeiss* trial shells was the likely cause of resistance to their more widespread use, *Gualdi* introduced the idea to limit

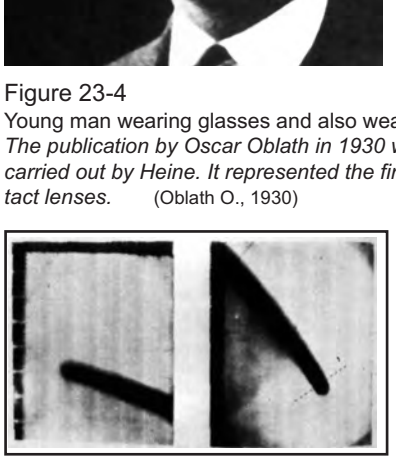


Figure 23-5
Microphotographs by Gualdi of border grinding and finishing in Zeiss contact lenses (1932).
These microphotographs by Vincenzo Gualdi provided evidence in 1932 of large finishing disparities in the borders of Zeiss contact glasses that would explain certain intolerances.
(Gualdi V., 1932a)

Figure 23-6
Illustration by Gualdi showing the benefit of contact glasses in a myopic female patient (1934).
After his invention of new types of contact glasses of Italian manufacture, Vincenzo Gualdi published in 1934 the results of his researches in the ophthalmology journal that had the largest circulation of that era. The illustration shows at left to right: the patient without correction, the same patient with glasses and the same patient with contact lenses.

(Gualdi V., 1934, fig. 6-8)

to six the number of trial contact glasses in a set. The ones three would comprise the scleral part only, the optic being measurable by keratometry and spectacle lenses. Because of the intolerance and the inadequacy of the *Zeiss* contact glasses, *Gualdi* proposed to make lenses that were ground with a better-adapted border. In the same year, he presented these new contact lenses to the Congress of the Italian Society of Ophthalmology. (66) Thus, the new 'made-in-Italy' corneo-scleral contact lenses of *Gualdi* required only six trial contact shells with haptic curvatures of 10.50, 11.00, 11.50, 12.00, 12.50 and 13.00 mm, manufactured in series and at an affordable price. Trial glasses determine the refraction and the refractive power is ground as a function of this information. Insertion of the contact shells is performed using a suction cup. *Gualdi* observed cases of corneal edema and was aware of patients who complained of reduced vision and seeing colored halos round lights. According to *Gualdi*, those shells with short corneal radii of curvature that do not touch the cornea except at the periphery near the limbus, are better tolerated than those with a higher radius that does touches the cornea at its apex. The more peripheral the contact is, the better the tolerance.

The work of *Gualdi* became better known after his 1934 publication in German and his original proposition to provide low-priced glass contact lenses that had the same curvature both for the corneal and the scleral parts. (67) The mass production of these trial lenses made them more affordable for every fitter. The six monocurved trial shells had a posterior radius graded in half-millimeter steps from 10.50 to 13.00 mm. Their total diameter is 20.00 mm, their weight 0.50 grams, with a margin would be particularly well suited to conjunctival support. At the time of the trial fitting, the ophthalmologist ignores corneal adaptation. He researches solely the most satisfactory scleral portion. Then he performs an additional refraction of which the corresponding equivalent power is ground onto the anterior surface of the corneal part. With some justification, some of his contemporaries judged the use of these types of trial shells as impractical, as *Obrig*, amongst others, states:

"*However, it does not seem logical or possible to obtain a good scleral fit and the same time clear the cornea properly with a lens having one single continuous radius of curvature. If the portion of the lens arching over the cornea is fitted to clear the cornea, the scleral portion must necessarily be fitted tight at the edge, so as to raise the lens sufficiently to obtain clearance. While useful for diagnostic and temporary refraction, these lenses have not proved satisfactory as corrective lenses.*" (68)

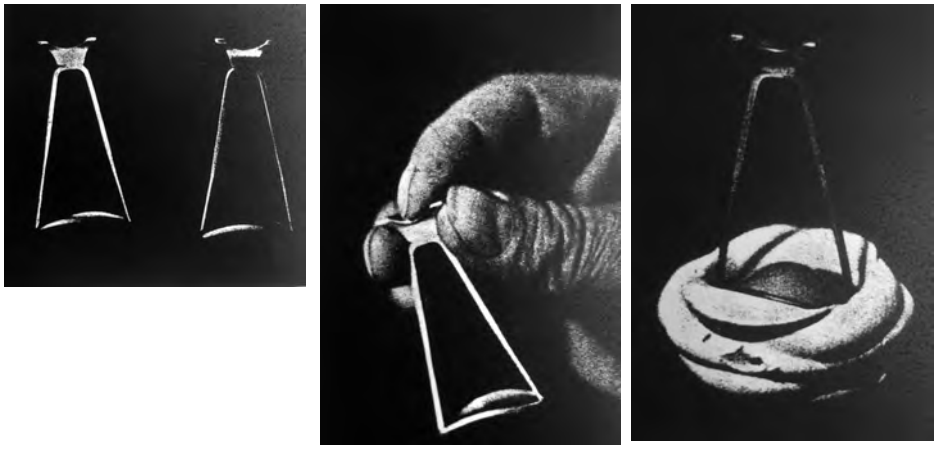
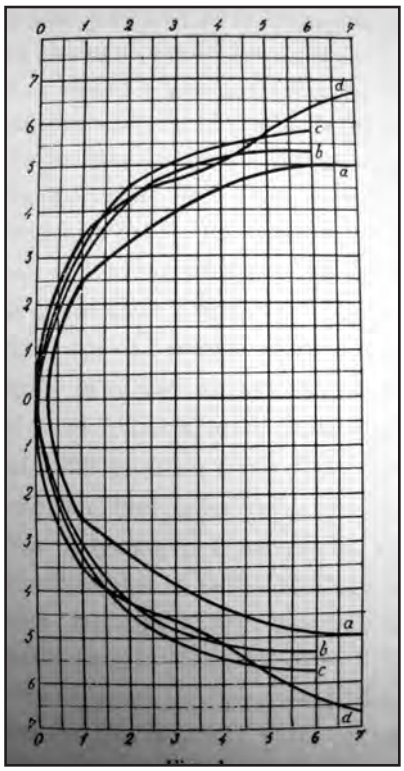


Figure 23-7 (a,b & c)
Technique of Bruno Prister's ocular moldings (1933).
In 1933, Bruno Prister described an ocular molding technique for the eyeball using dental wax at body temperature, illustrated from left to right:
a/ Empty mold-holders, then mold-holders roughly filled from the negative side with dental wax,
b/ How to place mold-holder in eye,
c/ The molding is transferred with precision onto a plaster of Paris contra-type.
(Prister B., 1933b)

3.2. - Bruno Prister and other Fitters (1933-1935)

In 1933 *Bruno Prister* (Trieste) also forged a reputation for ocular molding and the manufacture of molded contact shells. (69) He proposed a technique for molding using dental wax, a disc of which he inserted at body temperature by means of an adapted imprint-holder that he placed on the anesthetized globe of the eye after lightly heating it with warm water. After hardening of the wax with a frozen swab or brush, he removed the supporting structure and withdrew a plaster positive. Based on these models, *Prister* asked *Müller-Welt* (Stuttgart) to manufacture the contact shells. He described the molding technique at great length, illustrating the oval supporting structure of the imprint holder, the difficulty of removing the supporting structure from the eye and the precision necessary for removing the cast from the plaster mass. (70) Fitters of contact lenses criticized the technique for its impracticability, as *Obrig* summarizes:

"*The difficulty of wax casts is the comparative lack of details and the absence of any indication of the size or*



shape of the cornea. Only the general form can be obtained in this way." (71)

In a study on the etiology of keratoconus in 1934, *Filippo Caramazza* (Bologna) described the use of contact glasses that could be worn for hours without complications, but he acknowledged that he had no practical experience of these. (72) In the following year 1935, *Andrea Biffis*, clinical assistant at the Padua Ophthalmology Clinic, published a summary of the publications of her era in regard to the curvature of the anterior segment of the globe. For her personal experiments, she used a projection photographic method of the lateral view of the anterior segments of cadaver eyes that were documented on frameworks divided into squares. When she had analyzed the curvatures, she concluded that the anterior segment is, in fact, aspherical and that it had many irregularities. (73) Other publications followed in Italy as the years went by, but there was, for the most part, little new information. Thus it was, in 1935, with *Mario Trematore* and later, in 1936, *Luigi Zoldan* presented a case of bilateral peripheral corneal ectasia that was successfully treated with contact glasses. (74)

Figure 23-8
Projection studies of the anterior ocular globe profile by Biffis (1935).
By using a photographic examination method comprising projection of the lateral view of the anterior segment of cadaver eyeballs, Andrea Biffis concluded that the sclera is aspherical in shape. (Biffis A., 1935)

4 - The Glass Corneo-scleral Shells in the other Western European non-German speaking Countries (1920-1940)

4.1 - In France

4.1.1 - Georges Weill (1928)

The first communication in French on *Zeiss* ground glass contact glasses for the correction of keratoconus was presented on 1st July 1928 by *Georges Weill* before the Ophthalmological Society of Eastern France. (75) He was Professor of Ophthalmology in Strasbourg and, the year before, he had published a review article on the etiological theories of keratoconus. In that article, he expressed regret over the absence of French publications on contact glasses. He recalled his own article of 1916, published in German, and also the failure of experimental trials of contact lenses without a scleral flange that were furnished for him by *Zeiss* before World War One (76):

"*The first models from Zeiss, the ones before the war, while giving better visual results than those of Müller, were badly tolerated because they used the cornea as the only point of support. Since then, the Zeiss Company has modified their shape by adding a small collar, which applies to the conjunctiva, as I recommended to them so many years ago. This shape of prosthesis appears to me to fill the desiderata that one has the right expect of a contact lens: i.e. give a very appreciable increase in the vision and be tolerated for almost the whole*

day. Regarding this last aspect of tolerance by the eye, results have been variable especially at the beginning."[77]

He described the selection procedure of the new *Zeiss* ground contact lenses, with the four models of trial lenses:

"*Zeiss manufactures four models of the prosthesis, each bearing an individual number corresponding to its refractive power. After instillation of two drops of butelline 2%, the prostheses are introduced one after the other in order to find that which gives the best acuity and adding a convex or a concave glass as required in the cases where this combination would give a better visual acuity than just the simple contact shell.*
Once the best visual acuity is obtained, it is sufficient to indicate the number of the prosthesis and if necessary the trial glass that has to be added, in order to obtain from Zeiss a corresponding one-piece prosthesis, i.e. making the added-on spherical glass superfluous." [78]

Then *Weill* presented three favorable clinical observations:

"*1) M.F., Professor at Strasbourg University. Vision OS without glasses: 5/50, with Zeiss prosthesis # 90: 5/9. Vision OD without glasses: finger counting at 1 meter, with prosthesis # 90: 5/12*
2) Ms. W., Vision OS without glasses: 40/60, with Zeiss prosthesis: 5/6; Vision OD without glasses: 2/60, with Zeiss prosthesis: 5/6.
3) Sister M., Vision OD without glasses: finger counting at 50 cm, with prosthesis 5/10. Vision OS without glasses: finger counting at 1 meter, with prosthesis 5/8." [79]
Weill concludes:

"*The price of these prostheses is rather high: approximately 250 to 300 Francs apiece, but the advantage they have over other methods of treatment for keratoconus and the really surprising improvement that they give from the workplace point of view, more than justifies their expense.*" [80]

With the exception of *Georges Weill* of the Strasbourg Eye Clinic and subsequently his successor *Jean Nordmann*, France was not really touched by the phenomenon of contact lenses at this period of her history.

4.1.2 - The Haas Report (1937)

There was a flurry of interest when, in 1937, at the request of the Paris Society of Ophthalmology, *Emil Haas* (Paris), an ophthalmologist, was commissioned with the annual report on the theme of 'Contact Glasses' (Les Verres de Contact). [81] This document of 160 pages contains an in-depth summary of historical, theoretical and clinical practice aspects of contact lenses. It also provided a model for several works of the same type in years to come. Notwithstanding the gaps and several errors, the *Haas* report represented an interesting account of half a century of knowledge, just before glass was abandoned in favor of plastic materials for contact lens manufacture. The presentation of the *Hass* report was followed by discussions that highlighted the general ignorance of the majority of the attendees. *Jean Nordmann* (Strasbourg) alone advised the use of *Müller-Welt* contact glasses and reserved *Dallos* molded contact glasses only for failed fits of the former. *Henricus Jacobus Maria Weve* (Utrecht) described the contact glass manufacturing at the Utrecht Ophthalmology Clinic and the results obtained by *Thier*. And *Pierre Dumont* reported his successful use of the new *Zeiss* contact glasses. [82]
In 1938, *Haas* completed his report and emphasized the practical aspects of the four types of contact glasses available in Europe. [83] In the same year, *Jules Szymanski* (Warsaw) repeated his preceding Polish communication to the French Society of Ophthalmology. He described his method of selecting contact shells using calibrated corneal and scleral metallic rings. [84]

4.2 - In Switzerland

In Switzerland, *J. Strebel* (Lucerne) became, after 1931, a passionate advocate for 'orthopedic treatment' of keratoconus by means of contact lenses; He called these the 'glasses of the future'. In the course of the five previous years, he had fitted *Müller* contact shells that were extremely well tolerated in six patients affected by keratoconus. Three of these had been noted to have flattening of their cones. He had used an adjuvant treatment of 'Vaseline' combined with boric acid, in addition to olive oil or liquid paraffin as well as instillations of 'Novocaine' when very severe pains occurred. He had observed a progressive thickening of the corneal

tissue and regression of the cone that was verified by keratometer readings. In myopias, he obtained comparable successes with *Zeiss* contact shells. [85] In the following year (1932) *Strebel* described a 'Law of Asymmetry of the Anterior Scleral Cap' often cited by his contemporaries. He noted that asymmetries of the anterior scleral cap were proportional to the function of and related to the insertion of the rectus muscles. Furthermore these asymmetries provided proof that the anterior scleral segment is not spherical, except in patients affected by keratoconus. This would be an advantage for their 'orthopedic' treatment [86]:

"*There is relatively little scleral asymmetry in keratoconus patients and there exists good peripheral adherence of the contact shell, even if it often rubs in the center and produces erosions there. According to my own experience over several years, this central irritation could flatten the cupula of the cone as the result of cicatrization, reinforce the cupula of the cone and normalize the radii of curvature. I have designated this the 'orthopedic treatment of keratoconus'. Progressively, the prolonged wearing of the contact shell produces a thickening of the excessively thin corneal tissue. The progression of the cone is not only stopped, but the orthopedic corset of the contact shell produces a cicatricial flattening and – provided there is sufficient follow-up a relative therapeutic healing*." [87]

Dallos, *Obrig* and others would confirm these observations on scleral asymmetry in the moldings in the years that followed. They questioned the proclamations of *Hartinger* regarding an ocular sphericity similar to that of the spherical haptic of the *Zeiss* contact shells. *Strebel* became an ardent defender of the *Müller-Welt* contact lenses with aspheric and asymmetric haptics.
Several years later, in 1937, *Strebel* presented a new account of the orthokeratologic success of contact glasses in keratoconus. In this condition, the therapeutic efficacy of the *Zeiss* contact shells was superior to that of *Muller*'s contact glasses. In the clinical case presented, there appeared a normalization of the cone as evidenced by corneal radii of curvature from 4.90 to 7.10 mm. For this reason, he abandoned the surgical treatment of keratoconus. [88] In 1938, at the time of the discussion of a paper by *Knüssel* in connection with contact glasses, *Strebel* criticised the *Zeiss* contact glasses in respect of their basic inconvenience: they did not take into consideration the anterior scleral asymmetry that exists in nearly 50% of cases or the coefficient of elasticity of glass. That coefficient is too different from that of sclera to allow the adaptation that an acetyl cellulose or celluloid contact shell could allow. [89]

4.3 - In Belgium

In Belgium, *Emile Gallemaerts* published in 1933 an interesting comprehensive review on contact glasses based on a selection of the publications available to him. Unfortunately, he did not include any bibliographical references. He concluded his review:

"*I have thus reviewed more than 120 publications on contact or adherent glasses: the indications for using them are precise for keratoconus and they are also useful in high myopias, hypermetropia and aphakia; they are also prescribed from the standpoint of therapeutics, esthetics and professional use. That is a long way for wishing to employ them for the whole of humanity and proscribing eye glasses, as certain persons have recommended*." [90]

In 1939, the use of contact lenses in the Belgian army was broached by *Charles Schepens*. [91] Although fitting may be difficult, the contact shells would be useful, above all, in aviation. This author predicted that the use of plastics lighter than glass would ameliorate wearing the shells.
In the same year, the Brussels ophthalmologist, *Adrien Fritz* reported that he had performed ocular moldings with dental wax and had made from that a corneo-scleral shell out of plastic material. He did not, however, indicate which material he had used. [92] During the discussion, *Roger Weekers* referred to celluloid contact shells that had been presented by *Teissler* at the Cairo Ophthalmological Congress. The surfaces of these revealed splits, but they did, however, provide useful optical correction. [93]

5 - The Glass Corneo-scleral Shells in Central and Eastern non German-speaking Europe – (1920-1940)

5.1 - In Hungary

5.1.1 - Fésus and Dallos (Budapest, 1929)

In March 1929, during a discussion of a communication of *Fésus* at the Hungarian Society of Ophthalmology regarding the failure of *Zeiss* contact lenses in the fitting of a patient with keratoconus, *Joseph Dallos* reported that he preferred the latter because of their optical quality which gave a good visual acuity:

"*From an optical point of view the Müller contact shells are placed far behind the Zeiss contact lenses that are preferred. Dallos presented 4 patients in which he has corrected very satisfactorily the bad visual acuity of the keratoconus. One of these patients (a female) easily tolerated the contact glass for 10 hours*." [(94)]

In November of the same year (1929), *Joseph Dallos* reported the successful fitting of 17 keratoconus patients and two with keratotorus using ground *Zeiss* contact shells of which one well-chosen curvature allows a good positioning on the globe of the eye. He had also observed that the tolerance was better when the eyeball was not perfectly spherical [(95)]:

"*After several tries the patient succeeded in inserting these highly curved cups himself without interposing air bubbles. Removal was carried out by means of a simple prosthetic hook. The shells are little or not at all irritating, if one takes care that the glass cornea is not too closely in contact with the cornea itself (curvature adapted) and that the eye becomes accustomed gradually to the wearing of the shell. The protrusion of the globe plays no role. Aspherical globes support the shells even better than those that are truly spherical. However, pronounced discomfort is never produced because of adherence of the shell*." [(96)]

The trials of *Müller* contact shells by *Fésus* and the ocular moldings performed by *von Csapodi* had swept away the reservations of *Dallos*. The latter had made further changes to the method of molding up to the time of his departure for London.

5.1.2 - Györffy and Mihàlyhegvi

After *Dallos* had left the Budapest University Clinic, the fitting of contact glasses was entrusted to the young chief clinical assistant, *Istvàn von Györffy*. His predecessor had not left him any consignment or any equipment and he found himself under the obligation to rediscover the procedures and to develop the equipment necessary. *Von Györffy* quickly abandoned experimenting with glass in order to orientate himself towards the various methacrylates that had just been put on the market. His first results were presented in 1939 and were pursued in greater depth in the years to follow. In 1942, he published an important paper on tears and their behavior with contact lenses. *Györffy* also measured the lachrymal pH, noticing that this varied between pH 6.3 and 8.4 and recommended a buffering solution as a function of the lachrymal pH that would prolong the wearing time of contact lenses between 20 and 100% compared to saline solution.[(97)]

In 1940, *Géza Mihàlyhegvi* presented a historical summary and a eulogistic assessment of contact lenses that slowed the progression of myopia and caused keratoconus and corneal scars to regress. He also proposed a variation in ocular moldings by using aluminum tubes of 20.00 to 27.00 mm in diameter. These gave him better results than the fenestrated shells that were generally used. He explained that the 'cure' of the keratoconus observed in 11 patients and the regression of myopia by shortening of the anterio-posterior axis of the globe occurred as the result of flattening of the corneal radius. The same result could also be obtained by metallic plates of 9.00 mm in diameter placed on the eye during the night. These works on orthokeratology are also published in Italian. In the following years, *Mihàlyhegvi* carried out further in-depth researches, notably those dealing with the fluid meniscus and the improvement in vision obtained using contact lenses in certain cases of retinal degeneration. [(98)]

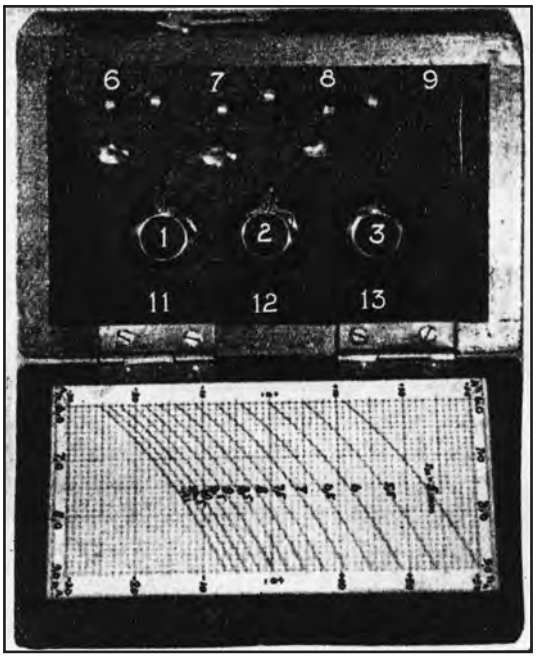


Figure 23-9
Szymanski's metallic trial contact shells (1936, 1937).
Because he was dissatisfied with the Zeiss trial contact shells, Jules Szymanski (Warsaw, Poland) proposed to replace these with a trial set of calibrated metal rings. Three have perforations in their centers and correspond with the scleral radii of curvature; the remaining four do not have a haptic part and correspond with corneal radii.
(Szymanski J., 1936, 1937)

5.2 - In Poland

In all countries, the over-optimistic presentations on the correction of cases of keratoconus became the norm and were no longer in the exclusive bailiwick of ophthalmological congresses. Evidence of such dissemination was manifested by the German-speaking Polish ophthalmologist, *P.A. Jaensch* (Wroclaw) in 1929 [99]:

"*The modern optico-orthopedic treatment of keratoconus includes the use of the adherent glasses of Zeiss and the contact shells of Müller-Wiesbaden. These are two excellent prostheses. The first have the advantage of greater optical precision, as they are ground, but the second are better tolerated by the patient and episodes of irritation of the globe are seldom encountered and less marked. Both prostheses render excellent service, as we found from our own experiences, particularly the contact shells of Müller; the results are so satisfying that they compensate largely for any disadvantages*." [100]

In 1931, *Rosenhauch* (Krakov) also made a presentation describing the new *Zeiss* contact shells and reported the case history of a patient fitted with these. In the course of the discussion, *Lauber* and *Schweig* described good results that they had obtained using *Muller* contact shells. (101)
In 1936, *Wiktor Reis* (Lvóv) described the history of the development of contact lenses and he ended with a description of favorable results in the recent fitting by *Dallos* of keratoconus in a medical student by the name of *Filip Wachtel*. In the same year *Jules Symanski* described his experience with *Zeiss* contact shells. He found that fitting these was very problematical. He proposed selecting contact shells with a set of calibrated metallic rings. The ones three are perforated in their centers and correspond with scleral radii of curvature. The other four have no haptic part and correspond to the cornea. [102]
In 1938, *Wachtel*, who had been the subject of *Reis*'s publication two years before, reported his own personal experience of intolerance to *Zeiss* contact shells and his satisfaction with *Dallos* lenses. He wore these without problems for the correction of his keratoconus and they allowed him to pursue his medical studies. [103]

5.3 - In Rumania

At the Congress of the Rumanian Society of Ophthalmology, *Nicholas Blatt* described his fitting successes for contact lenses in 38 patients with high myopia using blown *Müller* contact glasses. He was to publish this communication in the Archives of Ophthalmology in the following year, where it was destined to cause great reverberations. [104]

5.4 - In Czechoslovakia and Slovenia

In Czechoslovakia, in a 1929 publication on the etiology of keratoconus, *Löwenstein*, Professor of Ophthalmology at the University of Prague, described his predilection for ground *Zeiss* contact lenses as compared with the blown contact lenses of *Müller*: *"Vision right eye: counting finger at ¾ meter (...). With Zeiss contact lens # 90: 0.3. With the Müller contact shell for keratoconus, that, contrary to our usual experience, was less well tolerated at the beginning, reaches 0.4."* [105] In the years that followed, *Viktor Teissler* and his son *Jaroslav Teissler*, an ophthalmologist, were engaged in interesting research studies. These were presented in part at the International Ophthalmological Congress, held in 1937 in Cairo. After a historical summation, they gave an account of their experiments using materials that were an alternative to glass. Thus *Victor Teissler* modulated some plastic materials, Celluloid and Celon, between two brass molds. Manufacture was quite problematical: shells that remained transparent were used for correcting refractive errors, while the more or less opaque shells were used for preventing symblepharon or for X-ray diagnosis after including a lead thread. By their researches, *Janislav* and *Victor Teissler* are in line with the precursors of plastic contact lenses because they went beyond celluloid contact shells worn for 24 hours and tried pmma in the form of Plexiglass and Nidrosa. [106]
In Slovenia, *Prevec Slavko* described, in 1937, the state of development of contact lenses along with their history and theoretical aspects. [107]

6 - The Glass corneo-scleral Shells in other Countries, outside of USA and Europe

6.1 - In South America

The first publication on contact glasses from this part of the World comes from Argentina in 1927. The author, *Rómulo Gil*, presents a detailed historical retrospective inspired by the thesis of *F.E. Müller*, therefore partly erroneous. He meticulously describes *Zeiss* contact glasses for keratoconus, but does not include any evidence of their being used in his clinical practice. [108] In a general review, in 1933, describing the optical treatment of keratoconus, *E. Huber*, Chief of Ophthalmology at Rosario Hospital (Santa Fe Province), devotes several pages to the hydrodiascope and to contact lenses. After a historical part and a lengthy citation from *Heine*, he describes the *Zeiss* ground contact shells, taking his inspiration from documents and reprints that were distributed by *Zeiss* and some descriptions from *Heine* of bloodless conjunctival areas that he illustrated with photographs. His personal experience is disappointing, however, for, in the 10 patients in which *Huber* tried contact glasses, not one of these had obtained satisfactory tolerance with the trial lenses (cristales de ensayo) that he had at his disposal. He therefore contented himself with reporting the successes experienced by *Heine*. The bibliography is succinct and is limited as far as contact glasses are concerned to the essentials of the articles published in 1930. [109]
In the same year, *Enrico Bertotto*, ophthalmologist at the Italian Hospital of Garibaldi in the same city of Rosario, published a historical account and a description of *Zeiss* contact glasses. The clinical case presented concerns a young female who was suffering from keratoconus in both eyes. She was fit in Buenos Aires with contact glasses that the author of the paper had to change after she had worn these for only two months. He reported the clinical details of this re-fit. He continued his research and published in 1940 positive results with contact lenses delivered by *Hamblin-Dallos*. [110] In 1934, *Huber* develops new medical indications for contact lenses and illustrates these by presenting three patients whose corneal ulcers were cured thanks to contact lenses filled with ointment. [111]

6.2 - In Africa, Australia and Asia

In 1936, *Mohammed Bey Sobhy* (Egypt), presented the new developments in the domain of contact glasses to the Egyptian Society of Ophthalmology, basing these mainly on the publications of *Heine*. [112]
The first publication from South Africa was in 1930 when *J. Wassernaas* reported his observations on four patients with contact glasses worn for more than six months. [113]
The first Australian article published was that of *J. Ringland Anderson* in 1930. He was the ophthalmologist on staff at the Alfred Hospital in Melbourne. The historical section is limited to the *Müller Brothers* of

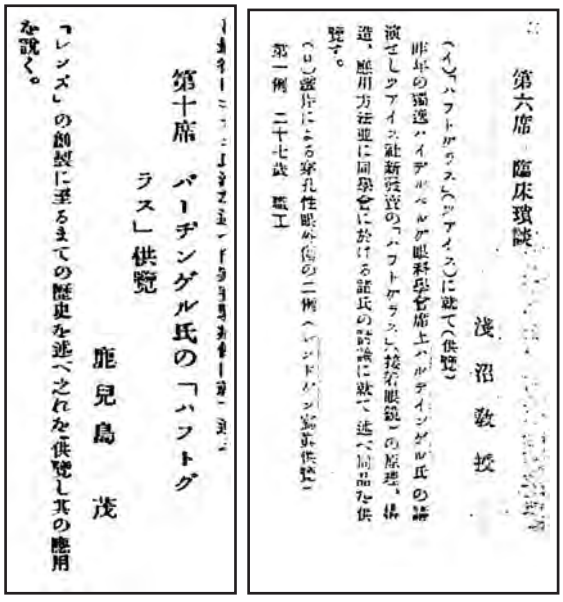
Wiesbaden and *Zeiss* (Jena). The author is familiar only with the three trial lenses for keratoconus, but he amalgamates his knowledge of these with the characteristics of *Zeiss-Heine* contact glasses. [114] In 1940, *James A. Flynn* described his experience using *Dallos* contact lenses sold by *Theodor Hamblin* Ltd. This evidence takes into account the difficulties of the new procedure of marketing of the *Dallos* contact shells taken over by *Hamblin*'s. This Australian physician practiced Negocoll moldings that he forwarded to London. In return he received a trial contact shell that he sent back for modifying or exchange for as long as necessary. Fitting contact glasses thus took at least 6 months, which made the process very onerous. [115]

Figure 23-10
Use of contact glasses for cosmetic purposes (1938).
This young female succeeded in hiding the corneal nebula in her left eye during the marriage ceremony. She did this by using a cosmetic contact shell.
(Mukerjee SK., 1938)

In Auckland, New Zealand's North Island, *Eugene Hirst*, who had emigrated from Czechoslovakia, manufactured, in 1939, contact lenses using impressions of the eye. He was a dental technician and he molded lenses over a stone cast. In Wellington, *Peter K. Higginbotham* was the first to use contact glasses from *Nissel* then made them himself. [116]

In India, *P.K. Biswas* published, in 1936, a description of *Zeiss* and *Müller* contact glasses. In 1938, *S.K. Mukerjee* (Calcutta) covered the staphyloma and the corneal tattoos of a young West-Indian female using a contact shell painted the same color as the other eye. [117]

In Japan, following his first publications on returning to Tokyo from Jena, *Shinobu Ishihara* and subsequently *Mikijiro Nishimura* on his time with *Siegrist* in Berne, crisis that was raging in Asia. This prevented Japanese ophthalmologists from attending the European congresses that followed. [118] When the glass corneo-scleral shells were introduced by *Zeiss* agencies in Japan, they do not seem to have been used on a grand scale. Above all, information was transmitted by written documents or second-hand. Thus, in 1930, *Shigeru Kagoshima* made a presentation describing *Zeiss* shells and the history of contact glasses. He made another presentation in 1935 on the development of recent contact lenses. [119] At the 11th Congress of the Nagasaki Ophthalmological Society held in 1931, *Takeo Asanuma* made a presentation and gave a demonstration of ground *Zeiss* contact glasses that he had brought back with him after a visit to Germany and he gave an account of *Hartinger*'s presentation in Heidelberg and the discussions that followed it. *(120)* In Volume IX of the 55 Volume Encyclopedic Treatise published by the Japanese Ophthalmological Society, Professor *Nakamura Yasushi* (Nippon University) also included in 1935 the known information on contact glasses. [121] However, the Japanese literature of this era would not give us any evidence of clinical application of contact lenses. [122]



第十席　パーヂングル氏の「ハフトグラス」供覧

鹿兒島　茂

「レンズ」の創製に至るまでの歴史を述べそれを供覧し其の應用を說く。

第六席　臨床瑣談

淺沼敎授

Figure 23-11
Japanese publication on contact lenses.
At left: Evaluation by Shigeru Kagoshima of Zeiss-Heine contact glasses at the 180th Meeting of Kumanato Ophthalmological Society (December 13th, 1930). (Kagoshima S., 1930).
At right: Report on the presentation by Takeo Asanuma at the 11th Meeting of Nagasaki Ophthalmological Association, (February 13th, 1931).
(Asunuma T., 1931)

Notes in Chapter XXIII

1. According to Bowden T.J., 2009.
2. Paxton G., 1931.
3. Pascal J.L., 1930a, b.
4. Rugg-Gunn A., 1930a, 1930b (published 26 dec.1930).
5. Heine L., 1931b.
6. Rugg-Gunn A., 1931a.
7. Rugg-Gunn A., 1931b. Presentation to the Oxford Ophthalmological Congress on 9-11.July 1931.
8. Greeves R.A., 1931.
9. Beaumont J.H., 1931a, b. Presentation on the 10th October 1930 to the Royal Society of Medicine, Section of Ophthalmology, London.
10. Joyce R. Dwyer., 1931. Presentation in Dublin to the Irish Ophthalmological Society on 24th July 1931.
11. Rugg-Gunn A., 1932.
12. Rugg-Gunn A., 1931a, 1932. Presentation to the Royal Society of Medicine, Section of Ophthalmology, November 13 1931. Starting in 1931, Zeiss contact shells were imported into the British Isles.
13. Rycroft B.W., 1932.
14. Wright R.E., 1932.
15. Rycroft B.W., 1933.
16. Williamson-Noble F.A., 1934. Presentation on 9th March 1934 to the Royal Society of Medicine, Section of Ophthalmology, London.
17. Rugg-Gun A., 1935. Presentation to the Royal Society of Medicine, Section of Ophthalmology in London on 14th June 1935, followed by discussions by J. Gray Clegg and A.G. Palin.
18. Clegg J.G., 1935.
19. Palin A.G., 1935.
20. Focus, 1935.
21. A.B., 1938.
22. According to Bürki E., 1948.
23. Dallos J., 1938. Presented at the Oxford Ophthalmological Congress on 8th October 1937, followed by discussions by Williamson-Noble, Mann and Rugg-Gunn.
24. Williamson-Noble F.A., Mann I., 1938b; Rugg-Gunn A., 1938.
25. The exchange between the manufacturers Keeler and Clement Clarke and the Director of the Ophthalmology Clinic at Utrecht X.M. Weve materialized in November 1937 when a bona-fide contract was signed. On the same occasion, a movie on the manufacture of molded contact shells was shot in Utrecht with Maurice Mostyn-Brown supervising.
26. Ophthalmic Zelex, Amalgamated Dental Company.
27. Whiting M.H., 1937.
28. Mann I., 1938a. In this article, 27 pages in length, the bibliography is limited to 30 articles consulted. The other citations are second-hand and often erroneous. This partly explains the numerous errors that are still repeated nowadays in English language publications.
29. Mann I., 1939. Presentation to the Royal Society of Medicine, Section of Ophthalmology London on 9th December 1938.
30. Williamson-Noble F.A., 1936b. Presentation to the Oxford Ophthalmological Congress on 1-9th July 1938.
31. Reid A.M., 1938. Presentation to the North of England Ophthalmologic Society, Session 1937-1938.
32. Mukerjee S.K., 1938.
33. Davis W.H., 1939.
34. Phillips T.J., 1939. Presentation to the Royal Society of Medicine, Section of Ophthalmology, London, 9th December 1938.
35. Williamson-Noble F.A., Dallos J., Mann I., 1940.
36. Flyn J.A., 1940.
37. Klein M., 1943.
38. Mann I., 1942.
39. Mann I., 1944.
40. Dallos J., 1946.
41. Müller A.E., 1889. See Müller's description of the haze in volume II, pp. 91-93.
42. Sattler C.H., 1935. See chapter 20, § 3.3: 'The contributions of C.H. Sattler'.
43. Bowden T.J., 2009, p. 115-116.
44. Schepens C., 1946.

45. "Joseph Dallos est le père du procédé de fabrication du verre de contact par moulage individuel. J'ai pu observer son travail à Londres depuis plusieurs années. Je me souviens qu'il y a sept ou huit ans, il était fort partisan du verre de contact en matière plastique. Actuellement, il fabrique toutes ses prosthèses en verre. La raison qu'il donne est que la matière plastique se déforme à l'usage et se raie très rapidement. Il me semble que le moulage de l'oeil au moyen d'une substance plastique genre 'Negocoll' a perdu de son importance. L'atelier de moulage possède une grande collection de verres groupés par famille. Quand un nouveau malade se présente, on lui essaye d'abord un verre de la collection. On détermine ainsi quel est le verre le plus approchant et l'on en fait une copie en matière plastique. Cette copie est ensuite modifiée de façon à s'adapter parfaitement. On utilise dans ce cas la matière plastique parce qu'elle se travaille plus aisément que le verre. La prosthèse définitive est faite en verre. Les essais prennent de douze à dix-huit séances. Le verre est porté d'abord pendant une à deux heures par jour seulement, même s'il peut être toleré plus longtemps. Ce n'est qu'au bout d'un an environ que le patient le porte pendant huit, douze, voire même seize heures par jour dans les cas favorables."
46. Cross A.G., 1949; Choyce D.P., 1954.
47. Treissman H., 1949.
48. Hirtenstein A., 1950.
49. Dallos J., 1954; Choyce D.P., 1954.
50. Zeeman W.P.C., 1931; Wibaut F., 1931. Presentations to the Netherlands Ophthalmological Society on 13th to 14th December 1930.
51. Weve W.P.C., 1932a, b. Presentations to the German Ophthalmological Society in Leipzig from 1st to 9th May 1932 and to the Netherlands Ophthalmological Society in Amsterdam on 22nd July 1932.
52. „Diese Spiegeluntersuchung wird sehr erleichert durch das Aufsetzen einer kleien Hornhautkontaktschale von Zeiss. (...) Es ist ein Leichtes, das Schälchen nach eventueller Verscheibung wieder ohne Luftblase auf die Hornhaut zu bringen. Die Hornhaut bleibt klar und unregelmässiger Astigmatismus infolge von Eintrocken bleibt aus. Es sei noch bemerkt, dass diese Schälchen auch bei Meridianbestimmungen gute Dienste leistet; da dadurch der sog. Meridianfehler infolge von Astigmatismus vermieden wird." (Weve, 1932 b, p. 110)
53. Weve H.J.M., 1934.
54. Thier P.F.X., 1936a, c. Presentation to the Netherlands Ophthalmological Society on 15th December 1935 in Amsterdam.
55. Thier P.F.X., 1936b, 1937a, b. Presentation to the Netherlands Ophthalmological Society on 23rd and 24th May 1936 in Utrecht.
56. Weve H.J.X., 1937a. Presentation to the Netherlands Ophthalmological Society on 28th August 1937.
57. Weve H.J.X., 1937b. Discussion of *Haas*' report presented in Paris on 14th November 1937.
58. In 1937, the manufacturers Keeler and Clement Clarke of London visited Thier's laboratory. Professor Weve authorized them to film the manufacturing and fitting procedures for molded contact shells. This remarkable documentation, which was very innovative for that time as it was shot in color, has been preserved by Mr. Richard Keeler (London) of Keeler's and he authorized us to view it.
59. Thier P.F.X., 1938a, b. Presentation to the Netherlands Ophthalmological Society on 29th to 30th January 1938 in Utrecht and discussions.
60. Weve H.J.X., 1938: "Het voornaamste vraagstuk is het haptische probleem. Opdat een glas, zonder bezwar 8 uur per dag kan worden dedragen, is in den regel een zeer zorgvultige aanpassung noodig. Daarom is de toekomst niet aan het massaproduct, doch aan het individueel aangepaste contactglas."
61. Thier P.F.X., 1938a, b. Presentation to the Netherlands Ophthalmological Society on 10th and 11th of December 1938.
62. Thier P.F.X., 1940a, b.
63. Oblath O., 1930; Mamoli L., 1931.
64. Gualdi V., 1931. The Zeiss contact shells were sold in Italy during this era by the Italian representative of Zeiss, La Meccanoptica S.A.
65. Gualdi V., 1932a. Presentations to the Congress of the Italian Society of Ophthalmology in Rome on 22-24 October 1931 and to the Florence Academy of Medical Physics on 21st January 1932.
66. Gualdi V., 1932b. Presentation on 13th to 15th September 1932 in Parma. The new Gualdi contact shells are manufactured and sold by the Officina Scientifica Meccanica A. Frusoni, Firma Fabri, Piazza S. Maria Maggiore, Firenze.
67. Gualdi V., 1934.
68. Obrig Th., 1942, p. 161-162.
69. Prister B., 1933a. Presentation to the Medical Association of Trieste.
70. Prister B., 1933b.

71. Obrig Th., 1942, p.207.
72. Caramazza F., 1934.
73. Biffis A., 1935.
74. Trematore M., 1935; Zoldan I., 1936. Presentation to the 33rd Congress of the Italian Society of Ophthalmology in Trieste, 7-9th October 1935.
75. Weill G., 1928. Presentation to the Ophthalmological Society of Eastern France on 1st July 1928 at Nancy.
76. Weill G., 1926. See volume II, chapter 18, § 1.1.2, pp. 284-285: The Strasbourg Experiments.
77. "Les premiers modèles de Zeiss, d'avant guerre, tout en donnant de meilleurs résultats que ceux de Müller, étaient mal supportés puisqu'ils prennaient la cornée comme seul point d'appui. Depuis que la maison Zeiss en a modifié la forme en y ajoutant une collerette qui s'applique sur la conjunctive comme je lui avais recommandé il y a bien des années, cette forme de prothèse me parait remplir les desiderata qu'on est en droit de demander à un verre de contact: c'est à dire de donner une augmentation très sensible de la vision et d'être supporté pendant presque toute la journée. À ce dernier point de vue de la tolérance de l'oeil, les résultats sont variables, surtout au début."
78. "Zeiss fabrique 4 modèles de prothèses portant chacune un numéro special correspondant à leur réfraction. Après instillation de deux gouttes de butelline à 2%, on introduit les prothèses l'une après l'autre pour trouver celle qui donne la meilleure acuité visuelle en ajoutant au besoin un verre convexe ou concave dans les cas où cette combinaison donnerait une meilleure acuité visuelle que la coque simple.
Une fois le maximum de vision obtenu il suffit d'indiquer le numéro de la prothèse; éventuellement le verre qu'on a dû ajouter, pour obtenir de la maison Zeiss une prothèse correspondante, c'est-à-dire rendant le verre sphérique surajouté inutile."
79. " 1° M.F., professeur à l'Université de Strasbourg. Vision O.G. sans verre : 5/50, avec prothèse Zeiss n°90: 5/9, Vision O.D. doigts à 1 mètre, avec prothèse n°90: 5/12 .
2° Mlle W., Vision O.G. sans verre: 4/60, avec prothèse de Zeiss, égale 5/6. Vision O.D. sans verre: 2/60, avec prothèse de Zeiss : 5/6.
3° Soeur M., Vision O.D. sans verre: doigts à 50 centimètres avec prothèse: 5/8."
80. "Le prix de ces prothèses est assez élevé; environ 250 à 300 francs pièce. mais l'avantage qu'elles ont sur les autres modes de traitement du kératocône et l'amélioration vraiment surprennante qu'elles donnent au point de vue capacité de travail, justifient amplement la dépense."
81. Haas E., 1937. 'Rapport' (Report) presented to Paris Society of Ophthalmology on 14th November 1937.
82. Nordmann J., 1937; Weve H.J.M., 1937; Dumont. P., 1937.
83. Haas E., 1938.
84. Symanski J., 1936, 1937: presentation in Paris on 28th June 1937; Dumont P., 1937.
85. Strebel J., 1931.
86. Strebel J., 1932.
87. "Anders verhält es sich bei Keratokoni, die relativ Skleralasymetrie aufweisen, so dass die periphere Haftung gut ist, wenn auch die Schale zentral oft scheuert und Erosionen macht. Nach meinen langjärigen Erfahrungen können diese zentralen Reizungen die Kegelkuppe narbig abflachen, kräftigen und die Radien normalisieren, was ich als "Orthopädie des Hornhautkegels" bezeichnet habe. Allmählich findet durch längeres Tragen eine Verdichtung der zu dünnen Konusstellen statt. Das Weiterschreiten des Kegels scheint nicht nur gehemmt, sondern das orthopädische Korsett der Kontaktschale bedingt eine narbige Abflachung und – bei genügender Ausdauer – eine relative Heilung." (Strebel J., 1932, p.639)
88. Strebel J., 1937.
89. Knüsel O., 1938. Presentation before the Swiss Society of Ophthalmology, from 13th to 19th June 1938 in Lucerne, followed by a discussion by J. Strebel.
90. Gallemaerts E., 1933: "J'ai ainsi passé en revue plus de 120 publications sur les verres de contact ou adhérents: les indications de leur emploi sont surtout précises dans le kératocône, utiles dans les myopies élevées, l'hypermétropie et l'aphakie; on les prescrit aussi au point de vue thérapeutique, esthétique et professionnel. De là à vouloir les employer pour l'humanité entière comme certains l'ont préconisé, et proscrire l'emploi des lunettes, il y a loin."
91. Schepens C., 1939.
92. Fritz A., 1939. Presentation on 30th April 1939 to the Belgian Society of Ophthalmology.
93. Weekers R.., 1939; Teissler J., 1938a.
94. Fésüs A., 1929; Dallos J, 1929. Presentation to the Hungarian Society of Ophthalmology in Budapest 8th March 1929: "In optischer Hinsicht stehen die Müllerschen Schalen weit hinter des Zeisssschen Kontaktgläsern, er möchte letztere bevorzugen. Stellt 4 Kranke vor, bei denen er wegen Keratokonus die schlechte Sehschärfe sehr gut korrigieren konnte, einer dieser Patienten trug das Kontaktglas 10 Stunden

ohne Beschwerden."

95. Dallos J. 1930a, b; Csapody I.v. 1930a. Presentation at the Hungarian Society of Ophthalmology in Budapest on 28th November 1929, followed by discussions of I.v. Csapody, B.v. Pellathy and E.v. Grosz.

96. « Nach einiger Übung gelingt es dem Patienten, sich selbst die stark gewölbte Schalen ohne Einlagerung von Luftblasen, einzusetzen. Die Entfernung geschieht mittels eines einfachen Prothesenhakens. Die Schalen reizen wenig oder gar nicht, falls darauf geachtet wird dass die Glaskornea der Hornhaut nicht fest anliegt (passende Wölbung) und dabei das Augen sich allmählich an das Tragen der Schalen gewöhnt. Die Prominenz des Bulbus spielt hierbei keine Rolle. Asphärische Bulbi vertragen die Schalen noch besser als sphärisch gestaltete, doch wurden erhebliche Unannehmlichkeiten durch die Ansaugung der Schale nie verursacht".

97. Györffy I.v., 1939, 1940a, b, c, 1941a, b. (Presentations to the Hungarian Society of Ophthalmology on 8th October 1939 and 13th April 1940) and Györffy I.v., 1942a, b.

98. Mihàlyhegyi G., 1940b, c, 1941a, b, c, d. (Presentations to the Hungarian Society of Ophthalmology on 13th April and 6th October 1940) and Mihàlyhegyi G., 1941e, f, 1942a, b.

99. Jaensch P.A., 1929a, b. Presentation of 15th March 1929 at the Medical Section of the Silesian Society for the Culture of the Fatherland (Medizinische Sektion der Schlessigen Gesellschaft für vaterländische Kultur). Jaensch practiced in Wroclaw (former Breslau) that was in the Administrative Capital of Lower Silesia. This comprised, at this period, a German-speaking majority population with its own associations and structures, particularly medical.

100. "Der modernen optisch-orthopädischen Behandlung stehen den Haftglässern von Zeiss und den Kontaktschalen von Müller (Wiesbaden) zwei ausgezeichnete Prothesen zur Verfügung. Die ersteren haben den Vorzug der grösseren optischen Genauigkeit, da sie geschliffen sind, die letzteren werden aber vom Patienten besser vertragen, die Reizzustände des Bulbus sind seltener und geringer. Beide leisten vorzüglichen Dienste, wie an eigenen Beobachtungen besonders mit Müllerschen Kontaktschalen hervorgeht; die Erfolge sind so befriedigend, dass sie die Mängel mehr als ausgleichen."

101. Rosenhauch, 1931. Presentation at the 15th Congress of Polish Ophthalmologists in Krakow.

102. Reis W., 1936; .Symanski J., 1936. The same paper will be read again in 1937 before the French Society of Ophthalmology.

103. Wachtel F., 1938a, b.

104. Blatt N., 1932a, b., 1933. Presentation on 31st May 1931 at the Congress of the Romanian Society of Ophthalmology.

105. Löwenstein A., 1929: "Visus rechts: Fingerzählen ¾ m (...) mit Zeißschen Kontaktglas Nr. 90m = 0,3. Mit Müllerschen Keratokonusschale die übrigens im Gegensatz zu unserer sonstigen Erfahrungen für den Anfang erheblich schlechter vertragen wurde 0,4."

106. Teissler V., 1938 a; Teissler J., 1938 a, b. See in this volume, chapter 24, § 1.2.

107. Slavko P., 1937.

108. Gil R., 1937. Unfortunately the text includes numerous imprecision and errors, particularly those introduced by F.E.Müller in his thesis published in 1920 and notably that Sulzer had begun his researches '12 aňos más tarde' (12 years later) than Fick. Errors are found in the transcription of proper names: 'Galezosky' for Galezowski., 'Löwenstein' and 'Löewenstein' for Lohnstein, etc. Gil seems not to have consulted any original document and to have basically reproduced documents circulated by the firms of Müller and Zeiss. Gil did not include any bibliography in his article.

109. Huber E., 1933. Published following a communication with case presentation to the Circulo Médico de Rosario. The author misspells the proper names ("Schulzer" for Sulzer) and forgets to cite Kalt. Bibliography includes South American papers: Gil (1927), and Dodds Leonel (1927). El queratocono y los cristales de contacto. Revista Médica de Cuyo, 1942, (documents we were unable to verify).

110. Bertotto E.V., 1933. Communication with case presentation on 8th September 1933 to Circulo Médico de Rosario, and Bertotto E.V., 1940.

111. Huber E., 1934.

112. Sobhy M.B., 1936.

113. Wassernaas J., 1930. Cited by Rycroft. (Journal of the Medical Association of South Africa, 4 1930, 459).

114. Anderson J. R., 1930.

115. Flyn J.A., 1940.

116. Bowden T., 2009 p. 148, spelled as 'Higginbottom'.

117. Mukerjee S.K., 1938.

118. Ishihara Shinobu., 1914, 1925. See volume II, chapter 16, pp. 247-248: Ishihara's study on Anisometropic Myopia using Contact Lenses.

119. Kagoshima S., 1930. Presentation on 13th December 1930 at the 180th Meeting of the Ophthalmological Society of Kumamoto. The review Rinsho Ganka Iho gives only a brief summary of this conference.
120. Asanuma T., 1931. Presentation on 13th February 1931 at the 11th Meeting of the Nagasaki Ophthalmological Society. We have only a two-line summary available of this communication.
121. Nakamura Y., 1935a, b. cited by Mizutani Y., 1966.
122. Personal communication from Professor Saiichi Mishima in December 1999.