CHAPTER XXVIII

Therapeutic and Diagnostic Applications of Contact Shells and Contact Lenses

Introduction

It is tempting to use contact shells and lenses as a mechanical means for protecting injured ocular tissues and for maintaining therapeutic agents in contact with these. Ocular protection by glass prostheses generally predates the use or contact shells and glasses for this purpose. The literature abounds with communications on such uses, which seems to have been facilitated from the moment the tolerance of contact shells was better assured. Unfortunately the long-term results of various trials have rarely been reported, even in the most respected treatises and articles published after 1920.
Add to this, the diagnostic uses including contact shells for radiological localization and contact glasses designed for the examination of the ocular media. Contact shells were also used as an ocular (eyepiece) in a Galilean telescopic system for chorio-retinal lesions. Note too that the majority of authors are however content to list indications without presenting a significant number of clinical examples. [(1)]

After the 1950s and with the introduction and marketing of corneal diameter contact lenses, corneo-scleral contact shells progressively lost their optical indications. On the other hand, their usefulness for medical indications was confirmed and documented.

This owed much to the initiative and drive of *Frederick Ridley*.
The timing of the non-refractive use of contact shells requires that two chronological periods be distinguished: the years between 1920 and 1950 and the second half of the 20th Century.

1 - Contact Shells and Therapeutic Corneo-scleral Lenses in Use between 1920 and 1950

Introduction

For this period, during which contact shells were used essentially with the aim of correcting refractive errors, we should distinguish the following contact shells that were used in other ways:

1/ Contact shells used in the presence of ocular and palpebral pathologies.
2/ Contact shells used with the aim of protecting the eye against radiation.
3/ Contact shells used as diagnostic aids.
4/ Contact shells used as an ocular (eyepiece) as part of a telescopic system in the presence of a macular lesion.
5/ Cosmetic contact shells.
6/ Contact shells used for so-called orthopedic treatment of the cornea.

1.1 - Contact Shells and Lenses in the Presence of Ocular and Palpebral Pathologies

Contact shells were recommended from the very outset after their discovery because of their mechanical action in separating bulbar from palpebral conjunctiva. In this way, they maintained open the palpebral sulcus, thus avoiding and even preventing the often inevitable symblepharon following chemical burns. The presence of a corneo-scleral contact shell would also protect the globe against friction from the lid margin and prevent corneal lesions from trichiasis. It also would protect the cornea in cases of palpebral paralysis and prevent a neuro-paralytic keratitis. In practice such actions could be combined and the presence of a contact shell could have several purposes.
It was also tempting to use contact shells for covering or maintaining a corneal graft in position: thus, immediately after their invention, *De Wecker* and *Demarres* carried out some trials for this purpose. (2) It was not, however, before a further half-century had elapsed that this indication was broadly exploited. Besides, the idea of using a contact shell for maintaining in-situ various therapeutic products close to a pathological cornea or conjunctiva was promoted right from the beginning, even if tolerance of the device was not completely assured. (3)
This technique was more widely used after 1920, above all, thanks to *Müller´s* blown contact shells. However, Zeiss contact lenses were unsuited to therapeutic use in deformed or disfigured eyes because of their 'perfect sphericity'.
With more perfected contact shells, especially after the introduction of plastic materials, their therapeutic use became more current. Each clinic or hospital possessed sets of contact shells, assigned respectively to protection, lavage or maintenance of a therapeutic agent. From amongst the hundreds of publications on contact shells for therapeutic use, one can indicate those most typical from the development of the techniques of the era and those that seem to have impressed contemporaries the most.
After 1917, *Illig* recommended a contact shell without a corneal part and with perforation of the scleral part for the prevention and treatment of symblepharon, complicating chemical and thermic burns. *Paul Carsten* also employed this contact device. (4)
In November 1922, *Max Weihman*, ophthalmologist in Berlin, presented a paper to the Congress of the Berlin Ophthalmological Society: 'Treatment without bandaging of corneal ulcers and epithelial lesions by means of transparent contact shells.' (5) He announced that the shells (manufactured by *Müller-Uri* in Berlin) provided effective protection for the cornea. This preliminary communication was followed in the next year by a more detailed publication. He described how the contact shells were transparent in their corneal part and milky white in the scleral part. They were asymmetrical and specific for each side, allowing for them to be supported in the conjunctival cul-de-sacs. They were available in various curvatures. Such transparent protective bandages provided innumerable advantages: elimination of contact between the cornea and the conjunctiva, no risk of irritation by standard dressings, no interference with tear flow and maintenance of a certain level of vision in the treated eye. They also protected the eye against rubbing by the lids, they maintained contact with a wound by means of a therapeutic agent. Finally, they prevented the risk of rupture of a corneal ulcer.

In a paper on 'Pregl's Solution', *Rudolf Schneider* used an iodized antiseptic colloidal solution that he described in 1925 for the treatment of corneal ulcers. The substance was instilled under the shell into the precorneal space. *Schneider* insisted, however, that neither the contact shells nor the solution were always tolerated. (6) If one takes into account that contact with the antiseptic solution was only for 3 to 5 minutes, he proposed to establish a prolonged antiseptic bath treatment using Müller blown glass contact shells: "*I placed a Müller adherent glass on the sick cornea and I filled the space between the cornea and the glass with Pregl's iodized solution. The action of this therapeutic agent was thus prolonged for up to 3 hours. Some patients were intolerant of this type of treatment by reason of painful episodes and global irritations. Such patients did not tolerate either an adherent lens filled with other liquids or isotonic saline solution.*" (7)

In the same epoch, *Knapp* filled the concavity of the contact shell with a tattooing solution intended to cover with pigment and thereby hide a leucoma. The procedure was not without pain and triggered a polemic with *Friede*, who preferred to use tinted contact shells. (8) In 1926, *Fritz Meyerbach* reported using *Müller-Wiesbaden* contact shells at the Ophthalmology Clinic at Frankfurt-am-Main for the reduction of a descemetocele by compression. Etiology was gonorrheal keratitis. He had observed improvement in the vision, good tolerance for the contact shell and regression of the corneal ectasia. The author was of the opinion that, since the time of utilization of blown contact shells, the era of the surgical treatment of corneal ectasias had been revolutionized. For this indication, blown glass contact shells were definitely preferable to ground Zeiss contact shells. (9)

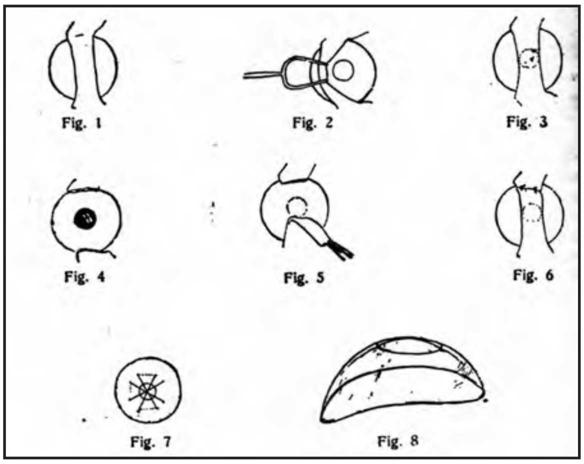

Figure 28-1
Rosengren's contact shell for holding corneal graft in position.
Rosengren described a corneal grafting technique associated with the insertion of a contact shell for the maintenance of graft. (Rosengren B., 1930)

Figure 28-2
Therapeutic contact shells with opening for instillation of therapeutic agents.
Ocularists supplied contact shells blown from soft glass, modeled from ocular prostheses equipped with an opening for the instillation of therapeutic products.
(Private collection)

In Vienna, *Maria Proksch* presented several patients in 1928, in which corneal contact shells were used for the treatment of corneal degenerations. The purpose of this treatment was to favor the postoperative corneal cicatrization and to treat eczematous keratitis. In the following year, *Deutsch* recommended the treatment of postoperative corneal scars and interstitial keratitides by using contact shells. (10)

However, in 1930, *Birch-Hirschfeld* had more reservations and advised against the use of contact lenses in the presence of pathological conditions of the cornea. (11) In the same year, *Rosengreen* presented to the Swedish Ophthalmological Society the case of a corneal graft held in position by a shell made from blown glass. This happened when *Müller*, the ocularist, was visiting the Lund Ophthalmology Clinic. (12) In spite of unfavorable operative results, the author emphasized the interest of a technique that was usable in the absence of fixation of the graft to surrounding tissues in its environment. He adds: "*It is of interest to note here that with the technique employed, one was able to fix the graft and to procure a satisfactory union under the above-mentioned unusually unfavorable circumstances. Unfortunately, on account of other complications, the gain was light. The method, however, may possibly deserve to be still further tested; such contact glasses have therefore been procured for the clinic from F. Ad. Müller Söhne, Wiesbaden, intended for human eyes as well as for experimental investigations of rabbit's eyes, recently initiated.*"
The use of corneo-scleral contact shells for the covering of perforating wounds during healing by first intention gave rise, in 1930, to interesting confrontations between *Ohm* and *Comberg*. *Ohm* who was Professor of Ophthalmology in Bottrop, (Germany), drew attention to a then new application for contact glasses by posing the question: 'Are contact-glasses able to be used for patients with perforating ocular injuries?'. (13) According to *Ohm*'s suggestion, an adequate contact shell could protect the eye in patients with a perforating injury. It could also favor the maintenance of the anterior chamber without, however, interfering with the

management of the lesion: “*There are situations in which, in the presence of perforating corneal wounds, one cannot perform a conjunctival flap in order to bring about immediate coverage. (...) One can ask oneself if, in the first instance, one could not place on the cornea an adherent glass, which, if well positioned, would protect the wound from infections arising from the conjunctiva, thereby providing protection that would be superior to a simple bandage. (...) That would perhaps allow us to postpone general anesthesia to the next morning. This would sometimes be useful, particularly in children. (...) I submit this method for discussion, because I have not yet had the opportunity to try it out because of the unavailability of adequate contact glasses*.”(14)

Comberg gave the reply to *Ohm*’s question. His opinion was, however, that the placement of a contact shell on a perforated globe caused ciliary pain that does not respond to local anesthesia and that the absence of lacrimal exchange would rapidly cause infection. *Comberg* had been the initiator of *Zeiss* special ground contact glasses for localization of intraocular foreign bodies and he cites here his experience as a radiologist: “*I have been using adherent Zeiss contact glasses for several years. This is suitably lead marked for radiological localization. One is thus often placed in the situation, in which it is necessary to place the contact glass on the eyes of some patients afflicted with penetrating corneal wounds fairly recently. (...) However, I think that the reasoning is not right. Stagnation of tears occurs under the adherent lens; rinsing of the conjunctival sac by the flow of tears is missing. It must therefore be admitted that, for this reason, wearing an adherent glass for several days always causes an accumulation between the lens and the eye of an ever-enlarging quantity of germ-containing liquid. This is something that would not improve the situation*.” (15)

This point of view will next be taken up again by *Heine* and other authors will join the discussion. In 1931, in reviews concerning the use of contact lenses, *Victor Much* cites shells for corneal protection when indicated in cases of palpebral trichiasis and the maintenance in position of corneal grafts where the contact shell would not only protect the cornea, but would accelerate healing of the laceration. Other authors, e.g. *Ludovici Mamoli* in Italy, have also described this procedure. (16)

In 1932, *Thamm* (Halle) reported good results in corneal ectasia. The same year, under the title of 'The contact glass as an aid in corneal plastic surgery', Lt. Colonel *R.E. Wright* delivered the results of his experimental grafting of tissues, i.e. conjunctival and cutaneous epithelium on perforated corneas. These diverse tissues are held in place by a contact glass, the nature of which he does not indicate, either in regard to what kind of contact lens or its provenance: “*A fairly flat contact glass was then applied, which held the flap stretched in position. It was not removed for seven days, but the flap was very carefully inspected through the glass from the second day onwards. On the fourth day, it seemed that the flap had failed to take, as its end was free inside the concavity of the glass. On removing the glass carefully three days later, it was seen that the graft had taken immediately over the prepared area*.” (17)

Wright also described other interesting ideas: these included a contact shell made from paraffin and a contact glass filled with eye ointment: “*When experimenting with contact glasses as an aid to grafting, it occurred to me that they could also be used in the treatment of corneal ulcers, in order to maintain an antiseptic agent in effective strength in contact with the lesion, e.g. iodoform. This was tried, but my experience of the method is insufficient to justify an opinion as to its value*.”

The year 1933 was marked by *Heine*’s publication. He reported 29 clinical cases that he had successfully treated using contact shells. These included marginal dystrophy, trachoma, pannus, corneal erosion, corneal ulcer and keratitis. Also, *Bruno Prister* in Italy described the indication for the use of molded contact shells he had manufactured. (18)

The first communication from South America concerned the management of serpiginous corneal ulcers using corneal contact shells. This was presented in 1934 by *E. Huber* who emphasized, by means of supporting photographs, their excellent tolerance and efficacy. Next, in 1935, *Sattler* found that contact shells had a beneficial effect on cicatrization. Then, in the following year, *Biswas* reported how he had treated 10 cases of interstitial keratitis and the conjunctival complications of trachoma in this way. In the same year, *Rugg-Gunn* reported a patient successfully treated with a diagnosis of acute corneal ectasia and *Luigi Zoldan* described a similar case with bilateral peripheral ectasia. (19)

In 1936, *Dallos* proposed that contact shells be used as “*protective glass, for instance, in cases of incurable entropion, trichiasis and lagophthalmos*". In the same year, in the USA, *D.M. Rollet* brought to the notice of his colleagues 'The value of the contact glass in the therapy of lagophthalmic and neuroparaytic keratitis'.

He reported two cases of corneal ulcer: in the first case, the ulcer was associated with hypopion; in the second case, it was due to neuroparalytic keratitis with lagophthalmos. In the first patient, he had instilled atropine and 'silver proteins' in the contact glass and, in the second case, only *Ringer*'s solution. Both patients were cured, the first in 10, the second in 9 days respectively. *Rollet* drew attention to the ease of this treatment and the excellent results obtained. [20]

In 1937, *M.H. Whiting* reported that he had obtained visual improvement from the implantation of buccal mucosa in an eye affected by pemphigus that he had fit contact glasses filled with liquid paraffin. In the same year, *Ida Mann* reported that, in two cases of pemphigus accompanied by conjunctival lesion, the cornea had cleared underneath the contact shell. In the following year, she reported again on the treatment of conjunctival pemphigus with symblepharon. This was in a female patient who regained useful visual acuity as the result of an oculoplastic operation with addition of protection by contact shells.
However, in the same year, in his report to the Paris Ophthalmological Society, *Emile Haas* declared that he had serious reservations regarding these indications for contact shells. He drew attention to the 'lack of severity in the various recommended indications, e.g. for the prevention of symblepharon'. Contact shells could have been replaced by standard treatment. He wondered if, with symblepharon, the contact glass might not be extruded by proliferation of tissue in the cul-de-sac or that the presence of the contact glass might cause additional sufferings for the patient. He noted also that, in trichiasis, the shell was only a palliative measure because of its limited tolerance. [21]

The most spectacular results were, however, those obtained in the late sequelae of mustard gas burns suffered by front-line troops in France during World War I (1914-1918), treated in London and published in 1939 by *Ida Mann* and her collaborator, *T.J. Phillips*. The latter reported the first eight patients treated at the Moorfields Eye Hospital Contact Lens Clinic. In addition, this presentation covered the principal medical indications: the prevention of symblepharon, conjunctival pemphigus, spastic entropion, high myopia, corneal cicatrices, keratitides from mustard gas poisoning. In 1944, *Ida Mann* made a further report on this subject and described, in greater depth, the favorable treatment of 84 cases of mustard gas keratitis fit with contact lenses. [22]

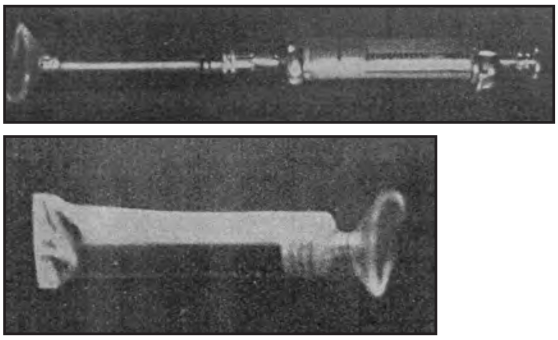

Figure 28-3
Therapeutic contact shells of A. Fritz.
In 1940, Adrien Fritz of Brussels proposed creating an orifice equipped with a screw socket in the centre of therapeutic contact shells. This would enable eye ointments (upper figure) and drops (lower figure) to penetrate. It would also enable lavages to proceed without displacing the contact shell. (Fritz A., 1940).

In 1940, *Adrien Fritz* proposed equipping the contact shells used for the prevention of symblepharon with an orifice prolonged into a tube through which eye ointments could be introduced or instillations performed, including lavages. *Hambresin* had already pointed out the favorable therapeutic effect of contact lenses in pemphigus cases. In the same era, the Russian *D.G. Sverdlov* used porcelain contact shells with a larger central opening that could facilitate lavage of the conjunctival cul-de-sac. The oval contact shells had a diameter of 23 to 31 x 17 to 25 mm and a thickness of 2 to 3 mm. [23]

In 1942, *Ewing Adams* reported a contact shell being worn for the whole day by a patient in order to protect the cornea against trichiasis. In 1943, *Klein* treated two cases of neuroparalytic keratitis with contact shells, the molding process of which could be performed without topical anesthesia. [24]

In the USA, *Struble* and *Bellows* described in 1946 'a contact eye cup for corneal baths with solutions of penicillin' for the treatment of corneal infections. They used these shells to perfuse the eye for 30-minute periods. [25]

In Japan, A. *Hagiwara* recommended in 1948 a penicillin bath under a contact shell with perfusion. Similar proposals were rapidly adopted worldwide by most hospitals and each Eye Clinic possessed several contact shells for this reason. Such shells were categorized as 'shells for lavage' or 'corneal protective shells'. They were used for local treatment of corneal pathological conditions.
In 1949, *A.G. Ourgaud* (Marseille) reported the repositioning of anteriorly subluxated corneal transplant, following the example of *Fritz*, who had obtained, in the same year, anatomical restoration in two cases of

corneal graft ectasia.
In Great Britain, *M. Klein*, who had previously described the use of contact shells in the treatment of neuroparalytic keratitis, used in 1949 a 'Contact Shell Applicator for use as a corneal bath' (manufactured by *George Nissel*). This consisted of a contact shell designed to form a chamber for the fluid. Two small studs served as a handle when this device was inserted. Each of these had a hollow bore reaching into the fluid chamber, one for filling the chamber by means of an eye-dropper, the other for the escape of air. In 1950, *Istvàn v. Györffy* published an interesting historical retrospective in English and reported his favorable experience with therapeutic contact lenses made from plastic. This is what he said: "*The perforated shells are very useful for stopping recurrence and smaller symblepharons and ankyloblepharons after severing scars or strands. (...) Plastic shells were used only in preference to glass, porcelain or metal. (...) The perforated shells are made from thicker material (1 to 1.5 mm). This is better for prevention of symblepharon. We generally make a corneal opening of 10-12 mm.*" [26]

Figure 28-4
Klein's contact shell applicator for corneal bath.
In 1939, M. Klein asked Nissel to supply him with a contact shell for the local application of drugs to the eye. This shell has two studs on the corneal portion. For irrigation, a suitable flask or undine can be connected with rubber tubing.
(Klein M., 1949)

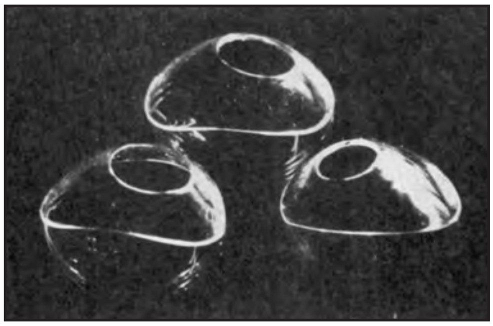

Figure 28-5
Györffy's perforated plastic contact shells.
In 1950, Istvàn von Györffy recommended plastic contact shells with an opening of 10 to 12 mm for treatment of ocular burns.
(Györrfy I.v., 1950)

1.2 Contact Shells used for Protection against Radiation

1.2.1 – Prevention of Photophobia

By 1888, *Adolf Eugene Fick* had already described replacement by contact lenses equipped with opaque diaphragms as a substitution for corneal tattooing and protection against glare caused by corneal scars. Meanwhile, we should note that, in 1918, *Pischler* of Klagenfurt (Austria) had prescribed a corneo-scleral shell with painted iris for a patient who had been a victim of aniridia following a perforating wound. [27]

In spite of the fact that contact shells were often uncomfortable, several authors undertook trials to ease discomfort in photophobic patients, whether albino or aniridic.

During this era, one is aware of heated discussions between *Friede*, *Asher* and *Streiff* regarding the benefits and risks of contact shells in albinos, as compared with other forms of treatment. In 1924, *Reinhart Friede*, ophthalmologist at Jägersdorf (Czechoslovakia), had actually proposed treating albinism surgically by tattooing the eyes and lids. He described, on this occasion, the alternative of using glass prostheses opacified with a painted diaphragm: "*One could also think of placing, a glass prosthesis, shaped like an ocular prosthesis in the conjunctival sac. This would have a corresponding central opening and, on its posterior surface, a non-translucent layer. Theoretically, one could thus stop abnormal intraocular light dispersion*." [28]

However, in 1926, some two years later, *Friede* expressed his reservations on the efficacy of treatment by painted iris shells, considering that these are not always well tolerated. He thus entered into a dispute with *Karl W. Ascher*, part-time university lecturer (Privat Dozent) in Prague, who had published in 1930 an article on tinted contact shells that could be used for the treatment of albinos as alternative to the classical management by surgery, whether by tattooing or again by the injection of Indian ink (also called 'China Ink'), recently introduced by *R. Friede* and *P. Knapp*. [29] For the manufacture of contact shells for albinos, *Zeiss* had proposed soldering a transparent central part into a colored periphery. However, *Asher* preferred to use a combination of the well-matched coloration techniques of *Müller-Wiesbaden* and Zeiss contact shells.

He announced that similar contact shells would already have been delivered to *Löhlein*, *Scheerer*, *Goldschmidt*, *Lauber*, *Pichler* and others, but for the fact that they were poorly tolerated.

In 1931, *Ascher* again presented favorable results obtained with *Müller* contact shells, the posterior haptic parts of which were painted with opaque black enamel. The anterior surface was white and included drawings of small blood vessels. Of course, these first contact lenses for albinos were not equipped with any optical correction. In opposition to this optimistic presentation, *Friede* responded with an acerbic criticism and listed the disadvantages of contact shells with painted irides for albinos as follows:
-Because of the white corn-paste skin color of the albino's face, only a blue or grey coloration could be considered for the iris, but brown must be avoided.
-The pupillary diaphragm created tubular vision, restricting the visual field.
-The contact glasses would have to be worn all day and exchanged in the course of the day depending on lighting and type of work undertaken by the wearer.
-With contact glasses comes the risk of bacterial accumulation on the posterior surface.
-The cost price of such contact glasses is very high (about 50 Marks a piece).
-Frequent replacements are necessary because of the risk of breakage plus wear and tear.
He concluded that even well tolerated contact shells for albinos are not, in any event, a practical solution, taking into account the then current techniques for manufacture of contact lenses. (30)

In 1932, *J. Bernardo Streiff* (Genoa), having experimentally measured the dispersion of light in albino eyes, also aniridic eyes, described good objective and subjective results obtained with contact glasses manufactured by *Müller-Wiesbaden* and coated on their posterior surfaces with black and brown enamel paint: "*Then, at the beginning of November 1930, I received also the answer to my suggestion to provide such light-protective shells from Dr. Fr. Müller (Wiesbaden): he indicated to me that his firm had been occupied with this problem already for several years at the request of and with suggestions from Löhnlein, Scheerer, Lauber, Goldschmidt and others. The samples that the Müller firm had kindly placed at my disposal for experimentation were formed from two different glass coatings and this meant that they were too thick to be tolerated between eyelids and eyeball. Furthermore, they were too uneven in their transparent pupillary part to produce a appropriate optical correction. This was because of the way in which they were manufactured. For this reason, I advised painting the posterior surfaces of the contact shells I was currently using with black paint. The Müller company also did the same thing, i.e., they provided for me, for my experiments, through a glass painter, shells of which the posterior surfaces were enameled in black and brown*." (31)

The experiment using these blackened contact shells on a young albino gave a satisfactory result: there was improved visual acuity, much of the glare disappeared and the shell itself was tolerated [in one eye] for up to 10 hours a day. Unfortunately, the other eye was totally intolerant and the patient was lost to follow-up.

In the same era, *Heine* recommended the use of Umbral-tinted contact shells, of which the mildest filter (25%) would be recommended for cosmetic reasons in order to 'provide more expression to the eyes of actors and singers, essentially females'. Shells with stronger filtering tints would be indicated in photophobia and for antiglare purposes. (32)

In 1934, at the Congress of the Hungarian Ophthalmological Society, *Joseph Dallos* demonstrated a painted contact glass with ground optic for an albino that was well tolerated. The proceedings report of the session indicated that this was a colored contact glass from *Müller-Wiesbaden*. Taken in context, it would appear that *Dallos* had had the optic ground, which process was reported unrealizable with blown glass shells. (33)

Contact shells for photophobic patients are subsequently described from time to time by interested authors, e.g. *Much*, *Gallemaerts*, *Weve*, *Haas*, *Thier* and *Györffy*. (34) We should note particularly *McKie Reid*'s 1938 presentation, reporting the improvement in a patient who was very handicapped by congenital aniridia. He had been fit with a scleral contact shell equipped with a refractive correction in the corneal part, which had itself been opacified except for a central stenopeic sector. The addition of a -4.00 diopter spherical correction allowed improvement of the visual acuity. In 1944, *L. Kazdan* of Toronto (Canada) reported that he had successfully fit a seriously injured only eye with a specially made contact lens with corneal portion surrounding pupil painted black to take the place of the absent iris. It incorporated the necessary optical correction to give the patient normal vision. (35)

In 1950, *J. Fuchs* reported using a special Müller-Welt contact shell in a patient with traumatic iris coloboma.

This enabled him to eliminate both the glare and the corneal astigmatism at the same time. The manufacturer had interposed an opaque lead layer equipped with a stenopeic hole between two layers of plastic material. (36)

Also in 1950, *E. Gogler* of Linz (Austria) demonstrated contact shells developed by the Aspiron Company (Vienna). These were equipped in their opaque pupillary parts with a stenopeic opening 2 mm in diameter, whilst the iris and scleral sectors remained opaque. The author of this paper did however remark "*the fit of these contact shells has to be very meticulous in order to have good centering in spite of the nystagmus*." (37)

1.2.2 – Protection against Ionizing Radiation

In 1929, *E. Wölflin* published a paper on 'Protective Prostheses' (Schutzprothesen) against forms of ionizing radiation, to which the eye risked exposure at the time of treatment by such radiation. He had *Müller-Wiesbaden* prepare for him contact shells made from glass of high lead content, in order to absorb exposure to radiation in patients receiving radiotherapy. In 1932, he recommended new models of lead containing glass shells. These had now a thickness of 1.3 mm and they had a layer of nickel coating fixed onto a cadmium base. The weight of these shells was less than 10 gram. They were presented in a box containing three contact shells of different size, one of which was intended for infants. (38) In the course of the following years, other manufacturers, including *Mager and Gugelman* (USA), were to produce nickel-plated lead protective eye shield for protect the eye during radium and X-Ray therapy treatment of the head, eyelids and adnexa.

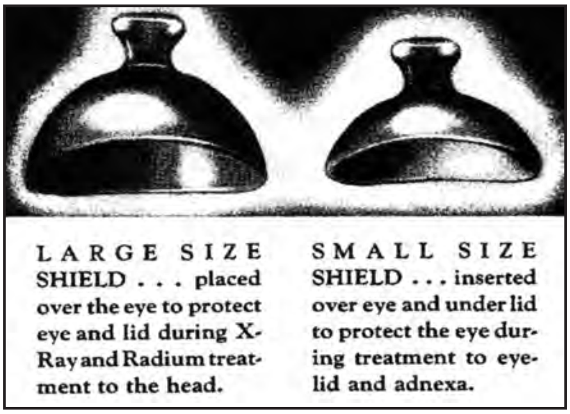

Figure 28-6
Protective eye shields for radium and X-Ray therapy.
Advertisement of Mager & Gougelman Inc. (Chicago) of nickel-plated lead eye shields for radium and X-Ray therapy. The large-sized shield is placed on the outer surface of the eyelids to protect eye and lids during treatment of the head. The small-sized shield is inserted underneath the lids in order to protect the eye during treatment of the lids and ocular adnexae.
(Advertising Mager & Gougelman Inc., 1940)

1.2.1 - For Use with Ocular and Orbital Surgery

Already, by 1916, *C.V. Majewski* had recommended that the globe be covered by glass prostheses in order to protect it during surgery on the eyelids. The procedure was widely used and extended to other interventions involving the ocular globe and adnexa. (39)

The proposal that *H.J.M. Weve* made in 1932 to use contact glasses of corneal diameter for monitoring the retina during retinal detachment operations seemed to have been well accepted, because, according to *Zeiss*, the company had sold in 1934, (two years after their description), 62 models of these 'special lenses according to Weve'. (40

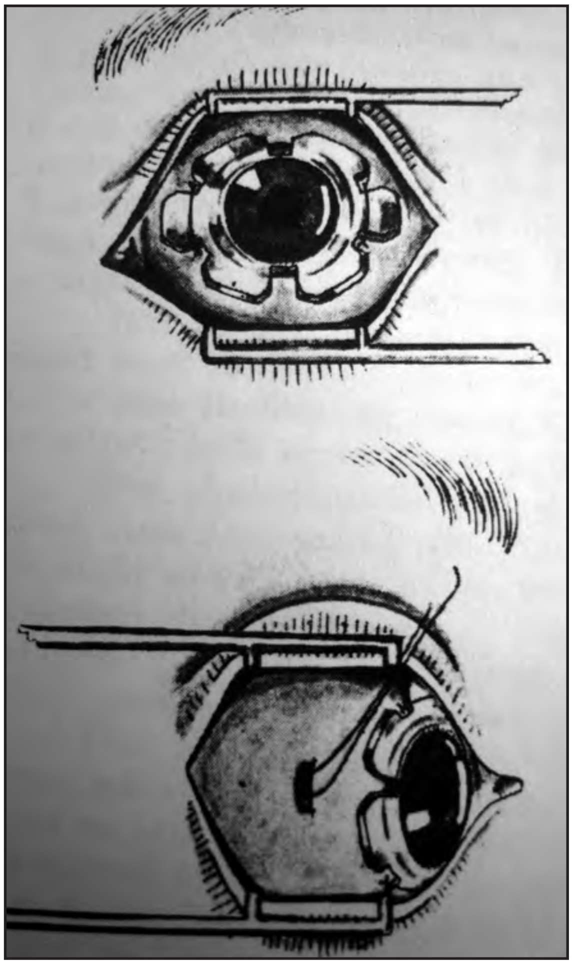

Figure 28-7
Contact shells sutured onto the eyeball for retinal surgery.
Miklos Klein of Budapest (Hungary) proposed a device for maintaining corneal transparency during retinal surgery. He noted that Weve's corneal shell does not remain in good position when the eyeball is turned away from the primary position and the shell itself becomes separated from the eyeball. He suggested using an oval-shaped glass, the length of the major axis being 18 mm and the minor axis 14 mm. The glass is fastened to the globe by silk sutures, which pass over notches at the end of the oval.
(M. Klein., 1935)

Various authors had described protection of the eye by contact shells during surgical procedures. Thus, in 1935, *Miklos Klein* (Budapest) took up once again *Weve*'s idea of contact lenses for the retinal detachment operation, but described an oval-shaped contact shell, the length of the major axis being 18 mm and the minor 14 mm: "*The glass is fastened to the globe by silk sutures which pass over notches at the end of the oval*." [41]

In a communication in 1950, *J. Fuchs* recommended totally opaque black Plexiglas contact shells in order to protect the globe during eyelid or lachrymal duct operations and to prevent patients from observing the surgeon's procedures. [42]

1.3 – Contact Devices for Diagnostic Aid

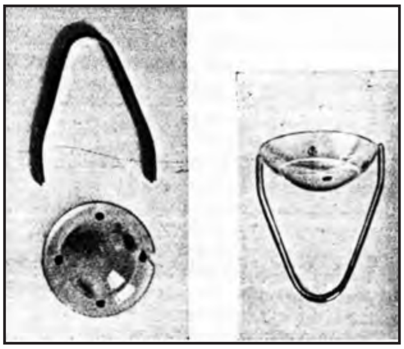

Figure 28-8
Comberg's contact shell for diagnostic radiology.
The contact glass developed by Comberg in conjunction with Zeiss is provided with four lead markers. When it is inserted into the conjunctival sac, the markers are positioned at the corneal limbus, one marker 90 degrees from the other. The shell is placed and centered with special forceps on an anesthetized eye.
(Comberg W., 1927).

1.3.1 – Shells for Radiological Location of orbital and intraocular Foreign Bodies

The *Wessely* and *Engelbrecht* contact shells for radiological diagnosis were widely used and improved during World War I. In 1926, *W. Comberg* described a contact shell developed in collaboration with the engineer *Henker* of *Zeiss* to be used in the X-Ray diagnosis of intraocular foreign bodies. The contact shell possessed a slightly projecting posterior border in order to favor its adherence to the globe. Near to the periphery were incrusted four lead markers for localization.

He recalled that *Chevallereau* in 1911 and *Engelbrecht* in 1918 had carried out similar experiments using celluloid contact shells incrusted with crossed metallic threads, the extremities of which were anchored to the conjunctiva. The most widely used contact shell was *Wessely*'s, which was a blown glass shell for insertion like an ocular prosthesis and manufactured by *Müller-Wiesbaden*. It had the disadvantage, however, that it became displaced from its position on the ocular globe during movements of the latter. In order to reduce this inconvenience, *Comberg* had suggested a mirror in order to immobilize the patient's direction of gaze

In the following year, *Comberg* completed his publication with technical details how to take X-Ray pictures with an 'adherent contact glass suitable for radiology' (Röngtenhaftglas). For insertion and removal of the shells, *Comberg* recommended using a specially adapted pair of forceps. He recalled that these glass shells had a total diameter of less than 20 mm, that they were positioned on the limbus, by means of markers in the four meridians. Large extracts from this article were distributed later in *Zeiss* advertising brochures. [43]

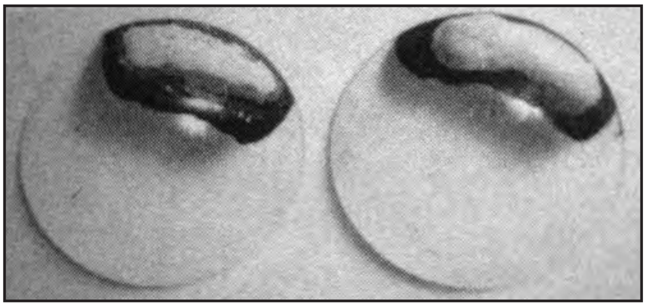

Figure 28-9 -
Comberg's radiological shell.
Comberg designed in 1927 a scleral contact lens to which a radiopaque plaque was attached.
(Haugwitz Th.v., 1986)

Comberg's method was widely used, especially after its publication in the USA by *Raymond L. Pfeiffer*, who added several improvements, but kept the shell with four radio-opaque markers. He judged that intraocular foreign body localization with the aid of *Comberg*'s contact glass was accurate, straightfor-

Figure 28-10
Wessely's radiologic contact lens set.
Wessely designed a whole set of contact lenses. Each contact lens had a specific radiopaque mark and this made a more exact localization possible.
(Haugwitz Th.v., 1986)

ward, easy to perform, adaptable and requiring minimum of apparatus. The problems of localization and of the operative procedure for intraocular foreign bodies became very important during the World War years and there were multiple publications. Thus *J.L Reis* preferred 'corneal contact rings' to the various model types of plastic contact shells equipped with metallic markers. (44)

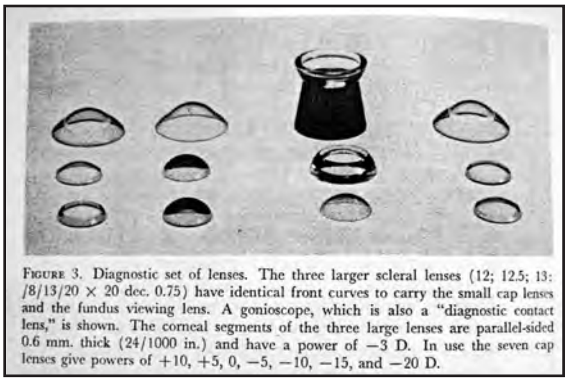

Figure 28-11
Ridley's presentation of his diagnostic contact lens set.
In his 'Doyne Memorial Lecture' in 1954, Frederick Ridley presented 'The Contact Lens in Investigation and Treatment'. He showed an illustration of his diagnostic set with principal contact lenses. The same illustration is used with minimal modifications in the following years.
(Ridley F., 1954, 1962)

1.3.2 – Shells for Examination of Ocular Media

Following the descriptions of *Salzmann* and *Koeppe*, gonioscopic contact shells experienced increased popularity. A detailed description of this development would be outside of the subject of this treatise.
For focal illumination of the anterior chamber by gonioscopy, *Manuel Unribe Troncoso* introduced his first gonioscope in 1925, the progressive improvements of which were to facilitate that technique of examination and particularly its use in binocular microscopy. (45) The most significant progress in this field must be attributed to *Hans Goldmann* who designed, in conjunction with *Wilhelm Haag-Streit*, a new slit-lamp microscope to enable routine gonioscopy. After 1937, *Wilhelm Haag-Streit* registered a patent for a contact shell made from acrylic resin resembling glass shells for the examination of the interior parts of the eye, but significantly lighter and smaller. Such a shell also contained a small mirror for gonioscopic examination:
"*Contact shell for the examination of the internal parts of the living eye, characterized by the fact that it is made out of artificial resin, which has a refractive index quite similar to that of silica glass and of which the specific weight is, at most, half as high as that of silica glass and in which a mirror for examination of the angle of the anterior chamber can be placed in the wall of the shell.*" (46)

H.S. Gradle described in 1938 a gonioscopy glass that *Benjamin Friedman* improved two years

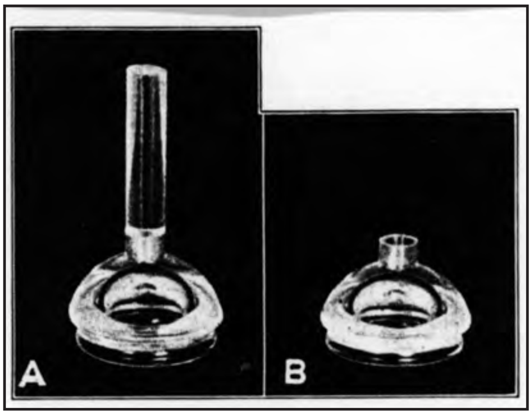

Figure 28-12
Barkan diagnostic contact lens made from Lucite.
In 1940, Otto Barkan constructed a contact glass, made from Lucite, intended for the examination of the anterior chamber angle. A small detachable handle facilitated placement of the lens in the correct position (Figure A). Figure B shows the Lucite contact lens with handle detached.
(Barkan O., 1940)

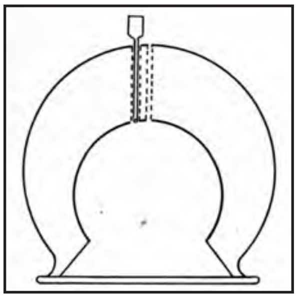

Figure 28-13 -
Friedman's proposal to facilitate filling a gonioscope with fluid.
In order to overcome the difficulty in expelling air from the hollow of the gonioscope, Benjamin Friedman proposed, in 1940, an improvement. He had asked Obrig Laboratories to drill a narrow channel through the center of the lens and another about 2 mm away from the center. With a hypodermic needle, he filled the concavity of the lens with fluid. Meanwhile, the air escapes from the center hole as the fluid enters. The butt of the needle in-situ offers a convenient handle for manipulating the contact glass.
(Friedman B., 1940)

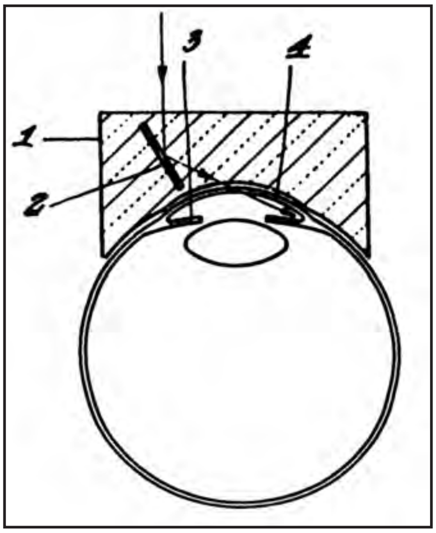

Figure 28-14
Haag-Streit gonioscope patent.
In 1937, Wilhelm Haag-Streit registered a patent application for a contact glass made from synthetic resin to be used for examination of the inner parts of the living eye. The contact shell was characterized by the inclusion of a mirror for examination of the angle of the anterior chamber.
(Haag-Streit W., 1937)

later. In 1940, *Otto Barkan* developed a diagnostic contact lens for studying the angle of the anterior chamber under microscopy, followed by a surgical contact lens for use in glaucoma operations. This is a small contact lens with radiating projections for use in operations for retinal detachment and so on. (47)
The examination of the center and the periphery of the retina was rendered possible thanks to the ingenuity of *Goldmann* and *Busacca*. The use of a contact lens with a flat anterior surface eliminates the corneal refractive power in such a way that the virtual image of the fundus is produced in the anterior segment of the eye. Used by *Koeppe*, the concept was rendered accessible by *Goldmann* and *Haag-Streit*, who developed instruments that were light, easy to manipulate and position against the anesthetized cornea with an interface optically neutralized by methylcellulose. Their simple instrument permitted easy examination of the axial area of the vitreous and the posterior pole. At the same time, the lens is provided with three mirrors for examination of the retinal periphery.

1.3.3 – Devices for the Study of Ocular Movements

In order to totally occlude an eye in the course of physiological experiments on vestibular ocular movements and nystagmus, *Johannes Ohm*, Professor of Ophthalmology at Bottrop (Ruhr, Germany), used, in 1923, a ground Zeiss contact lens rendered opaque by a layer of black lacquer. He described this as 'The invisible adherent eyeglass as an aid for the examination of ocular movements' (Das undurchsichtige Augenhaftglas als Hilfsmittel bei der Untersuchung von Augenbewegungen):
"*On can eliminate vision, without rendering examination impossible, by placing on the cornea an adherent black-lacquered Zeiss glass. The Zeiss Firm placed such a glass at my disposal six months ago. (...) I am pleased to state that one can thus very satisfactorily observe rotational vestibular nystagmus and 'after-nystagmus'. (...) Probably one could also even link the recording drum with the contact glass*." (48)

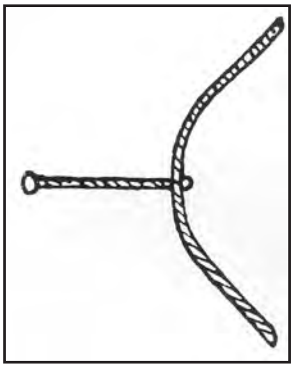

Figure 28-15
Corneo-scleral contact shell for the recording of nystagmus. *Zeiss fabricated this contact shell for O. Wiedersheim. His anterior surface is covered with black varnish. In its center, there is fixed a metallic point with a reflecting mirror on its extremity. Recording of the reflection of a ray of light projected onto this device allows study of miners' nystagmus.* (Wiedersheim O., 1928, 1929)

Between 1929 and 1931, *Wiedersheim*, senior medical officer to Saar Mines (Germany) applied these research findings to miners' nystagmus. In collaboration with *Zeiss*, he developed a contact shell for recording ocular movements. In the center of the corneal part of the contact shell, he attached a small projecting point on the extremity of which was placed a glass pearl with a mirror reflecting a spot of light, allowing observation of movements of the eyeball: (49)
"*For observation of very small movements, it would be necessary to enlarge them. To achieve this, Zeiss, Jena made a contact glass for me, the cupola of which carries a nickel projecting peg 1 cm in length. The peg is soldered onto the inner surface of the cupola of the contact glass and is very stable because of this. The peg carries a glass pearl at its tip, onto which is glued a silver mirror. If light falls on this glass pearl the trajectory is seen in enlarged scale using the above-described nystagmus aperture. The insertion and removal of the contact glass under light anesthesia is very simple because of the readily gripped peg.*" (50)

1.3.4 – Aid for Study of Binocular Vision

In 1921, *H. Erggelet* had published an important treatise on binocular vision in cases of anisometropia. He reviewed his preceding cases at the Jena Ophthalmology Clinic. In order to make himself anisometropic as a unilateral aphake for these experiments, he employed a corneal diameter contact lens: "*There was unfortunately only one glass cornea available as an adherent glass without a scleral portion. Allowing for the fact that there was a divergent meniscus, its edge is thicker than its center and forms a step. The lids hit against this frequently and displace the lens during blinking*." (51)

This experiment was also described in 1922 by *M. von Rohr*: "*Dr. Erggelet, who has emmetropic eyes of high acuity and enjoys perfect vision, made one of his eyes temporarily hypermetropic, requiring a corrective glass of 13 diopters. He used a contact glass for this purpose and was able to wear it for some time, from 25 to 30 minutes. In 1913 we could make these contact glasses in a primitive form only, so that the movement of the eye-lid sometimes dislodged the contact glass*." (52)

1.4 - Contact Shells in Retinal Diseases as Ocular in a Telescopic Device

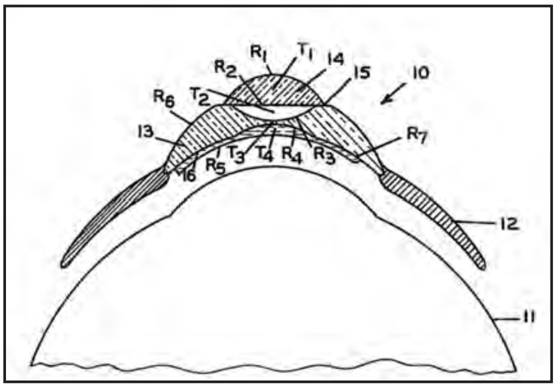

Figure 28-16
Feinblooms's patent for a telescopic contact lens.
This figure shows the principle of the telescopic system patented in 1937 by William Feinbloom: The central corneal portion (10) consists of a glass body member (13), the outer edge of which is secured to the scleral rim (12). The central portion of the body member (13) is biconcave and a positive lens (14) is obtained by cementing a shoulder, or the like (15), onto it. The usual physiological saline solution (16) is between the eye and the body member. The biconcave portion of the body member (16), the positive lens (14) and the saline solution (16) form a Galilean telescope.
(Feinbloom W., 1937)

Joseph Dallos seems to have been the first to conceive a telescopic device incorporating a contact lens. In 1934, at the Hungarian Society of Ophthalmology, he had described the equipment for a patient in which he used an inverse Galilean system. He called this a 'Semi-rigid afocal system' (Halbstarre afokale System), in which a contact lens was used as ocular (eye piece) and highly convex spectacles lens as objective:
"*The afocal combination of a convex and a concave lens produces magnification with the telescopic spectacle. (...) Magnification systems for continuous use are recommended for partially sighted persons. (...) Unlike rigid afocal systems, the combination of a very concave contact lens placed on the eye and moving with it and a convex spectacle lens presents the advantage in that the visual field and the field of regard are not restricted, just as orientation is easier and the wearing inconspicuous*." [53]

In August 1936, *William Feinbloom* had filed a patent for a 'Telescopic Contact Lens'. Registration was completed in 1937 and the telescopic contact lens patented in 1940. The telescopic system described was incorporated in the optical part of the corneo-scleral contact lens. One part of this was formed by a "*glass body member having a negative central area*" and the other by a "*positive lens carried on the front of the said body member in axially spaced alignment, so constructed that there exists an air space between the adjacent surfaces*." The positive lens, the negative lens and the fluid lens between the eye and the body member form a Galilean telescope. His description represents an imaginative, but quite impractical speculation. [54]

In 1938, *Paul Boeder* described the theory of power magnification obtained by the combination of a contact lens and spectacles. He seems, however, not to have tested the principle in actual practice. In the following year (1939), *Jerome W. Bettman* and *Stuart McNair* fitted a 'contact lens-telescopic system' for a patient diagnosed with severe macular degeneration, previously corrected by *Zeiss* telescopic spectacles. The authors, both ophthalmologists at Stanford University, combined a highly divergent contact lens with a highly convex spectacle lens :
"*The cornea acts as a converging lens of approximately 45 diopters because of its curvature. A contact lens eliminates the cornea as a refracting medium. The converging power of the contact lens, which depends on the curvature of the corneal segment of the contact lens, is substituted for that of the cornea. Consequently, we decided to use a contact glass on which an entirely flat surface had been ground, as this would optically eliminate the cornea as a converging lens. In other words, the cornea, which acts as a strong converging lens, could be optically neutralized*." [55]

The authors observed that, compared with *Zeiss* telescopic spectacles, which the patient wore previously, his distance vision was at least as good, but his near vision was decidedly better. Besides reducing cosmetic disfigurement, the field of vision was unrestricted. One also notes the registration of application for a patent, in 1936, by *Bausch* and *Lomb* for the correction of anisometropia resulting from unilateral aphakia. This was achievable by wearing a highly convergent contact lens on the aphakic eye and a divergent lens in the patient's spectacles, or alternatively, a very divergent contact lens on the other eye and a convergent spectacle lens. [56]
The contact lens telescopic system was often used, but was uncommonly referred to in communications or publications. An exceptional case report was, however, noted in 1950 by *H. Fischer von Bunau*. An emmetropic orchestral conductor with only a bare 5/50 of visual acuity in each eye was able to return to conducting thanks to this system. He used to wear a -30 diopter power contact lens in both of his eyes, combined with a spectacle lens of +33 diopters. This gave him, according to the author, binocular vision and a visual acuity

of 5/5, which enabled him both to conduct the orchestra and read the musical instrument parts in his score. (57)

1.5 - Cosmetic Contact Shells

Müller-Brothers (Wiesbaden), *Müller-Welt* (Stuttgart), and *Müller-Uri* (Berlin) considered contact shells to be an adjunct to their professions as manufacturers of ocular prostheses. It was normal that they included cosmetic contact lenses within their domain, especially as they dominated the manufacturing techniques for prostheses and, above all, the processes for their coloration. Basically, such prostheses were placed on disfigured or atrophied globes and their use was not a subject of specific publications, aside from some exceptional cases.

In 1926 *Müller-Welt* (Stuttgart) had obtained a patent for a 'device for supporting paralysed eyelids' (Vorrichtung zum Anheben von gelähmten Augenlider). It was intended to replace ptosis spectacles, in that the posterior part of the frame was provided with a small metallic cradle that rested on the superior tarsal fold of the blepharoptotic upper eyelid in order to raise it and correct the ptosis. The patent indicates that "*hooked protuberances are positioned on the convex external part of a thin glass contact shell which, by supporting the lid, are capable of preventing ptosis*". The device was subsequently improved and was often tried, notwithstanding the irritation due to pressure of the lid on the superior part of the contact shell and the tendency of the shell to be displaced downwards. (58)

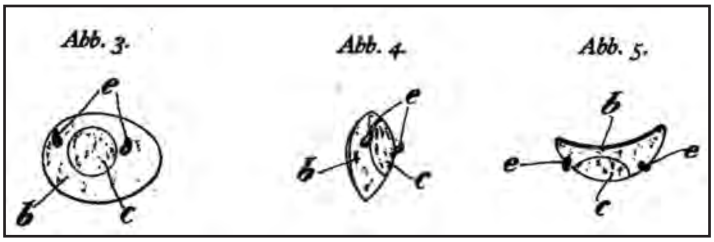

Figure 28-17
Müller-Welt patent for contact shell to raise and support paralyzed eyelids.
The patent registered by Müller-Welt of Stuttgart concerns a contact shell, the external convex surface of which is provided with two or more curved protuberances in the shape of hooks that hold up the upper lid and thus counteract palpebral ptosis. (Müller-Welt, 1925)

Figure 28-18
Contact shell with ptosis hook.
The ocularists supplied contact shells blown from soft glass and modeled after ocular prostheses. Each shell has two hooks on its outer surfaces and these are intended to support the border of upper eyelids affected by ptosis.
(Private Collection)

S.K. Mukerjee (Calcutta) was the author of an excellent English publication, which appeared in 1938. He had obtained relief of photophobia and significant cosmetic improvement for his patent by hiding a staphylomatous corneal nebula previously treated by numerous tattoo pigmentations of her eye. He was describing the case of a young East Indian female 16 years of age and achieved this good result by using a contact shell painted in the color of her other eye. (59)

Figure 28-19
Illustration of the cosmetic contact shell prescribed by Mukerjee.
The left eye of this young female was disfigured by scars and areas of pigmentation produced by unsightly tattoos (above). The cosmetic contact shell had a beneficial effect (see below) by hiding these blemishes, at least during the marriage ceremony. (Mukerjee S.K., 1938)

In 1942, the optometrist, *Ewing Adams* (Detroit, Michigan) reported how he had fit contact lenses following tenotomy in a hyperopic patient with alternating strabismus. This patient had also received orthoptic reeducation without great success. *Adams* remarked: "*Neither surgery nor refraction is successful in removing the psychological factor in these squint cases because of the inevitable and necessary spectacle correction, which keeps alive the old sensitiveness to the ocular defect. Elimination of this difficult psychological problem has been made possible only through contact lenses*."

The author used molded contact shells in order to allow for post-operative conjunctival scarring. By including prisms in the refractive correction of the molded shell, he was rewarded by a highly satisfied patient. [60]

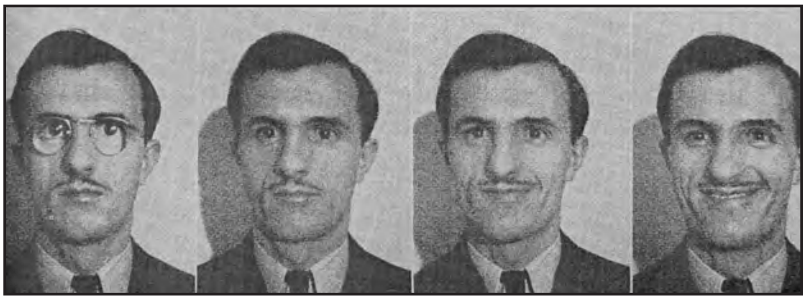

Figure 28-20
Contact lenses following tenotomy in alternating strabismus.
After more than ten years of prescribing eyeglasses, orthoptic treatment and surgical operation in a severely hyperopic patient with very pronounced alternating strabismus, optometrist Ewing Adams obtained marked cosmetic and visual acuity improvement using molded corrective contact shells as described in his publication.
(Adams E., 1942)

In 1940 and 1945, *Reuben Greenspoon* published his successes in fitting contact lenses to movie stars in order to change the appearance of their eyes. This could involve changing iris color, making the eyes look older or simulating a blind eye. [61]
Reuben Greenspoon, then his son *Morton* and their company 'Professional Visioncare Associates' became the consultant and the reference for special effects contact lenses for film and television industry. The different kinds of special effect contact lenses included mirrored lenses, arcus senilis, blind effect, animal, alien, vampire and demon variations, fluorescent and blue screen providing theatrical special attends. Outstanding credit are given to the colored contact lenses of *Debra Paget*, the film star in the film 'Broken Arrow' (1950), also the painted contact lenses that simulated the apparent large diameter iris of the gorillas eyes in 'Planet of the Apes' and of *Richard Baker* in 'King Kong'.

1.6 - Contact Shells for 'Orthopedic Corneal Reshaping'

The use of so-called 'orthokeratology' with contact shells has resulted in numerous arguments. After 1932, in the clinical part of his report, *Victor Much* made a plea for 'the orthopedic treatment of patients with keratoconus and myopia'. [62] The rationale for this depended on 16 clinical cases in which he demonstrated modifications in the corneal curvature resulting from the wearing of contact glasses. His article was also supported by 22 bibliographical references to authors who recommended corneal compression because of its orthokeratological effect. *Johannes Evangelista von Purkinje* had already previously recommended ocular compression at night and *Photinos Panas* (Paris) had highlighted in his 1888 report the cure of keratoconus that had been obtained by *Eugene Kalt*. In 1922, *Tatsuyi Inouye* (Tokyo) had also described regression of myopia and cure of corneal staphyloma using elastic dressing. [63] The allusions of his contemporaries to the orthopedic effect of contact glasses are noted in *Much*'s bibliography.
This article received only a very mitigated reception and, notably, produced a controversy between its author and *Dallos*, who had, in the interim, become an advocate of respect for ocular tissues and their metabolism. According to *Much*, it was *Heine* who had pushed him along the pathway of orthokeratological correction of ametropic corneas in spite of his own reservations.[64] *Much* had found support and confirmation of the value of corneal reshaping, especially in the publications of *Strebel* (Lucerne). *Dallos*, however, showed that such reshaping was, in fact, iatrogenic and resulted from the compression of the corneal tissues and was thus the cause of the intolerance that prevented *Zeiss-Heine* contact glasses from being worn for more than a few hours. *Much*, inspired by both *Heine* and *Strebel* published in 1934 a virulent defense of orthopedic treatment. This resulted in one last controversy with *Dallos*.[65]

In 1937, *J. Strebel* (Lucerne, Switzerland), basing his ideas on a detailed observation of regression of keratoconus by Zeiss contact shells, claimed that the condition was curable by a 'corset effect'. By means of Novocaine instilled into the eye and alternating with paraffin or almond oil, he reduced the pain caused by the compressions. In the following year (1938), *Dubois* reported that one of his patients had experienced a significant regression of keratoconus with visual improvement. This was maintained without glasses. In the same year, *Martin Schmidt* tried to explain the compressive effect of contact shells on the development of keratoconus. [66]

In 1940, *Géza Mihàlyhegyi* reported the histories of 11 young patients in which he observed slowing of the progression of their myopia and regression of keratoconus by using contact lenses. He became an ardent proponent of 'Corneal Modeling'. He advised combining the wearing of contact lenses with the nighttime use of metallic plaques that were to be placed on or under the lids. This was particularly advantageous in young myopes. *Mihàlyhegyi* also claimed that contact between the corneal apex and the contact glass was not only well tolerated, but was actually beneficial in slowing the rate of progression of the condition. During the discussion of the presentation, *Csapody* correctly stated that treatment of the myopia would only make sense if it produced durable stabilization, rather than transient modification of the corneal curvature. The idea of reshaping the cornea by the use of contact shells or contact lenses was subsequently revisited and tried by many authors across the world.[67]

2 - Therapeutic Corneo-scleral Shells after 1950 and Flush-fitting Shells

Introduction

During the first half of the 20th Century, the technique for the manufacture of scleral contact shells had certainly developed, but the molding procedure remained uncertain, as did the transfer of the mold to dental stone. Molding the plastic material was also challenging. Because of this situation, fitting scleral shells was performed mostly by 'trial and error'. Several experienced practitioners practiced adjustments under fluorescein, but these represented only a small proportion of fits.
When corneal contact lenses became better known and more widely distributed, the majority of fitters devoted their efforts to the latter and corneo-scleral shells became objects of curiosity to be used infrequently in a few specialized hospital units.
It must be stated also that, except for those of *Dallos* and his disciples, corneo-scleral shells were of the 'fluid type' during this era and had a large clearance over the corneal area.

2.1 – The New Approach of Frederic Ridley

It is to *Frederic Ridley*'s credit that he introduced, in 1948, the concept of a corneo-scleral shell that was parallel to the surface of the ocular globe in all respects [68]. In successive publications, *Ridley* questioned the molding procedures that were previously used. The shells and molding instruments of the past were unsuitable because they created distortion. To rectify this, he proposed a set of eight trays:
"*The ideal tray should conform a closely as possible to the globe. (...) It should be of the right size and decentered. (...) The tray should be of the thickness of the finished lens and freely perforated so that the material flows out – but not excessively – under the tightly closed lids. Such a tray may be said to 'float' while the material is setting and the model obtained is as nearly as possible that of the eye as it will be when the lens is worn. (...) Calculation shows that these conditions can be satisfied by two internal curves corresponding to eyes of 12.5 mm scleral radius and over and 12.5 mm radius and under. Each type of tray is made in two sizes 26x24 and 25x23, 25x23, 25x25 and 24x22 mm., appropriately decentered. Eight trays in all thus provide a pair of each combination*."

These reflections, confirmed by therapeutic successes, merited *Frederick Ridley*'s promotion in 1951 to his position as Director of the Moorfields Contact Lens Unit at High Holborn (City of Westminster) and the Central Eye Hospital, Judd Street. Starting in 1953, he described his clinical survey of 600 consecutive National Health Service cases fit out of the total of 1.000 cases fit each year. Under consideration were, above all, high myopes (44%), corneal nebulae (15%), unilateral aphakes (13%) and keratoconus (8%). He obtained favorable results with the longest wearing times ever reached. In *Ridley*'s own words: "*28% wear their lenses all day long and the remainder average nearly 11 ½ hours a day.*" [69]

Year	Title
1940	Modern Trends in Ophthalmology
1944	The Tears
1946	Recent Development in the Manufacture, Fitting and Prescription of Contact Lenses of Regular Shape
1948a	The Use of Contact Lenses
1948b	Contact Glasses and Veiling
1949	Developments in Contact Lens Theory and Practice -- Moulding, Computation and Veiling
1953a	Clinical Survey of 600 U.K. National Health Service Contact Lens Cases
1953b	Contact Lenses in Unilateral Aphakia
1954	The Contact Lens in Investigation and Treatment
1955	Contact Lenses in Corneal Grafts
1956	Contact Lenses in the Treatment of Keratoconus
1957	Safety Requirements for Acrylic Implants
1958a	Applicators for Irradiation of the Conjunctival Sac
1958b	Sterile Drops and Lotions in Ophthalmic Practice
1961a	Eye Rubbing and Contact Lenses
1961b	The Role of Contact Lenses and Shells
1962	Therapeutic Uses of Scleral Contact Lenses
1963a	Scleral Contact Lenses – Their Clinical Significance
1963b	The Current Status of Contact Lenses
1963c	Contact Lens Theory and Practice
1964	Contact Lenses – The Role of the Ophthalmologist
1966	Safety Requirements for Contact Lens Materials and their Manipulation and Use. Materials and Manufacture (co-author)
1967	Contact Lens Fitting –Theoretical Considerations

Table 28-1
List of the most important publications by Frederick Ridley.

Ridley distinguished three types of therapeutic scleral contact lenses depending on indications:[70]

Firstly, scleral lenses with optical power: These lenses are intended essentially for unilateral and binocular aphakia as well as anisometropia. In his 1953 review, *Ridley* described 103 fits of this type. 84 of which were successful. In 1962, after fitting 800 cases of unilateral aphakia, he stated the following:
"*In this group, almost exactly one half have been fitted. It is essential to separate traumatic from non-traumatic unilateral aphakia since the age and sex distribution are different and the incidence of dense suppression in the non-traumatic cases is higher. (...) When binocularity is restored, the results are good. (...) When binocularity is not restored, the patients are able to wear their lenses, but do not do so because there is no visual reward.*" [71]

Secondly, fluid type lenses with limbal clearance: These lenses are specifically intended for the correction of keratoconus. They possess more than 0.2 mm

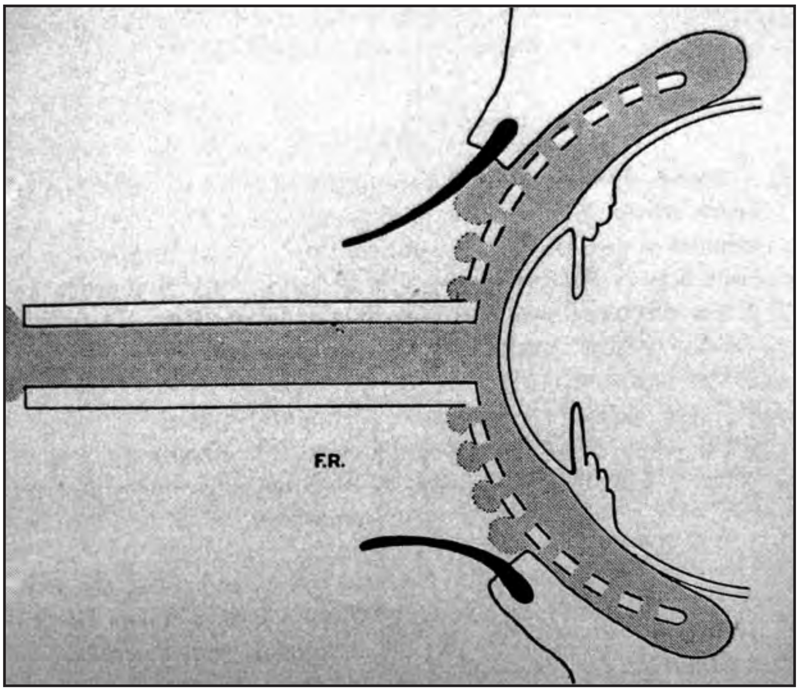

Figure 28-21
Ridley's diagram showing an 'ideal' fitting and molding tray in-situ:
The 'tray' (to adopt the dental term) is perforated and is provided with a drilled central handle for injection. The 'ideal tray' should conform as closely as possible to the globe, allowing between 0.5 and 1 mm of material. The tray should be of the thickness as the finished lens and be perforated so that the material flows out from under the lightly closed lids; such a tray may be said to 'float' while the material is setting. The model obtained is as nearly as possible that of the eye as it will be when the lens is worn.
(Ridley 1949, fig. 128)

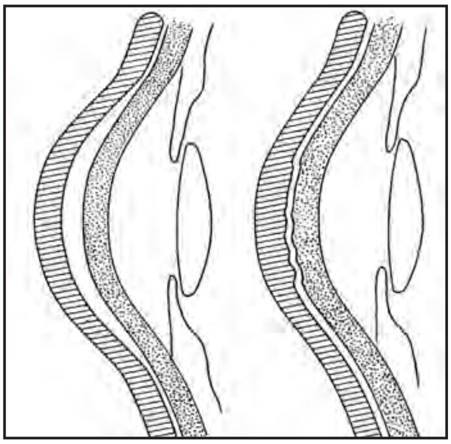

Figure 28-22
Comparison of 'standard' and 'flush-fitting' scleral contact shells.
Left: A standard corneo-scleral contact lens has anterior and posterior optical surfaces and vaults the cornea, leaving a space between itself and the cornea.
Right: A flush-fitting scleral contact shell has an anterior surface that copies the mold of the irregular anterior ocular segment. Only a capillary layer of tears separates the lens and the scarred irregular anterior cornea.
(According to Girard LJ., Soper JW., 1966)

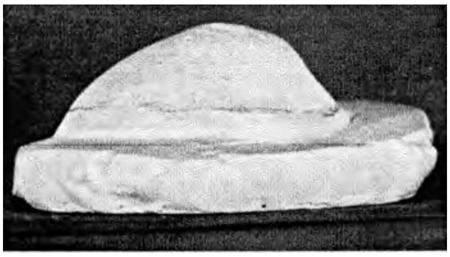

Figure 28-23
Side view of the cast of the anterior surface of the eye demonstrating surface contour.
The cast of a pathological eye reproduces the corneal and scleral irregularities to which the flush-fitting lens adapts itself in close conformity.
(Goren, 1970)

clearance between apex of the cornea and the posterior contact lens surface. *Ridley* reported a series of 83 patients, then, later two other series of 300 and 350 fits of this type. He insisted that such lenses had to be "*always molded to avoid optical touch; this necessitates an almost perfect mold. (...) Where scleral lenses fitted in this way are available, it is rarely necessary to contemplate corneal grafting. On the average, the visual improvement with contact lenses over spectacles is six fold. (...) Such patients wear their lenses well and, in ten years, in which 350 such cases have been fitted at Moorfields, only 6 individual eyes are known to have come to grafting operation. It seems certain that a properly fitted scleral lens not only restores visual acuity, but prevents the progress of the disease.*" (72)

Thirdly, flush-fitting or neutral-fitting scleral lenses: This type of contact shell presents a new type of therapeutic approach, in that these optically neutral contact shells can be used for the treatment of conjunctival and corneal conditions. In the flush-fitting scleral lens, the posterior surface of the shell is everywhere equidistant from the anterior ocular surface. It is a direct copy of the mold of the anterior ocular surface, unmodified, unpolished and including both cornea and sclera. It follows in detail the surface contour of both. Only a capillary layer of tears separates the lens from the eye: "*a perfect glove-fit is, without a doubt, the most satisfactory of all contact lenses from the wearing point of view*."

No optical surface is created on the back surface of the shell. Thus, there is no actual lens but only a shell. However, usage has established the expression 'flush-fitting lens'. It is an aid to healing and, for this reason, optical correction is not important.
In the hands of *Ridley*, flush-fitting contact lenses have given excellent results in cases of corneal nebulae as an alternative to corneal grafting (1.300 cases), in improvement after corneal grafts, in vascularizing keratitis, in chemical burns, in corneal abscess and perforation, in ulcerations and in pemphigus: "*The mechanics of contact lens wearing are the same in all these cases: to protect the eye from drying; to separate the conjunctival surfaces and to afford a mechanical barrier to irritation of the globe and cornea by ingrowing lashes, inturning lids or rough tarsal plates (...) Apart from increased visual acuity, freedom from discharge and complete comfort are achieved at once and the patient's lot may be improved dramatically.*" (73)

In his 1962 review, *Ridley* delivers a statistic of 5,400 patients, of which 61% had been successfully fit. He repeated that, in the flush-fitting scleral lens, the posterior surface of the contact shell must not be modified in any manner whatever that may be and that no correction can be ground onto the posterior surface of the lens. (74)

Two other types of cosmetic contact shells are also described and used by *Ridley*:

- Cosmetic cover shells, which are flush fitting shells each with a painted iris or other cosmetic addition. They are molded over the anterior surface of the globe and are indicated in microphthalmia, in ugly, deformed, phthisical or otherwise disfigured useless eyes. In albinism, contact lenses, simulating artificial eyes with opaque sclera and iris, but with an optically working pupil, give protection from glare and improve the patient's comfort.
- Evisceration shells manufactured according to the impression over an evisceration with cornea retained. Compared with normal ocular prostheses, these contact shells maintain the orbital volume with all cosmetic and functional advantages.

2.2 – Flush-fitting Shells in the USA

In 1959, *Ridley* traveled to the USA to present his experiences. He was invited again in 1966. (75) The flush-fitting technique was applied in the large centers, notably by *Louis J. Girard* and *Joseph W. Soper* at Houston. In 1966, these authors published their first results. They repeated these numerous times. (76) They were, however, quite reserved in regard to certain indications. For example, in stromal herpes, where a contact shell is not indicated at the stage of evolving dendritic ulcers, they accelerated healing in the presence of stromal involvement. They estimated that "*pemphigus cannot be treated adequately*". In general these shells are to be avoided in all acute affections of the eye. Meticulous follow-up is always essential, because contact erosions can occur within a few days, necessitating remolding and manufacture of a new lens.
Unlike *Ridley*, these authors did not utilize sheets of PMMA, but developed a molding procedure starting with granules of polymethacrylate: "*We feel that, in using raw plastic, a more perfect shell is formed that will duplicate perfectly every detail on the stone cast. To use powdered plastic, it is necessary to make a mold to encase the material during the curing process.*"

In 1967, *Herbert L Gould* reported the results from 372 patients fit in the course of the four preceding years in New York in which he used 'flush-fitting' technique. He indicated that these shells "*proved to be of unique therapeutic value, often to the exclusion of any other approach.*" *J.H. Kratchmer*, *D. Miller* and colleagues also describe good results in subsequent years. (77)
However, *Ridley* expressed reservations in regard to the molding procedures used by these authors: "*I am unhappy about Dr. Gould's technique because he exposes his sheet to a flame (...) and about Mr. Soper's method because (...) he is introducing the oddest things*". According to the origin of the product, the constituents and the compounding technique used in manufacture, extreme toxicity may be introduced. The methylmethacrylate must be inert. Monomers must be eliminated: "*If pure methacrylate is used as a monomer, with a trace of benzol peroxyde only, and there is full thermostatic control of the polymerization, a totally inert sheet will result. Care must be taken in the amount of heat used, how it is used, and how it is processed, as well as what solutions are introduced to it*." In view of the importance of this question, *Ridley* published, in conjunction with *J.M. Estevez*, a seminal document concerning the safety requirements for contact lens materials, their manipulation and their uses. Unfortunately, this document is not well known. (78)
Ophthalmologist *Albert Darwin Ruedemann* of Detroit, Michigan used the original *Ridley* procedure he had learned in London. He practiced moldings using Jeltrate which is packed in a sterile sealed vacuum can and uses a particular press of the American Optical Company to mold polymethyl methacrylate plates. In 1970, he reported his experiences in several hundred patients, representing the whole range of indications. Finally, he asked himself why molded scleral lenses were successful: "*There is no doubt that the smooth non-irritating plastic surface of the lens is a factor. The easy passage of tears beneath the lens is also a factor. In our opinion, the 'splinting' effect of the lens, as well as the prevention of lid action is the best reason for the success of the scleral lens*." (79)

Other results were published in the same era. Thus, *Seymour B. Goren* (Chicago) reported the use of flush-fitting contact shells in nine patients after surgical intervention for acoustic neuroma. The flush-fitting procedure was, of course, also used in other regions of the world, e.g. its use was described by *H. Skydsggard* (eight cases) and in France by *Paul Cochet*. In many countries, however, it was not the subject of specific publications.(80)

Notes in Chapter XXVIII

1. Obrig T., 1957, p.56-87.
2. See volume II, p.313.
3. See volume II, chapter 19: 'Early Therapeutic Contact Devices'.
4. Illig H. & Carsten P.: see volume II, p.310-313.
5. 'Verbandslose Behandlung von Ulcus corneae und Epitheldefekten mit durchsichtigen Kontaktschalen'. Weihmann M., 1922, 1923.
6. Schneider R., 1925.
7. "Über die erkrankte Hornhaut wurde ein Müllersches Haftglas gelegt und der Zwischenraum zwischen Hornhaut und Haftglas mit Preglsche Iodlösung gefüllt. Dadurch ließ sich die Einwirkung des Mittels auf längere Zeit (bis 3 Stunden) ausdehnen. Manche Kranke vertrugen diese Art der Behandlung nicht. Nach kurzer Zeit traten Schmerzen und starke Reizung des Augapfels auf. Diese Kranken vertrugen das Haftglas auch nicht bei Benutzung anderer Flüssigkeiten oder isotonischer Kochssalzlösung."
8. Knapp P., 1925, 1927, 1930; Friede R., 1924, 1926, 1932.
9. Meyerbach F., 1926.
10. Proksch M., 1928; Deutsch A., 1929.
11. Birch-Hirschfeld A., 1930.
12. Rosengreen B., 1930. (17th Annual Meeting of the Society of Swedish Ophthalmologists, Uppsala, 11th May 1930).
13. 'Lassen sich Haftgläser bei durchbohrenden Wunden des Auges anwenden ?' - Ohm J., 1930.
14. "Es gibt Fälle von durchbohrenden Verletzungen im Bereich der Hornhaut, bei denen manche Gründe für sofortige Bindehautdeckung andere gegen sie sprechen. (...) Es fragt sich ob man es da in manchen Fällen nicht zuerst mit einem Haftglas versuchen soll, das bei gutem Sitz die Wunde vor Infektion vom Bindehautsack besser schützt als der einfache Verband. (...) Es erlaubt uns vielleicht, die Narkose bis zum nächsten Morgen hinauszuschieben, was besonders bei Kindern angenehm ist. (...) Ich stelle dieses Problem zur Erörterung, da ich eigene Versuche mangels geigneter Gläser noch nicht unternommen habe."
15. Comberg W., 1930. « Ich benutze seit einigen Jahren ein Zeiss'sches Haftglas mit eingelassenen Bleimarken zur Röntgenlokalisation. Man kommt dabei öfters in die Lage, Patienten das Haftglas aufzusetzen, die eine verhältnismäβig frische, durchbohrende Verletzung haben. Ich würde den Versuch aber auch sonst nicht als richtig bezeichnen. Es kommt unter dem Haftglas zu einer Stagnation; es fehlt hier die gute Durchspülung, die der Tränenstrom dem ganzen Bindehautsack gibt. Aus diesem Grunde ist anzunehmen, da sich nach mehrstündigen Tragen eines Haftglases jedesmal eine stärkere bakterienhaltige Flüssigkeit zwischen Haftglas und Augapfel ansammelt; mindestens würde die Situation dadurch nicht verbessert. »
16. Mamoli L., 1931; Much V., 1931a, b, 1932a, b, c.
17. Thamm W., 1932; Wright RE., 1932.
18. Heine L., 1933; Prister B., 1933a, b.
19. Huber E., 1934; Sattler CH., 1931; Biswa PK., 1936; Rugg-Gunn A., 1935a (Presentation to the Section of Ophthalmology, Royal Society of Medicine, London, on 14th June 14); Zoldan L., 1936 (Presentation to the 33e Congress of the Italian Society of Ophthalmology, Trieste, October 7th to 9th October 1935).
20. Dallos J., 1936; Rollet DM., 1936.
21. Whiting MH., 1937; Mann I., 1938b, 1939; Haas E., 1937.
22. Phillips TJ., 1939 (Presentation to the Section of Ophthalmology of the Royal Society of Medicine in London 9th December 1938); Mann I., 1939, 1944; Mann I., Pullinger RD., 1942a, 1942b.
23. Fritz A., 1940; Sverdlov DG., 1940.
24. Adams E., 1942a; Klein M., 1943.
25. Struble GC., Bellows JG., 1946.
26. Haginawara A., 1948; Ourgaud AG., 1949; Fritz A., 1950; Klein M., 1943, 1949; Györrfy Iv., 1950.
27. Fick AE: see volume II, chapter 10, p.12; Pischler: see volume II, chapter 19, p. 317.
28. Friede R., 1924 – "Weiters könnte man auch daran denken, in den Konjunktivalsack eine Glasprothese einzulegen, die der Bulbusprothese ähnlich geformt wäre, in der Mitte eine entsprechende Oeffnung hätte und an ihrer Hinterwand mit einer lichtunddurchlässigen Schicht belegt wäre. Damit könnte wenigstens vom theoretischen Standpunkte aus der abnormalen intraokulären Lichtzerstreuung Einhalt geboten werden."
29. Friede R., 1926; Asher K.W., 1930.
30. Ascher K.W., 1931; Friede R., 1931.
31. Streiff B., 1932. – "Ich bekam denn auch Anfang November 1930 von Dr. Fr. Müller aus Wiesbaden auf meine eigene Anregung zur Herstellung solcher Lichtschutzschalen die Antwort, dass F. Ad. Müller Söhne bereits seit Jahren auf Wunsch und nach Vorschlägen von Löhnlein, Scheerer, Lauber, Goldschmidt und anderer sich mit dieser Frage beschäftigt haben.Die Modelle die mir die Firma Müller in entgegenkommendster Weise zu Versuchen schickte, bestanden aus 2 Schichten verschiedenen Glases sie waren deshalb zu dick, um zwischen Lidern und Augapfel ertragen zu werden. Ferner fielen dieselben der besonderen Schwierigkeit der Herstellung entsprechend in bezug auf den für die Korrektion der Refraktion in Betracht kommenden durchsichtigen Pupilarteil leicht zu unregelmässig aus. Ich riet deshalb dazu, einfach Kontaktschalen auf der Rückseite bloss dunkel bemalen zu lassen. Auch dieser Vorschlag wurde von der Firma Müller bereitwillig in die Tat umgesetzt, d.h. sie liess mehre Schalen für mich zu Versuchszwecken bei einem Glasmaler rückseitig mit schwarzer und brauner Emaillefarbe versehen."
32. Heine L., 1931.
33. Dallos J., 1934.
34. Much V., 1931a, 1931b; Gallemaerts E., 1933; Weve H.J.M., 1934; Haas E., 1937; Thier P.F.X., 1940b; Györrfy L v., 1941a, 1941b.
35. Reid A.M., 1938; Kazdan I., 1944.
36. Fuchs J., 1950.
37. Gogler E., 1951 - "Dieses Kontaktglas muss sehr gut angepasst sein und auch trotz des Nystagmus einen guten Platz zu haben."
38. Wölflin E., 1929, 1932.
39. Majewski C.V., 1916; see volume II, chapter 19, page 312.
40. Weve H.J.M., 1932a, b; see chapter 27, § 3.2.6.
41. Klein M., 1935.
42. Fuchs J., 1950.
43. Wessely NK., & Engelbrecht K., (see volume II, chapter 19, page 318) - Comberg W., 1926, 1927; Zeiss C., 1927.

44. Pfeiffer R.L., 1944; Lodge W.O., 1945; Kraus J., Briggs W.A., 1945; Smith F.W.G., 1946; Reis J.L., 1946.
45. Koeppe L. & Troncoso M.U., see volume II, chapter 19, § 4, pp. 318-320.
46. Haag Streit W., 1937: "Kontaktschale zum Untersuchen innerer Teile des lebenden Auges, dadurch kennengezeichnet, daß sie aus einem Kunstharz besteht, das Vorzugweise einen Brechungsexponenten ausweist, der demjenigen von Silikatglas annähernd gleich ist und dessen spezifisches Gewicht vorzugweise höchtens halb so groß ist als das von Silikatglas, wobei in die Wandung der Schale ein Spiegel zum Untersuchen des Kammerwinkels eingebaut sein kann."
47. Gradle H. S., 1938; Friedman B., 1940; Barkan O., 1940; Haag-Streit W., 1937.
48. "Man kann das Sehen ausschliessen, ohne die Beobachtung unmöglich zu machen, wenn man auf die Hornhaut ein Haftglas von Zeiss legt, das mit schwarzem Lak undurchsichtig gemacht ist. Die Firma Zeiss hat mir ein solches Glas vor 6 Monaten freundlichst zu Verfügung gestellt. [...]. Ich möchte aber erwähnen, dass man den vestibulären Drehnystagmus und Nachnystagmus daran gut beobachten kann. (...) Wahrscheinlich kann man auch den Regestrierhebel noch mit dem Haftglas verbinden."
49. Ohm J., 1923; Wiedersheim O., 1928, 1929, 1931. (Presentation on 9th November 1930 in Düsseldorf at Meeting of Rhine-Westphalia Ophthalmologists).
50. "Zur Beobachtung sehr kleine Ausschläge ist eine vergrösserung der Ausschläge wünchenswert. Um dies zu erreichen, habe ich mir von Zeiss, Jena ein Kontaktglas anfertigen lassen, auf dessen Kuppe ein 1 cm langer Nickelstift angebracht ist. Der Stift ist an der Innenseite der Kuppe des Kontaktglases vernietet und hat damit eine vollständig stabile Lage auf dem Kontaktglas. Auf der Spitze trägt der Stift einer Glasperle, die mit einem Silberspiegel unterlegt ist. Lässt man den Lichtpunkt durch die oben genannte Nystagmusblende auf diese Glasperle fallen, so hat man die Bewegungsbahn in vergrössertem Maßstabe. Das Einführen und Entfernen des Kontaktglases bei leichter Anästhesierung ist durch den griffartigen Stift sehr einfach."
51. Erggelet H., 1921a, b; (see volume II, chapter 16, pp. 247-249). „Es stand leider nur eine Glashornhaut ohne Lederhautteil als Haftflas zu Verfügung. Da dieses ein zerstreuender Meniskus sein muss, so ist er am Rand dicker als in der Mitte und bildet eine Stufe. An dieser stossen sehr leicht die Lider an und verschieben das Glas beim Blinkeln häufig."
52. Rohr M. v., 1922.
53. Dallos J., 1934c: "Dallos; Halbstarre afokale System. – Die afokale Kombination einer konvexen und einer konkaven Linse ergibt eine Vergrösserung, wie bei der Fernrohrbrille. (...) Zum ständigen Tragen sind Vergrösserungssysteme bei Schwachsichtigen erwünscht. (...) Gegenüber den starren afokale Systeme hat die halbstarre Kombination eines stark konkaven mit dem Auge beweg-baren Kontaktglases mit einer einfachen konvexen festsitzenden Brille den Vorteil, dass das Gesichtsfeld und das Blickfeld frei, dadurch die Orientierung leicht, und das Tragen unauffällig ist."
54. Feinbloom W., 1936d, 1937b.
55. Boeder P., 1938; Bettman J.W., McNair G. S., 1939.
56. Bausch and Lomb, 1936a.
57. Fischer von Bunau H., 1950 (Presentation to the Netherlands Ophthalmological Society, 11-12 December 1948).
58. Müller-Welt Gebrüder., 1926: "auf der konvexen Außenseite einer dünnen Glaschale (...) hakenförmige gekrümmte Höker vorgesehen sind, welche das Lid stützend zu Untergreifen vermögen."
59. Mukerjee S.K., 1938.
60. Adams E., 1942b.
61. Greenspoon R., 1940, 1945a: see chapter 25, §3.11.
62. Much V., 1932b.
63. Inouye T., 1922a, b.
64. Much V., Personal communication in Vienna, October 1981.
65. Strebel J., 1931; Much V., 1934.
66. Strebel J., 1937; Dubois 1938; Schmidt M., 1938.
67. Mihàlyhegyi G., 1940a, b, 1941a, b, d, e, f, 1942a.
68. Ridley F., 1949 (presented in 1948).
69. Ridley F., 1953a.
70. Ridley F., 1962.
71. Ridley F., 1953b.
72. Ridley F., 1956, 1962, 1964.
73. Ridley F., 1961b, 1962.
74. Ridley F., 1962, 1963 a, b, 1964.
75. Presentations to the Detroit Ophthalmological Society, October 8, 1959 and to the International Congress on Corneal and Scleral Contact Lenses in Houston on March 20 to 24, 1966.
76. Girard L. J., Soper J. W., 1966; Soper J.W., 1967; Girard L.J., Soper J.W., Sampson W.G. 1967b; Girard L.J., Soper J. W., 1970b. (See other facts in chapter 25, § 4.4)
77. Gould H.L., 1967a, b; Kratchmer J.H. 1968; Miller D., Holmberg A., Caroll J.M., 1968.
78. Estevez J.M., Ridley F., 1966.
79. Ruedemann A.D., Jardon F., 1970.
80. S. B. Goren, Shoch D., 1970; Skydsgaard H., 1969; Cochet P.: personal communication.