

Chapter XVII

**THREE YEARS OF MONOPOLY
FOR MÜLLER'S CONTACT SHELLS**

Introduction

After the early disjointed and chaotic stages in the development of blown scleral contact lenses or shells (1) at the beginning of the 20th century, research of the Berne School of Siegrist demonstrated that scleral contact shells could provide a valid alternative to traditional treatments for keratoconus. This research was carried out during the time of World War I and was appreciated primarily in German-speaking countries. The marketing of these blown contact shells was, however, limited to the sphere of influence of Müller Brothers, who, during this era, had a *de facto* monopoly on their manufacture (2). As soon as blown contact shells were recognized as being a valid alternative in the optical treatment of keratoconus, they enjoyed relative success over a period of about ten years. This period was marked by two events that occurred in 1920: the introduction of the first ground contact lenses by Zeiss (3) and the publication of the “Inaugural-Dissertation” for M.D. by F. E. Müller.

This chapter describes the publications on blown contact shells for the period between 1917 and 1920, which was the time of quasi-monopoly for Müller Brothers blown contact shells. The end of this era coincided with the high point of their success and notably with the “Inaugural-Dissertation” (doctoral thesis) of F.E Müller.

A critical analysis of the events important for the history of principal acts of this period essential for the history of contact lenses and the correction of keratoconus will follow.

Year	Author	Title
1917	Grüter(Marburg)	Optische Hilfsmittel bei hochgradiger Schwachsichtigkeit infolge von Kriegsverletzungen (Optical Aids for Severe Low Vision Resulting from War Wounds)
1917	Sattler(Koenigsberg)	Keratokonus (Keratoconus)
1917	Wessely(Würzburg)	Wirkung der Kontaktgläser beim Keratokonus (Effect of Contact Glasses in Keratoconus)
1918	Pichler(Klagenfurth)	Totale Irisausreissung - Ersatz durch Schalenauge (Total Avulsion of the Iris - Replacement by Eye-shell)
1918	Eperon(Lausanne)	Korrektion des Keratokonus durch die Müllerschen Schalen (Correction of Keratoconus by Müller's shells)
1918	Siegrist(Berne)	Discussion of the Eperon presentation
1918	Hippel von(Göttingen)	Ueber die Behandlung des Keratokonus mit Müllerschen Kontaktgläsern (The Treatment of Keratoconus by Müller Contact Glasses)
1920	Clausen von (Halle an der Saale)	Keratokonus und seine Behandlung (Keratoconus and his Treatment)
1920	Siegrist(Berne)	Zu Aetiologie und Theorie des Keratoconus (Concerning Etiology and Theory of Keratoconus)
1920	F.E. Müller(Marburg Thesis)	Über die Korrektion des Keratokonus und anderer Brechungsanomalien des Auges mit Müllerschen Kontaktshalen (The Correction of Keratoconus and other Refractive Anomalies of the Eye by Müller's Contact Shells)

Table 17 - 1

Chronology of publications on Müller-Brothers blown scleral contact shells between 1917 and 1920.

1 - Source documents

Notwithstanding disadvantages described in detail by *Siegrist* and taken account of by the medical community, *Müller Brothers* blown contact shells edged their way little by little into the therapeutic arsenal of keratoconus, as evidenced by publications and scientific presentations. Those of *von Hippel* and *Clausen* as well as the M.D. thesis of *F.E. Müller* are the most striking of this epoch. The first two were important because they came from reputed University Eye Clinics and because they were to serve as a reference and an encouragement for other physicians, the last by reason of its widespread diffusion, which made it cited almost across the board.

1.1 - The publications (1917-1920)

Grüter (1917)

The physicians of the University Eye Clinic in Marburg (Germany), a town near Wiesbaden, of which *Bielschowsky* was Director, demonstrated their interest in contact lenses over the years. In 1917, *Grüter*, from this Eye Clinic, reviewed the means of optical correction of war-wounded persons in a publication entitled "*Optische Hilfsmittel bei hochgradiger Schwachsichtigkeit infolge von Kriegsverletzungen*" (*Optical Aids for Severe Low Vision Resulting from War Wounds*). Among the available modalities, he cited "transparent contact eye-shells" (durchsichtige Kontaktgeschälen), which he illustrated with the clinical history of a war-wounded person who had lost his first eye and whose second eye had been perforated by a piece of shrapnel. The latter was aphakic and its cornea was very significantly deformed as the result of a toric cicatricial astigmatism greater than 9 diopters. The firm *Müller Brothers* of Wiesbaden was to deliver a well-supported blown shell, notwithstanding the presence of air bubbles, which allowed the injured man to resume his trade of joiner:

"For the correction of keratotorus, I had the firm F. Ad. Müller of Wiesbaden blow a transparent 'contact-ocular-shell.' It is known that such shells have been manufactured for several years by the Müller firm for keratoconus correction. Blowing these shells requires considerable expertise because the shell must be adjusted precisely to the shape of the anterior segment of the globe. It does not sit directly on the cornea but is separated from it by a thin layer of tears. The spherical front surface of the shell represents, so to speak, the corneal surface, as there extends a liquid with the same refractive index both in front of and behind the cornea. The results obtained with contact shells are in general very favorable. Our patient has immediately achieved a visual acuity of 6/10 after compensation of moderate astigmatism produced by the shell surface." (4)

Sattler (1917)

During the same year (1917), the summary of a communication presented the previous year by *Sattler*, who was Professor of Ophthalmology in Koenigsberg (former East Prussia) to the local medical society was published with the title "*Keratokonus*". He reported his successful fit in a 17-year-old female affected by bilateral keratoconus, in whom a *Müller* blown contact shell had been worn up to eight hours a day and had improved the vision:

"The glass prosthesis could be worn every day, continuously from morning to evening, without the least inconvenience and did not disfigure the patient in any way; the visual acuity did not change at all after wearing the prosthesis for eight hours, and the globe was not irritated. The patient learned how to insert

and remove the glass shell herself and to avoid the appearance of air bubbles between the cornea and the prosthesis at the time of insertion.” (5)

Wessely (1917)

In the same year, Wessely of Würzburg (Bavaria) reported in a communication entitled “**Wirkung der Kontaktgläser beim Keratokonus**” (*Effect of Contact Glasses in Keratoconus*) the case of a young woman whose vision was improved by blown Müller shells:

“Female, 21 years of age, in whom a very pronounced bilateral keratoconus developed from the age of 12. Visual acuity = 1/60. [...] With contact glasses (blown shell-like prostheses of Ad. Müller Son's, Wiesbaden). Visual acuity = 1/4 for distance and 1/2 for near. For the moment, the patient wears the glass throughout the whole day without discomfort; it remains to be seen how long it will be able to be tolerated.” (6)

Pichler (1918)

In 1918, Pichler, who was ophthalmologist in Klagenfurt (Austria), published the clinical history of a man who was the victim of a perforating wound, resulting in avulsion of the iris: “**Totale Irisausreissung – Ersatz durch Schalenauge**” (*Total Avulsion of the Iris – Replacement by a Shell-eye*). The patient's complaints of persistent photophobia led the author to suggest inserting a “shell eye” (Schalenauge). To judge from the terminology he used, he had thought essentially of a shell such as is used to hide an ocular globe in phthisis or affected by other disfigurement accompanying microphthalmia. In the course of making his yearly professional trip to Klagenfurt, the oculist F.A. Müller accepted the order. After three attempts, the patient was fit with a contact shell, provided with a painted iris and a transparent pupil, which diminished his photophobia and restricted his visual field only minimally. The patient confirmed that he forgot about his shell during the day and that his eye was comfortable in the evening. Furthermore, on one occasion, he wore the contact shell three days and nights on end, causing corneal erosion. According to the oculist, this was the first time a total anirida had been corrected by a contact shell with a diaphragm.

The history of this patient demonstrates that Müller dominated the use of the technique for correction of refractive errors, as, in the course of his experiments, he manufactured a contact shell that corrected the myopia-producing effects of the previous models:

“The first two shell eyes were well positioned but had a divergent lens effect, for which the patient had to be corrected by powerful convex lenses. The third artificial eye corresponded quite a bit better, as the patient sees 6/12 and, after +2.0 diopters placed in front, he reaches 6/6.” (7)

Eperon (1918)

In May 1918, at the annual congress of the Swiss Society of Ophthalmology, Eperon of Lausanne (Switzerland) made a presentation entitled “**Korrektion des Keratokonus durch die Müllerschen Schalen**” (*Correction of keratoconus by Müller shells*). He showed the results of his experiments with an artificial eye filled with water, on which he was fixing Müller contact shells in order to measure their radii of curvature and refraction. He confirmed what Siegrist had already found, that the majority of the blown Müller shells were unusable because of their strong conical and cylindrical deformations:

“The determination of the optical parameters [of Müller shells] is an essential condition. The Javal keratometer is not easy to use unless you have a particular additional device. Eperon has constructed a type of artificial eye (demonstration), using water as the medium, where each of the different shells can be

inserted. In this way, their power and the curvature in each meridian can be easily measured by ophthalmoscopy, skiascopy, and keratometry. In general, the refraction of the Müller shells does not match the curvature of their front surfaces but is more or less lower because the back surface is more curved than the front (probably because of the blowing). Most of the Müller shells possess a refractive power less than that of the normal cornea. This explains the frequency of their astigmatism (regular or irregular) and even their conical distortion. An improvement in this direction is to be wished, for they are better tolerated than Sulzer's contact glasses although the latter are optically superior." (8)

He ends his description with the theme, thenceforth recurring, expressing the hope that contact lenses would permit the correction of every refractive error and even find an application as therapeutic devices:

"Well now then, they could be used advantageously, not only against keratoconus, but also against strong myopia (weakly curved shells), aphakia (highly curved), irregular astigmatism, and even as a protective device in some patients with neuroparalytic keratitis, etc." (9)

Siegrist (1918)

In the course of the discussion of Eperon's communication, Siegrist made a lengthy and extremely interesting comment, in which he recalled similar research at the Eye Clinic of Berne (Switzerland), regretting that grinding the optical portion of blown contact shells was unachievable. The insistence of von Hippel and the Müller Brothers that blown contact shells were superior to ground contact lenses did not meet with his agreement. Zeiss would otherwise have announced for his benefit the next sales pitch for ground contact lenses that were standardized and free of astigmatism. For removal of a contact lens, Siegrist recommended a suction cup and announced the manufacture of this as soon as the necessary rubber was available. Siegrist was convinced of a good future for contact lenses:

"I have already defended the opinion that the contact glass will probably be used in the future not only for the correction of keratoconus but also for the many different types of astigmatism and other anomalies of refraction. This new spectacle glass would avoid all the disadvantages of ordinary spectacle glasses, as it accompanies the eye in its movements and it is always separated from the cornea by the same distance filled with tears. For this reason it would represent an ideal spectacle glass." (10)

Actually, Siegrist practiced a very careful fit of Müller contact shells and sought out an even tear film, whereas the majority of his contemporaries, who were less experimentally inclined, introduced a thick tear meniscus between the cornea and the contact shell.

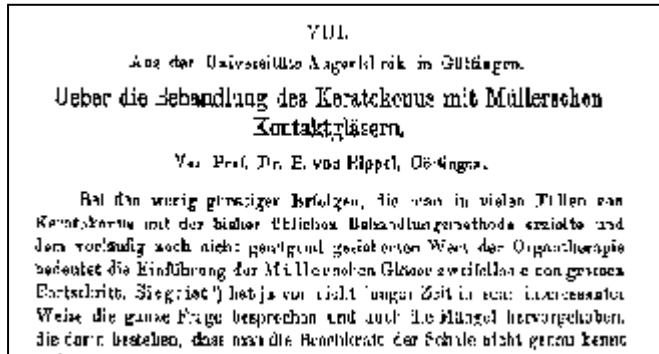


Figure 17-1
Communication of von Hippel on the treatment of keratoconus (1918).
The publication of Hippel's article "Ueber die Behandlung des Keratokonus mit Müllerschen Kontaktgläsern" (Treatment of Keratoconus using Müller Contact Glasses) constitutes the first in-depth research on the subject of Müller-Brothers contact shells originating in a reputable German university.
(HIPPEL, Eugen von, "Ueber die Behandlung des keratokonus mit Müllerschen Kontaktgläsern" Klinische Monatsblätter für Augenheilkunde, 60, 1918, 49-52. - Excerpt from page 49)

Von Hippel (1918)

In 1918, von Hippel, who was Professor of Ophthalmology in Göttingen (Lower Saxony) and at Halle before that, published the case of a nineteen-year-old female patient affected by bilateral keratoconus, entitled "*Ueber die Behandlung des Keratokonus mit Müllerschen Kontaktgläsern*" (*Treatment of Keratoconus by Müller's Contact Glasses*). He carried out preliminary experiments

that were made possible by the blown contact shells that were available to him, in the course of which one shell was worn for the duration of a whole day. The patient concerned was then sent over to Wiesbaden, where *Müller* blew new shells following the profile of the eye. These were "permanently well tolerated and there was great patient satisfaction". The patient wore them for a year in spite of the episodic presence of air bubbles. *Müller* then provided her with a new blown contact shell, under which the air bubbles no longer reappeared and which gave her a visual acuity of 5/10. The clinical observation was long and thorough. *Von Hippel* insisted that the patient got to the point that she could insert the lenses herself and that the keratoconus would regress, which the author attributed to the fortunate association of "organ therapy" and contact lenses. (11)

Von Hippel's publication was the first to come from a reputed German university and constituted an undisputable reference for later publications concerning blown contact shells. By basing his observations on the claims for the *Müller Brothers*, *Hippel* was highly optimistic concerning the quality of blown contact shells that he considered superior to those of ground manufacture. He concluded that the treatment by contact lenses thenceforth represented the procedure of choice and recommended that no further surgery be carried out for keratoconus without having tried contact lenses:

"Several years ago in Halle, I undertook my first attempt with Müller's shells on keratoconus and I often got excellent optical results, but in no case was the prosthesis tolerated for more than a few days. Now that technical advances have resolved these difficulties, treatment by prostheses could in the future become the procedure of choice, particularly if you have a wide range of these shells available. In any event, I no longer foresee an operation for keratoconus unless the treatment by prostheses is shown to be ineffective." (12)

It is probable that *von Hippel* had already benefited from a new techniques of glass blowing that the *Müller Brothers* had brought into focus with a new quality of glass in order to achieve a more regular corneal portion. In fact, he made the following announcement: "*The problem of manufacturing blown contact glasses that are free of flaws in the pupillary area will now be completely resolved.*" (13)

Clausen (1920)

In the course of a presentation in 1920 at the meeting of the German Ophthalmological Society, entitled "**Keratokonus und seine Behandlung**" (*Keratoconus and his Treatment*), Clausen, who had succeeded *von Hippel* at Halle University Eye Clinic, presented a study on the pathology and the medical and surgical treatment of keratoconus, in which he also touched on the optical management of the condition with contact lenses. He confirmed the value of *von Hippel's* advice of systematically trying contact lenses before considering a surgical operation for keratoconus, illustrating this with two clinical examples. The history of one of these patients is without interest, for he had been improved at the time of the trial but was then lost to

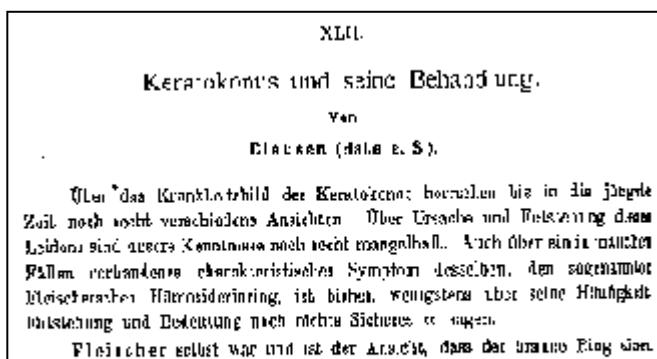


Figure 17-2

Clausen's presentation on the treatment of keratoconus (1920). The presentation by Clausen entitled "Keratokonus und seine Behandlung" (*Keratoconus and his Treatment*) in August 1920 at the annual meeting of the German Ophthalmological Society is a testimonial for Müller_Brothers blown contact shells.

(CLAUSEN, W. von, "Keratokonus und seine Behandlung" Bericht der deutschen ophthalmologischen Gesellschaft, 42, 1920, 288-294 - Excerpt from page 288)

follow up. For the other patient, however, *Clausen* had found "by chance" two shells that were appropriate from among the ten sent by *Müller*, which were worn for the whole day without the least difficulty.

For *Clausen*, the zone of support for *Müller* shells approached an ideal shape, but it had to be adapted to different profiles and topographies of the sclera. The corneal segment of the scleral lenses should be optically perfect, be polished to an extreme degree in order to be "non-reactive" to the cornea, be a glass of quality capable of withstanding the forced polishing and not allowing any porous mark to persist, which could be the origin of corneal adhesions and epithelial lesions.

The insertion of the contact lens would be straightforward and not necessitate any sterile saline solution as was thought necessary by *Weill*, for the space between the cornea and the back surface of the lens would fill spontaneously with tears, which would drive out the air bubbles. For removal of the contact lens, one could use the suction cup of *Siegrist*. Since the *Müller* shells were far from being perfect, *Clausen* hoped for a contact lens that would correct any refractive error, not by the refractive power of the tear lens, but by means of a ground optic in the corneal zone.

Clausen concludes with the traditional wish that the industry could bring itself to manufacture scleral contact lenses of which the corneal portion would be of ground optical quality and the scleral part would be fit to the form of the sclera:

"When it will become possible to include a precisely ground optical zone in the shells, you will have really achieved the production of a genre of ideal spectacles that could be utilized not only for the correction of keratoconus but also for other errors of refraction, including high myopia, hyperopia, high astigmatism and so forth." (14)



Abb. 38. Gummisauger zur Entfernung der Kontaktgläser von der Hornhaut nach SIEGRIST.

Figure 17-3

The suction cup of Siegrist.

The manufacture of the suction cup had been delayed because of the lack of rubber during the war years of 1914-1918. It was only after the reestablishment of normal trade links that Siegrist succeeded in getting the Büchi Company of Berne to manufacture and then conduct trials on various suction device prototypes, the best design of which achieved a widespread commercial distribution.

(SIEGRIST August, Refraktion und Akkommodation des menschlichen Auges, Springer, Berlin 1925 - Figure 38, p. 38)

Siegrist (1920)

During a presentation entitled "**Zur Aetiologie und Theorie des Keratokonus**" (*Concerning Etiology and Theory of Keratoconus*), Siegrist of Berne describes the fit of *Müller* shells in a case of *Down's syndrome*. The patient showed an improvement of visual acuity and was able to remove it easily with the new suction cup manufactured as the result of Siegrist's initiative:

"The first young patient is an endemic cretin who suffers from thyroidal atrophy. The other young patient is a mongoloid idiot who suffers also from an affection for which the internal secretions are considered responsible. One of the two patients is aged 17 years and he wears a Müller contact glass that has been measured and chosen by the best means possible according to my method. The visual acuity of the eye fit with this contact glass has gone from 0.1 to 0.6." (15)

This success confirms that Siegrist was perfectly mastering the art of contact lens fitting. He researched a parallel fit, which distinguishes him from some of his contemporaries who used the blown contact shells without taking account of their possible

incompatibility with the corneal geometry and who therefore complained about the poor results achieved.

Siegrist presented the suction device once again during the same year, in a demonstration session at the congress of the German Society of Ophthalmology (16). He regretted that his finalizing had been delayed because of the shortage of rubber during the war years.

1.2 – Friedrich E. Müller's “Inaugural Dissertation” (1920)

A significant document concerning the history of contact lenses that allows us to take stock of the situation during this era is the “Inaugural Dissertation” of *Friedrich E Müller*, the son and nephew of oculists *F.A. & A.C. Müller-Brothers* of Wiesbaden. Written under the supervision of Professor *F. Hofmann*, it was defended on August 2, 1920 at the Faculty of Medicine of the University of Marburg and entitled “*Über die Korrektion des Keratokonus und anderer Brechungsanomalien des Auges mit Müllerschen Kontaktshalen*” (*The Correction of Keratoconus and other Refractive Anomalies of the Eye by Müller's Contact Shells*).

This document is 59 pages in length and includes:

- an historical section,
- a description of blown contact lenses and of their optical effect,
- the transcription of some clinical cases,
- a value judgment of *Müller* contact-shells and of their use in practice.

Historical Section

The document begins with a historical section entitled “*Zur Geschichte der Korrektion von Keratokonus und der Kontaktshale*” (*On the History of the Keratoconus Correction and the Contact-shell*).

After listing medical and surgical treatments of keratoconus, as well as the optical management as recommended for keratoconus at the time, there follows a series of laudatory comments regarding the contributions of *Fick, Kalt, August Müller and Sulzer*. This historical introduction also includes numerous inaccuracies and ambiguous statements.

According to this thesis, the merit of achieving a durable success would be awarded to the contact shells manufactured by the father and the uncle of the author, the brothers *Friedrich A. and Albert C. Müller*, artificial eye makers in Wiesbaden. Their blown contact shells would have to satisfy three essential stipulations: good visual correction,

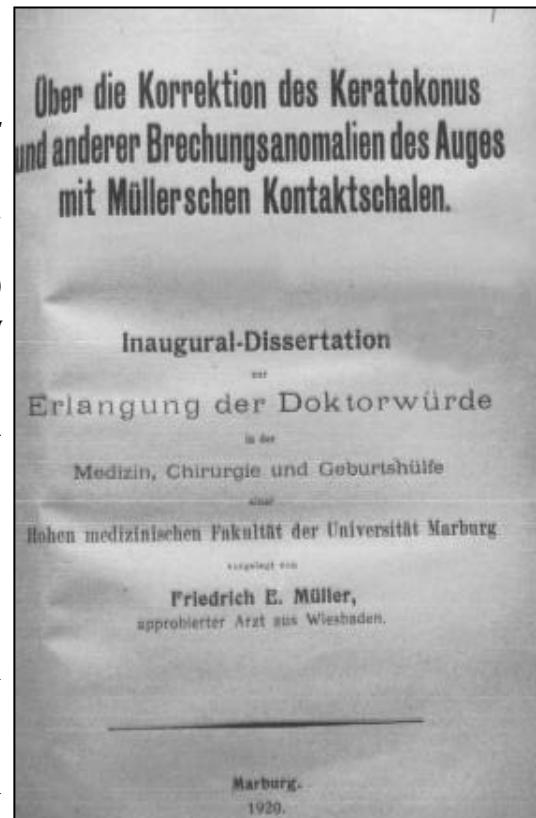


Figure 17-4

Friedrich E. Müller's "Inaugural-Dissertation" (1920). Title page of the "Inaugural Dissertation" for M.D. submitted by Friedrich E. Müller Jr. on August 2, 1920, to the Faculty of Medicine of Marburg. Although it dealt with an ophthalmological subject, the thesis was upheld not in this specialty but in general medicine.

(MULLER Friedrich E. Über die Korrektion des Keratokonus und anderer Brechungsanomalien des Auges mit Müllerschen Kontaktshalen, Inaugural-Dissertation Marburg, 1920)

ability to be worn for years without causing ocular irritation or lesions and acceptable cosmetic wearing.

The blown *Müller* shells were characterized by their wide scleral rim, which permits even support of the shell on the eye, peripheral to the cornea. The author also describes how *Müller* shells are readily distinguishable from the ground contact lenses of *Fick* and *Sulzer*:

"The essential difference between the external shape of these contact shells and those of A.E. Fick and Sulzer is that the former possess a larger scleral portion around the transparent glass cornea and that this curvature is shaped to fit the anterior segment of the globe. They are prepared in a single piece by blowing in the flame. The Müller contact shell thus possesses the same shape as the thin prosthetic shells used for covering up eyes that are amaurotic due to corneal leukomata or phthisis bulbi." (17)

Müller attributes ophthalmologists' distrust and suspicion of *Müller*'s contact-shells to the bad reputation acquired by the former ground contact lenses of *Fick* and *Sulzer*:

"Contact shells have for a long time been received with a certain suspicion the majority of ophthalmologists, as one knows from following the publications of A.E. Fick on the 'Kontaktbrille' (Contact-spectacle), that they provoked epithelial corneal lesions with violent irritation. Also, it was often believed that the normal cornea could not tolerate the contact of an ordinary prosthetic shell for a longer time without provoking lesions or ocular irritation." (18)

The focus of blown *Müller* contact-shells was to return to prosthetic shells used for protection of the globe, without there being carried out any prior research on their optical effects. Thus it was that *Müller* blew, in 1887, a protective shell with a transparent cornea in order to treat a lagophthalmos caused by palpebral retraction on a single-eye patient of *Sämisich*. In 1892, a female patient of *Fränkel* (Chemnitz) also received such a shell for the protection of an eye with inoperable trichiasis. It is on this occasion that *Müller* would have noticed the optical effects of the prosthetic shells, even if he did not recognize their significance:

"At this time, Müller-Wiesbaden noted that the 'glass cornea' of the shells produced by blowing possessed an optical effect with a diminution of the image, that could be modified at will at the time of manufacture. Development of contact shells in this optical direction did not attract much attention during this period of time, as minor ocular refractive errors are more readily corrected by normal spectacle glasses." (19)

Optical correction was used for the first time in 1908 at the request of *Pagenstecher* and *Axenfeld* in their attempts to correct the refractive errors of patients with keratoconus:

"It was only in 1908 that it was shown, at the time of correction with Müller's contact shells of two cases of keratoconus coming from the practice of professors Pagenstecher and Axenfeld, that they could also eliminate this significant visual disturbance." (19)

Since that time, *Müller*'s blown contact shells corrected numerous keratoconus cases with greater or less success:

"Since 1909, a large number of patients with keratoconus were corrected by Müller-Wiesbaden using these contact shells. The corrections had both good and less than perfect results. Almost without exception, the shells could be worn continuously and without discomfort, if they had been manufactured up to an adequate standard. Considering the professional and psychological advantages that they obtained from them, the patients have almost accepted a lesser correction of their vision if, for one reason or another, this point had not been reached." (20)

Description of Müller Contact-shells and of their optical Effect

F.E. Müller explains that the manufacture of blown scleral shells is empirical. By preference, the lateral view of the eye is examined, and from this starting point, the glass blower fashions the shell:

"The contact shell of Müller is comprised of one part scleral and one part corneal. As we have already explained, all the parts of the contact shell (including the glass cornea) are produced exclusively by blowing, without using any means of shaping other than the glance of the glassblower's eye. The result is determined uniquely by the individual skill of the skilled technician. Manufacture thus follows a very empirical pathway." (20)

The scleral portion resembles that of an ocular prosthesis; its support should be spread out as widely and as regularly as possible:

"The scleral portion of the shell, the color and vascular design of which resemble normal sclera, is formed just like a ocular prosthetic shell: a narrow part on the nasal side, a cutout above and inside corresponding to the trochlea, a wide lower part to give support to the shell in the conjunctival fold below, and a long gently-pointed temporal part. The curvature, i.e., the radius of the glass sclera, is different in every case. Certainly, there are no great variations in the shape and size of ocular globes, but they do vary depending on the individual case because of differing thickness of the bulbar conjunctiva, especially towards the equator of the globe. The contact shell, in order to be well fit and supported over the long term, must always rest as exactly as possible on all parts of the ocular globe without causing compression in any area, whatever that may be. Only in this case (and this is the reason why Müller's contact shells can be worn permanently and without irritation) should the adherence pressure between the glass shell and the ocular globe be spread out evenly over a wide area of the latter, and one thereby avoids the appearance of circulatory disturbances in the pericorneal zone, so important for corneal nutrition. With these reservations, the shell follows the movements of the globe and ensures a normal visual correction in all directions of gaze." (21)

The glass cornea is transparent and has an "optical power". The *Siegrist* studies have demonstrated that the optical qualities were not perfect for the lenses that he had analyzed. However, *Müller* points out that the shells delivered to *Siegrist* dated from before 1914 were the product of the first attempts at manufacturing, before research had been done regarding optical quality. Nowadays, the manufacturing methods allowed for the majority of the cases obtain corneal zones of optical quality without, however, reaching the quality of a ground glass cornea. Secondary grinding of a blown cornea would be unfeasible because the thickness of a blown contact lens is less than 0.50 mm. *Müller* next extends his comments to the measurement of the front and back curvatures of the corneal portion and to the false calculations of refractive power that some authors, such as *Siegrist*, had made because such are based uniquely on the radius of curvature of the front surface measured on the *Javal* ophthalmometer.

The utilization of a trial set of contact shells was also possible, but any rational approach could not be recommended, except that of *Siegrist*, which necessitates an enormous selection of contact shells. The optical correction is generally made by the liquid lens. *Müller* had an inkling that certain recent manufacturing trials allowed the production of shells incorporating optical power and would thus correct even aphakic patients and myopes. Everything depended nevertheless on the expertise and the dexterity of the glassblower.

Presentation of Clinical Cases

The presentation by *F.E. Müller* of the clinical histories of patients fit with blown contact shells comprises 20 observations, 17 of which are keratoconus patients. Some of these

Year	Author	Müller's comment
1913	Helmbold (Danzig)	Wears Müller shells for the past 8 years
1914	Bielchovsky (Marburg)	Wears Müller shells for the past 6 years
1920	Von Hippel (Göttingen)	Wearing Müller shells for 4 years
1917	Grüter (Marburg)	Aphakia recently fit

Table 17 - 2

The clinical cases described in the thesis of F.E Müller already cited by the ophthalmologists involved.

observations concern patients whose history had been published before, and we thus learn that such lenses were already being worn in 1920.

- The patient described in 1913 by *Helmbold* was fit in 1912 and was still wearing his shells for the whole day eight years later. (22)
- The patient described in May 1914 by *Bielchowsky* received his first contact shell in 1914 and was still wearing these six years later.
- The female patient affected by keratoconus who was the subject of *Von Hippel's* publication had been fit in 1916. She was still wearing the *Müller* shells in 1920.

According to the cited case reports, the patients were generally wearing their Contact-shells for 6 to 8 hours a day. Some experienced air bubbles or mild conjunctival reactions. Contact shells should be renewed after 2 to 4 years because of wear marks provoked by the erosion of the lens by tears. *Müller* recommended that a drop of diluted fluorescein be instilled in order to verify the even distribution of tears between contact shell and eye.

The description of clinical cases with high refractive errors corrected by blown contact-shells includes high myopia with nystagmus and including the two aphakic eyes cited by *Grüter* in 1917. (23)

Comments on Müller Contact Shells and their Practicality

It is apparent that the comments made by *F.E. Müller* on the value and usefulness of contact shells are not only excessively laudatory, but, at the same time, quite unreasonably optimistic:

- Contact-shells would be tolerated continuously without subjective symptoms and without ocular irritation or lesion.
- Their lifespan would be up to four years before there would be any need to replace them.
- The quality of the optical zone of blown contact-shells, while not reaching that of ground lenses, would allow a everyday life satisfactory correction for that would benefit patients afflicted by keratoconus.
- The limitations of blown contact shells were due to their empirical mode of manufacture, which rendered illusory the concept of a trial collection of graduated shells, as *Siegrist* suggests. The best results would be obtained with individually manufactured *Müller* shells in the presence of the patient, under which circumstances the skilled glassblower could take his inspiration directly from the profile of the diseased eye.

2. Discussion

2.1 – Terminology

The terminology used for the design of blown contact-shells during this epoch is quite random, both for manufacturers and users.

After having used the term “contact adhesion-spectacle” (Kontakt-Adhäsionsbrille), which is somewhat reminiscent of *Fick*'s term “Contactbrille” (contact spectacle), *Müller Brothers* replaced that expression with “corneal shell” (Kontaktschale) as from 1920. This was sometimes modified to “*Müller*'s contact-shell” on occasion (*Müllersche Kontaktschale*) or to “contact-shell for keratoconus” (Keratokonuskontaktschale).

2.2 – Manufacture

The manufacture by blowing of contact shells was always somewhat random and haphazard. Manufacture on location and in the presence of the patient was the preferred technique of the *Müller Brothers*. It is no surprise that most of the reports originated in towns situated near Wiesbaden. *Müller Brothers* also traveled across Germany and neighboring countries in order to blow the contact-shells that depended on the model of the corneal profile of the patient referred to them.

At the request of physicians, *Müller* provided a consignment of trial contact shells on loan. Thus, *Clausen* received ten shells for his early trial in 1920: “*Following my request, Müller (Wiesbaden) sent me ten keratoconus contact glasses. By chance, I found two of them, which improved the visual acuity to a surprising degree. This was probably quite by accident,*” (24)

Individual collections were less common. *Siegrist* possessed an extensive collection on which he depended for his trials. *Von Hippel* and *Clausen* in Halle were also equipped with such a collection. *Clausen* owned a tray of about a hundred test shells, to which *Sitschevska* bore witness after she referred a patient to him: “*The patient was taken to Professor Clausen's clinic at Halle in Germany, (...). There, of approximately 100 Müller contact glasses, the patient chose three pairs that he could wear comfortably.*” (25)

Siegrist described the best way of finding the appropriate optical correction:

“*In the last instance, the determination of contact glasses is made by trial and error, in just the same way as the determination of spherical refractive error is performed in an eye that is not affected by keratoconus. You try a given contact glass and, by placing plus or minus spherical spectacle lenses, you verify whether it is too weak or too strong. In this way you seek out a contact glass with a higher or lower number in your trial set, which you have taken care to mark clearly with the numbers until such time as the lens that totally corrects the error be found.*” (26)

Blown contact shells were of inferior quality, both in their corneal and scleral parts, as *Siegrist* demonstrated with the *Javal* keratometer at the time of his measuring experiments. *Eperon* confirmed it using an artificial eye provided with a cornea in the form of a contact lens. *Siegrist* emphasized the importance of the smoothness of the front optic zone:

"In any case, it is the curvature of the front surface of the contact lens that is the most significant. The back surface, in any case, loses its role, since (by the tears that have approximately the same index of refraction) it is fused with the front surface of the cornea." (27).

2.3 – The Choice of blown Contact-shells

Most of the ophthalmologists referred their patients to Wiesbaden or waited for the visit of one of the *Müller Brothers* to the town in which they lived. The patients whose contact-shells were blown according to the model of their corneo-scleral profile had to accept the contact -shell that was delivered to them. In the event of failure, the possibility remained to them to go back to the ocularist or to await his next trip for a new attempt at contact-shell blowing in order to produce a more appropriate device from both an optical and subjective viewpoint.

For the owners of small contact-shell trial sets or of sets loaned by the *Müller Brothers*, the choice of the best shell was made by trial and error, which required extreme patience on the part of the physician and the patient. The results were often disappointing. One can understand the comment of a female patient who "*would rather repeat the experience of giving birth to [her] seven children than wearing such an object, even if it were only for half a day.*" (28)

Those rare physicians who owned large trial sets of contact shells, such as the ophthalmologists at the Eye Clinics of Berne and of Halle, had attempted to classify shells according to their optic zone radii and refractive power. Their fitting technique started from a more rational starting point. These experienced physicians had made the observation that contact between cornea and lens was best avoided: "*The contact lens must never be in direct contact with cornea. There must also be a protective bed, preferably made of tears, between the cornea and contact lens.*" (29). F.E. Müller Jr. recommended verification on the presence of a tear film between the eye and the shell by the instillation of dilute fluorescein. Unfortunately, this verification was only of purely theoretical interest due to the impossibility of exchanging a poorly fit shell with a more appropriate one.

2.4 – Tolerance and Wearing Time

All publications emphasized the enormous patience that both ophthalmologist and patient required for the fitting of *Müller* scleral contact-shells. Furthermore, the patient had to put up with the discomfort resulting from the insertion and maintenance of the shell in his eye, even if the instillation of cocaine could relieve him temporarily.

Perfect tolerance of a contact-shell, i.e., one that was innocuous as far as the ocular tissues were concerned, was impossible to achieve with contact shells as approximate as those available. Review of the literature reveals a count of several hundred patients who tolerated and actually wore *Müller Brothers* shells after the initial period of enthusiasm. Reports to the congresses announced excellent results, but it was gleaned from the following discussion that the true picture was more disappointing and that abandonment of contact lenses in the shorter or longer term was the norm. The publications often describe excellent tolerance without, however, indicating the wearing time actually achieved by the patients.

2.5 – Complications

The method of fitting the contact shell with liquid before inserting and keeping that liquid in the space between cornea and contact lens was the subject of innumerable discussions.

We can say, with some reservations, that this criterion separated experienced fitters from those who were less so. Thus it was for *Siegrist*, *Clausen*, and generally all those medical practitioners who practiced as rational fitting as was possible. Taking into consideration the means of doing this in the epoch during which they lived, it would not be necessary to fill the shell with any specific liquid because “*with a shell that is well fit, most of the time the space between cornea and corneal shell of the contact glass fills itself on its own with tears*”. (30) *Clausen* observed one case where there appeared a serious infiltration of the corneal cone after prolonged wear. This resolved after only 3 or 4 weeks, but “*the patient refused to wear a contact shell again in this eye*”. (31)

2.6 – Insertion and Removal of Scleral Contact Shells and Lenses

The majority of authors agreed that the insertion of contact-shells was easy to teach to a patient. This was facilitated by the instillation of a drop of cocaine. It was, however, not the same with the removal of the shell, which could be done only with the help of a hook held by a third person: “*It is easy to teach a patient to insert his contact glass himself, but usually patients cannot remove their contact glasses from the conjunctival cul de sac without outside help.*” (32) For this reason *Siegrist* conceived the idea of a suction cup and arranged for the optician *Buchi* in Berne to manufacture several prototypes that could facilitate the otherwise difficult removal of contact-shells. However, marketing of *Siegrist*'s suction cup was postponed because of the shortage of rubber and did not occur until after World War I.

2.7 – Indications for Fitting Contact Lenses

During this epoch, the indications for fitting blown *Müller* contact shells still essentially remained restricted to keratoconus. *Von Hippel*'s rule not to operate any more on keratoconus patients without having previously performed a trial of contact-shells was reiterated by numerous authors: ‘*I would support von Hippel's observation not to operate on keratoconus except when the treatment by contact lenses is shown to be unsuccessful.*’ (33)

2.8 – Alternatives to Blown Müller Contact Shells

Blown *Müller* contact shells were compared with other methods of optical correction of keratoconus: notably ground contact lenses of *Fick-Sulzer* and hydrodiascopes of *Lohnstein*. At that time it was recognized the former were superior to the others mentioned.

2.9 – The Utopia of a Blown Contact-shell with Ground Optic Zone

The myth of scleral contact lenses with a blown haptic and a ground optic zone was to dominate this period in the history of contact lenses. In spite of the denials by *von Hippel* and *F.E. Müller Jr.*, certain speakers continued to claim at congresses that *Helmbold* had obtained lenses with an optic ground onto blown shells from *Zeiss* that he had sent to the firm in 1915. (34)

2.10 – The Impact of Blown Müller-Brothers Contact-shells

The impact of *Müller Brothers* blown contact-shells must be considered in the context of the era, even if certain historians attribute much importance to them. The blown shells were only used by certain ophthalmologists in the German-speaking milieu, particularly in areas such as university towns, where a circuit was carried out yearly or biennially by an itinerant glassblower for ocular prostheses. Certain patients who were fortunate enough to have the means to do so, made the trip to Wiesbaden, where they often stayed for several days or even a week. At any rate, they stayed for a sufficient time to allow for daily trials of shell models that had been retouched by blowing.

It must be admitted that each successful fit became the potential for a presentation at an ophthalmological meeting. It is likely that there were only several hundred successful fits during years of the monopoly of *Müller Brothers* contact-shells. Those attempts at fitting that were not crowned with success were not published. The personal contacts that *Müller Brothers* had with university eye clinics by virtue of their annual visits gave them a privileged position of observer or even advisor to the physicians of these hospitals. The ocularists performed multiple services, blowing prosthetic and other shells for specialized uses, including the treatment of symblepharon and the support of the upper eyelid in blepharoptosis patients, or, again, to respond to other clinical needs. It cannot be denied that, thanks to these contacts, the ocularists encouraged presentation to congresses and the publication of favorable cases. Failures were rarely mentioned and usually only during the discussion periods.

This contact was even more cordial when *F.E. Müller Jr.*, representing the third generation of the *Müller* family, achieved the degree of doctor of medicine and thus provided a cautionary note regarding true integration of ocularists into the medical professional milieu. The facts that he defended an “Inaugural Dissertation” in General Medicine and that it was not published under the authority and supervision of *Bielschowsky*, a respected professor of Ophthalmology at Marburg University, but under that of the professor of General (Internal) Medicine of this faculty, professor *Hoffman*, has not been publicly revealed. On the other hand, it is generally accepted that the M.D. thesis was widely circulated and that *F.E. Müller Jr.* personally gave a copy to the physicians at the hospitals he visited. (35) It is likely that a truly “ophthalmological” thesis would have demanded more detail and accuracy. One can only regret that this thesis did not reach the academic level or rigor of the theses of *Fater* and *Liidemann*, which were presented on the same subject under *Siegrist’s* supervision in Berne.

3 – An Critical Assessment of F.E. Müller's “Inaugural Dissertation”

The “Inaugural Dissertation” of *F.E. Müller Jr.* was widely circulated and is still in use today by historians who do not hesitate to reproduce certain passages of the text. This thesis and certain passages of it have served until now to uphold the myth of the *Müller Brothers* as the inventors of contact lenses and sometimes even to favor an amalgam with others of the same name, *August Müller* in particular.

In his thesis, defended on August 2, 1920, *F.E. Müller Jr.* put together a work that was superficial and partly erroneous and in which large chunks were recopied word for word from the brochure published ten years previously by his father, *Friedrich A. Müller* and his uncle, *Albert C. Müller*. The similarity between pages 10 to 12 of the thesis and pages 68 to 70 of the 1910 booklet is flagrant. The citations of clinical cases are copied word for word without suitable punctuation marks or other indications to inform the reader that they are citations.

There follow a few examples of such errors that concern *Fick*, *Kalt*, *August Müller*, and *Sulzer*:

- According to *F.E. Müller Jr.*, the “Kontaktbrille” (contact-spectacle) of *Fick* had a diameter equal to that of the cornea: “*The ‘Kontaktbrille’ consists of a thin glass spherical segment of roughly 8 mm radius of curvature with parallel surfaces and a total diameter equal to that of the normal cornea.*” (36) However, no passage in the works of *Fick* confirms that the “Contactbrille” had “a total diameter equal to that of the normal cornea”. We are dealing with a crude confusion between the first glass shell, placed on a rabbit’s eye, that *Fick* was very reticent about placing on the eye of a human and the description of the corneal zone (the “Glascornea”) of the “Contactbrille” (contact-spectacle) for use in humans that *Fick* had ordered through *Abbe* from the *Zeiss* company.
- According to *F E. Müller Jr.*, the contact lens used by *Kalt* had the same shape as that of *Fick*: “*during the same epoch as Fick, E Kalt published his experiments with his ‘verre de contact’ (sic); these lenses had practically the same shape as the ‘Kontaktbrille’ of Fick.*” (37) However, the first shells used by *Kalt* for the reshaping (redressement) of keratoconus were in fact cut off from the bubble made by a glassblower, and they did not resemble in any way the scleral shells delivered by *Abbe* to *Fick* that the latter had used for his patients. Besides, it was not *Kalt* but *Sulzer* who was first to use the expression “verre de contact”.
- According to *F.E. Müller Jr.*, *Sulzer* carried out his experiments around the year 1900: “*Roughly 12 years later, Sulzer repeated Fick’s experiments and ordered one-piece contact lenses to be ground.*” (38) This critical error is even more incomprehensible because the biographical reference to *Sulzer*’s publication bears the correct date of 1892.

The recognition that *F.E. Müller Jr.* gave to his namesake *August Müller* is ambiguous and incomplete: “*During the same epoch as Fick, August Müller constructed a ‘Hornhautlinse’ [...]. This ‘Hornhautlinse’ (cornea lens) was manufactured and ground like the Sulzer contact glasses, except that the surfaces of the ‘glass cornea’ were not parallel; the back surface had a radius of curvature of 8 mm, the front of 10 mm.*” (39) This statement is inaccurate. Even if *August Müller* had given the title “cornea lens”

(Hornhautlinse) to the corresponding chapter of his thesis, it was not a corneal lens, but a scleral lens of 20 mm in total diameter. *F.E. Müller Jr.* did not explain this to his readers.

One can speculate on the possible reasons for such an accumulation of errors in so widely distributed thesis. One explanation would be that *F.E. Müller Jr.* did not check the documents he cited or take cognizance of the available historical records of contact lenses reproduced in other publications, like those of *Rohr* and *Stock* (1912) and *Siegrist* (1916). It is true that the first concerned a contact lens ground by *Zeiss* and that the historical publication of *Siegrist* was critical of blown contact shells, which this author had just abandoned in favor of ground *Zeiss* lenses at the time of *F.E. Müller Jr's* "Inaugural-Dissertation".

A second explanation can be found in the argument that the point in common of the erroneous citations resides in the fact that they tried to prove that the first contact lenses were of corneal diameter and therefore without a scleral component. However, according to *Müller*, the success of *Müller* blown contact shells depended on the presence of substantial scleral support that permitted "bridging over" the limbus and the cornea. By concealing the fact that other existing contact lenses already had these properties, *Müller* gave the credit of having invented them to his family, took the opportunity to denigrate the contact lenses of *Zeiss*, his principal rival and feared competitor.

4 – A short Survey of any Misinterpretations

The utilization of blown contact shells between 1917 and 1920 is rarely described in detail by historians. Most of the time, this period is the subject of an ambiguous sentence that basically describes the marketing of the first *Zeiss* ground contact lenses. *Nissel* wrote a historical note on the generations of the *Müller* family in Wiesbaden. Most of this is a transcription of *F.E. Müller*'s “Inaugural-Dissertation”, most of the errors of which *Nissel* repeats. (40) These errors are to be repeated again and sometimes even amplified in numerous publications because *Müller*'s M.D. thesis is used as a reference for historians.

Conclusion

Between 1916 and 1920, the works of *Siegrist* and his colleagues demonstrated that contact shells or lenses were devices capable of providing a valid alternative to the traditional treatment for keratoconus. The production of blown contact shells produced by individual blowing by a skilled technician limited the wider distribution of these devices, which remained the monopoly of the *Müller Brothers*.

It is on this basis, combined with the experiences of *F.E. Müller Jr.*, that the favorable report of the results obtained with blown contact shells was produced in 1920. When, in the same year, the first ground contact lenses of *Zeiss* were put on the market, a decade opened that was characterized by comparisons between these two modalities, along with the advantages and corresponding disadvantages of each.

The monopoly of blown contact shells of the ocularists *Müller Brothers* of Wiesbaden ended in 1920, when *Zeiss* introduced the first ground contact lenses for the optical correction of keratoconus to the market. These were presented as a rational alternative to the blown contact shells, the manufacture and use of which was by trial and error.

Notes

1 In this chapter, we use often the generic term “contact lens” (*ISO 8320: Contact lens: a generic term including any lens designed to be worn on the front surface of the eyeball*). - *A scleral contact lens is worn on the cornea and the sclera – A contact shell: appliance similar in form to a contact lens but not designed to correct vision*). (See Appendix 10-1).

The essential difference between a contact lens and a contact shell is that the former has a specified front or back vertex power. Although a rigid contact shell has no specified power, it does allow the formation of a liquid lens that will correct regular or irregular astigmatism and may also correct part of the spherical component of a refractive error. Thus, an afocal contact shell is capable of providing reasonable visual acuity, especially in a condition such as keratoconus.

2 See chapter XV: *Early Blown Contact Lenses*. - At the same time the optician *Sutter* of Basle (Switzerland), delivered ground contact lenses, “*Sulzer lenses*”, intended to be used in experiments for the correction of keratoconus.

3 See chapter XVIII: *The Zeiss Contact Lens Prototypes*.

4 “*Infolgedessen habe ich zur Korrektion des Keratotorus von der Firma F. Ad. Müller in Wiesbaden eine durchsichtige Kontaktaugenschale blasen lassen. Solche Schalen werden bekanntlich schon seit einer Reihe von Jahren von der Firma Müller zur Korrektur des Keratokonus angefertigt. Das Blasen derselben setzt eine grosse Kunstfertigkeit voraus, da die Schale der Form des vorderen Bulbusabschnittes genau angepasst sein muss. Sie liegt der Hornhaut nicht unmittelbar auf, sondern wird durch eine dünne Schicht Tränenflüssigkeit getrennt. Die kugelige Vorderfläche der Schale stellt gewissermassen die Hornhautoberfläche dar, da vor und hinter der Hornhaut Flüssigkeit mit dem nämlichen Brechungsindex liegt. Die mit den Kontaktshalen erzielte Resultate sind meist recht günstig. Unser Patient erreicht nach Ausgleich eines mässigen, durch die Schalenoberfläche bedingten Astigmatismus, sofort eine Sehschärfe von 6/10.*“ (Grüter 1917, p. 1129-1130). Presentation on January 1917 to the *Marburg Medical Association* (Aerztliche Verein zu Marburg).

5 “*Die Glasprothese konnte täglich von früh bis abends ununterbrochen und ohne jede Beschwerden getragen werden und wirkte in keiner Weise entstellend; das Sehvermögen hatte sich nach achtständigem Tragen der Prothese nicht geändert, der Augapfel war nicht gereizt. Die Patientin hatte gelernt, die Glasschale selbst einzulegen, sowie herauszunehmen und bei der Einführung Luftblasen zwischen Hornhaut und der Prothese zu vermeiden.*” (Sattler 1917/a, p. 93). Presented on November 20, 1916, to the *Association for Scientific Medicine* (Verein für wissenschaftliche Heilkunde) in Königsberg (Germany). Also cited in Sattler 1917/b, p. 628.

6 “*21 jähriges Mädchen, bei dem sich seit dem 12. Lebensjahr doppelseitiger höchstgradiger Keratokonus entwickelt hat. Sehschärfe = 1/60. [...] Mit dem Kontaktglas (geblasene schalenförmige Prothese von Ad. Müller Söhne, Wiesbaden) S = ¼ für die Ferne und ½ für die Nähe. Patientin trägt das Glas zunächst ganze Tage lang beschwerdenfrei, wie lang es vertragen werden wird, bleibt abzuwarten.*” (Wessely 1917, p. 1621) Presentation delivered on November 20, 1917, to the *Medical district Association Würzburg* (Ärztlicher Bezirksverein Würzburg).

7 “*Die ersten beiden Schalenaugen sassen zwar gut, wirkten aber als Zerstreuungslinsen, weshalb der Kranke mit stärkeren Konvexgläsern korrigiert werden musste. Das dritte Kunstauge entsprach schon wesentlich besser, indem der Kranke mit demselben 6/12 sah, nach Vorsetzen von +2,0 dptr 6/6.*” (Pichler 1918, p. 73-74).

8 “*Unentbehrlich ist die Bestimmung des optischen Wertes derselben. Dazu ist der Javalsche Apparat nicht leicht anwendbar, ohne Hilfe von besonderen Vorrichtungen. Eperon hat eine Art künstliches Auge konstruiert (Demonstration), mit Wasser als Medium, in welchem jede einzelne Schale als Kornea eingeschaltet werden kann. So ist ihre Brechkraft sowie ihre Krümmung in jedem Meridian ophthalmoskopisch, resp. skiascopisch oder keratometrisch, leicht zu messen. Im allgemeinen ist die Brechkraft der Müllerschen Schalen nicht der Krümmung ihrer vorderen Fläche entsprechend, sondern mehr oder weniger geringer, weil die hintere Fläche stärker gekrümmmt ist als die vordere (durch das Blasen?). Die Mehrzahl der Müllerschen Schalen hat eine Brechkraft unter der der normales Hornhaut. Daher leiden sie häufig an Astigmatismus (regulär oder irregulär) und sogar an konischer Deformation. Wünschenswert ist ihre Vervollkommenung in dieser Beziehung, da sie besser vertragen werden als die Sulzerschen Kontaktgläser, welche ihnen optische überlegen sind.*” (Eperon, 1918, p. 460-461).- Presentation to the annual meeting of the Swiss Ophthalmological Society held May 25th and 26th, 1918.

9 “*Dann können sie mit Vorteil angewendet werden, nicht nur gegen Keratokonus, sondern auch starke Myopie (schwach gekrümmte Schalen), Aphakie (stärker gekrümmte), irregulärer Astigmatismus, sogar als Schutzapparate bei gewissen Fällen von Keratitis neuroparalutica, usw.*” (Eperon, 1918, p. 460-461).

10 “*Ich habe bereits die Ansicht vertreten, dass das Kontaktglas vielleicht in Zukunft nicht nur zur Korrektur des Keratokonus, sondern der verschiedensten Fällen von Astigmatismus und anderer Refraktionsfehlern benutzt werde. Dieses neue Brillenglas würde alle fehlerhaften Eigenschaften der gewöhnlichen Brillengläser vermeiden, da es ja das Auge bei seinen Bewegungen begleitet und jederzeit durch die gleiche mit Tränenflüssigkeit ausgefüllte Distanz von der Hornhaut getrennt ist; es würde also ein geradezu ideales Brillenglas darstellen.*” (Siegrist, in discussion Eperon 1918, p. 462).

- 11 Hippel 1918, p. 51-52. The history of this female patient will be described again by F.E. Müller in 1920, the fourth consecutive year of her wearing Müller's contact shells.
- 12 "Als ich vor einigen Jahren in Halle die ersten Versuche bei Keratokonus mit Müllerschen Schalen anstellte, erhielt ich zwar mehrfach ausgezeichnete optische Resultate, aber in keinem einzigen Fall wurde die Prothese länger als höchstens ein paar Tage vertragen. Nachdem die Technik diese Schwierigkeit überwunden hat, dürfte die Prothesenbehandlung in Zukunft das Verfahren der Wahl werden, ganz besonders, wenn man in der Lage ist, eine grösitere Auswahl solcher Schalen zur Verfügung zu haben. Ich würde wenigstens keinen Fall von Keratokonus mehr operativ angreifen, ehe sich die Prothesenbehandlung etwa als nutzlos erwiesen hätte." (Hippel 1918, p. 52).
- 13 "Die Aufgabe, die geblasenen Kontaktgläser im Pupillargebiet schlierenfrei herzustellen sei jetzt einwandfrei gelöst." (Hippel 1918, p. 50).
- 14 "Wenn es gelingen sollte, eine genau geschliffene optische Zone den Schalen einzufügen, dann wäre dadurch tatsächlich eine Art Idealbrille erreicht, die auch zur Korrektion von Keratokonus nicht nur, sondern auch von anderen Refraktionsanomalien, hoher Myopie, Hypermetropie oder ausgesprochenem Astigmatismus usw. verwendet werden könnte." (Clausen 1920/a, p. 293).
- 15 "Der eine Junge ist ein endemischer Kretin und leidet an Schilddrüsenatrophie. Der andere Junge ist ein mongoloider Idiot und leidet also ebenfalls an einer Affektion, für welche man Störungen der inneren Sekretion verantwortlich macht. Der eine der beiden 17jährigen Patienten trägt Müllersches Kontaktglas, welches nach meiner Methode genau gemessen und bestmöglichst ausgesucht worden war. Die Sehschärfe ist bei dem mit dem Kontaktglas bewaffneten Auge von 0,1 auf 0,6 gestiegen." (Siegrist 1920/b, p. 108). Presentation at the annual meeting of the Swiss Ophthalmological Society held on June 12th and 13th, 1920, in Berne.
- 16 Siegrist 1920/a, p. 340. Presentation to the congress of the German Society of Ophthalmology (Deutsche ophthalmologische Gesellschaft).
- 17 "Der wesentliche Unterschied dieser Kontaktshalen von denen A.E. Fick und Sulzer bezüglich der äusseren Form besteht darin, dass sie anschliessend an die durchsichtige Glaskornea einen grösseren Skleralteil besitzen, welcher der Wölbung des vorderen Bulbusabschnittes angepasst ist. Sie werden aus einem Stück durch Blasen in der Stichflamme hergestellt. Die Müllersche Kontaktshale ist demnach ähnlich geformt wie die dünnen Schalenprothesen, die zur Überkleidung eines anaurotischen Auges mit leukomatöser Kornea oder eines phthisischen Bulbus dienen." (Müller 1920, p. 9-10).
- 18 "Von Seiten vieler Ophthalmologen wurde den Kontaktshalen lange Zeit ein gewisses Misstrauen entgegengebracht, weil man aus Veröffentlichungen A.E. Ficks über seine Kontaktbrille wusste, dass durch sie Epithelschädigungen der Kornea und starke Reizerscheinungen verursacht wurden, aber auch, weil man vielfach glaubte, dass die normale Kornea die Berührung auch mit gewöhnlichen Schalenprothesen ohne Schädigung oder Reizerscheinungen nicht längere Zeit vertragen könne." (Müller 1920, p. 10).
- 19 "Damals bemerkte Müller-Wiesbaden, dass der durch Blasen hergestellten Glaskornea der Schalen eine optische Wirkung, eine Verkleinerung des Bildes, eigen ist, die man durch Blasen bei der Herstellung beliebig ändern kann. Der Ausarbeitung der Kontaktshalen in dieser optischen Richtung wurde damals keine weitere Aufmerksamkeit geschenkt, da nicht zu hochgradige Refraktionsstörungen des Auges zweckmässiger durch gewöhnliche Brillengläser ausgeglichen werden."
- [...] "Erst als es gelang, 1908, zwei Fälle von Keratokonus aus der Praxis von Prof. Pagestecher und Prof. Axenfeld mit Müllerschen Kontaktshalen zu versehen, zeigte es sich, dass mit letzteren auch diese erhebliche Sehstörung beseitigt werden kann." (Müller 1920, p. 11).
- 20 "Seit 1909 wurde eine grosse Anzahl von Keratokonusfällen von Müller-Wiesbaden mit seinen Kontaktshalen korrigiert. Oft mit gutem, oft mit weniger gutem Erfolg. Fast ausnahmslos konnten die Schalen, wenn sie zweckmässig gearbeitet waren, dauernd ohne Beschwerden getragen werden, und die dadurch beruflich und seelisch wesentlich geförderten Patienten nahmen dabei gerne eine nicht vollkommene Sehkorrektion hin, wenn eine solche aus irgend einem Grund nicht erreicht werden konnte." [...] "Die Müllersche Kontaktshale besteht aus einem skleralen und einem kornealen Teil. Wie bereits erwähnt, wird die Kontaktshale in allen Teilen - somit auch die Glaskornea - nur durch Blasen ohne jedes andere Formungsmittel als das Augenmass hergestellt. Nur die individuelle Geschicklichkeit des Künstlers beeinflusst und bedingt den Erfolg. Die Anfertigung geht also auf rein empirischem Weg vor sich." (Müller 1920, p. 12).
- 21 "Der Skeralteil der Schale - in Farbe und Aderung ähnlich der natürlichen Sklera - ist wie der einer Bulbus-Schalenprothese geformt : nasaler Teil schmal, oben innen Ausschnitt entsprechend der Trochlea, unten breit um der Schale eine Stütze in der unteren Übergangspalte zu geben, temporaler Teil lang, etwas spitz zulaufend. Die Wölbung, d.h. der Radius der Glassklera, ist für jeden Fall verschieden. Zwar ist die Form und Grösse der Bulbi durchschnittlich nicht sehr variabel, doch wird sie durch die sehr verschiedene Dicke der aufgelagerten Conjunctiva bulbi von Fall zu Fall wesentlich verändert, besonders nach dem Äquator des Bulbus hin. Die Kontaktshale muss aber, um gut zu passen und dauernd vertragen werden zu können, in allen Teilen dem Bulbus möglichst genau anliegen, ohne an irgend einer Stelle zu drücken. Nur dann - und dies ist der Grund, warum die Müllersche Kontaktshale dauernd und ohne Reizung getragen werden können - wird der Adhäsionsdruck zwischen Glasschale und Bulbus über einen grösseren Abschnitt des letzteren gleichmässig verteilt und es können keine Zirkulationsstörungen in der für die Ernährung der Kornea wichtigen zirkumkornealen Zone eintreten. Nur dann auch folgt die Schale den

Bewegungen des Bulbus und gewährleistet eine gleichmässige Sehkorrektion bei allen Blickrichtungen." (Müller 1920, p. 13).

22 Müller confirms on this occasion that Zeiss mistook Helmbold in confirming that the optical zone of blown Müller lenses could be ground. See chapter XV *Early Blown Contact Lenses*.

23 Müller 1920, p. 49-50. It concerns case # 18 (myopia with nystagmus), case # 19 : bilateral aphakia fitted with a shell with an integrated positive lens (eingearbeitete Pluslinse), without more precise details; and case # 20: corneal dystrophy and aphakia by an one-eyed, quoted by Grüter 1917.

24 "Auf Wunsch sandte mir Müller (Wiesbaden) 10 Keratokonuskontaktegläser. Zum Glück fand ich wohl rein zufällig darunter zwei, die das Sehvermögen beiderseits in überraschender Weise verbesserten." (Clausen 1920/a, p. 292).

25 Sitzchevska 1932, p 1053.

26 "In letzter Instanz kommt es bei der Bestimmung der Kontaktgläser eben doch auf das Probieren an, ähnlich wie bei der subjektiven Bestimmung der sphärischen Refraktion der keratokonusfreien Augen. Man probiert ein bestimmtes Kontaktglas, sieht durch Vorsetzen von sphärischen Plus- oder Minusgläsern, ob dasselbe zu schwach oder zu stark ist und sucht sich dann in seinem künftig genau nummerierten Kontaktglasbrillenkasten eine entsprechend stärker oder schwächere Nummer aus, bis das vollkorrigierte Glas gefunden ist". (Siegrist in his discussion of Eperon's communication, 1918, p. 461-462).

27 "Jedenfalls bleibt das Wichtigste immer die Wölbung der Vorderflächen des Kontaktglases, die hintere Fläche verliert sowieso an Wert, da sie durch Tränenflüssigkeit, die doch annähernd gleichen Brechungsindex besitzt, mit der Hornhautvorderfläche zu einem Ganzen zusammengeschmolzen wird." (Siegrist in discussion with Eperon, 1918, p 461).

28 "ich will lieber noch einmal meine sieben Kinder kriegen, als nur einen halben Tag so ein Ding tragen." (Schnaudigel 1922, p. 471).

29 "jedoch darf das Kontaktglas niemals der Kornea direkt aufliegen. Es muss unbedingt zwischen Glas und Kornea eine Schutzschicht, am besten aus Tränenflüssigkeit bestehend, vorhanden sein." (Clausen 1920/a p. 293).

30 "Der Raum zwischen Hornhaut und Hornhautschale des Kontaktglases füllt sich meist von selbst mit Tränenflüssigkeit." (Siegrist 1913/14, p. 411).

31 "Die Patientin war nicht wieder zu bewegen auf diesem Auge eine Kontaktshale zu tragen." (Clausen 1929, p. 112).

32 "Man kann jeden Patienten mit Leichtigkeit lehren, sein Kontaktglas selber einzuführen. In der Regel aber können die Patienten ihre Kontaktgläser nicht mehr ohne fremde Hilfe aus dem Konjunktivalsack entfernen." (Siegrist in discussion Eperon 1918, p. 462).

33 "ich möchte von Hippel beipflichten, wenn er den Keratokonus erst dann operativ angreifen will, nachdem die Prothesenbehandlung sich als nutzlos erwiesen hat." (Clausen 1920/a, p. 292).

34 For Helmbold 1913, see chapter XV: *Early Blown Contact Lenses*.

35 For example, the specimen of the thesis of F.E. Müller preserved at the library of the Ophthalmologic Clinic of Strasbourg has the notice "given by the author" (Überreicht vom Verfasser).

36 "Die Kontaktbrille stellt eine dünne Kugelkalotte aus Glas von etwa 8 mm Krümmungsradius mit parallelen Flächen und einem basalen Durchmesser gleich dem einer natürlichen Kornea dar." (F.E. Müller 1920, p. 6). - This error was unfortunately often recopied and accepted as intangible dogma by the majority of the historians of contact lenses – See chapter X: Adolf Eugen Fick's "Contactbrille".

37 "Zur gleichen Zeit wie Fick gab E. Kalt Versuche mit seinen 'verres de contact' bekannt; diese Gläser waren fast genau wie die Fickschen Kontaktbrillen geformt." (F.E. Müller 1920, p. 7). – See chapter XI: Eugène Kalt's "Optical Treatment" of Keratoconus.

38 „Sulzer nahm etwa 12 Jahre später die Versuche von Fick auf und liess Kontaktgläser aus einem Stück schleifen." (F.E. Müller 1920, p. 7). – See chapter XIII: *The Decades after the Invention*.

39 "Zur derselben Zeit wie Fick, konstruierte August Müller eine Hornhautlinse [...]. Diese Hornhautlinse war ähnlich angefertigt und geschliffen, wie Sulzers Kontaktgläser, nur waren die Grenzflächen der Glaskornea nicht parallel; die innere Fläche hatte einen Radius von 8 mm, die vordere einen von 10 mm." (F.E. Müller 1920, p. 7). – See chapter XII: August Müller's "Hornhautlinse".

40 In his translation of F.E. Müller's thesis, Nissel (1965) has also preserved Müller's spelling errors (e.g., "Sulcer" for Sulzer, "Isikara" for Ishihara, and so on). This error is very frequently repeated.