

Chapter 14

The Era of Hydrodiascopes

Introduction

Towards the end of the 19th century, contact lenses and contact shells (1) were relegated for a period to a subsidiary position by hydrodiascopes. This term was a shared designation for *Czermak's* orthoscope, so-called water cases, water chambers and water-filled goggles, all of the above being equipped with corrective lenses. (2)

In 1851, *Czermak* had achieved neutralization of corneal refractive power and elimination of the corneal reflex by contact of the eye with a liquid contained in a glass box. His "orthoscope" was originally intended for scientific use, but had been adapted for diagnostic use in the clinic by *Hasner* and by *Coccius*. The orthoscope could be tolerated by a patient for several minutes and facilitated the examination of the anterior segment of the eye. (3)

Czermak's publication would probably have passed by unnoticed, as had *Hasner's*, had not *Helmholz* revived interest in the orthoscope in his textbook on physiological optics successive editions (4), which had served as a textbook for generations of medical students and physicians. *Helmholz's* reference textbook included a detailed description of *Czermak's* orthoscope and was also illustrated with a copy of the diagram of this instrument. Furthermore, the orthoscope, as described by *Czermak*, remained an instrument for scientific use, notwithstanding various later modifications made by physicians for diagnostic purposes, e.g., by *Hasner*. Other modifications were also made for experiments with ocular fundus photography.

1 - Source documents

Year	Publication
1896	<i>Lohnstein (Berlin): "Zur Gläserbehandlung des unregelmässigen Hornhautastigmatismus" (Concerning the Treatment of Irregular Corneal Astigmatism by Glasses)</i>
1897	<i>Lohnstein (Berlin): "Die Berechnung der Planoconvex Linse des Hydrodiaskops" (Calculation of the Plano-convex Lens of the Hydrodiascope)</i>
1898/99	<i>Majewski (Krakow): "Ueber corriegierende Wirkung des Hydrodiaskops Lohnsteins in Fällen von Keratokonus und unregelmässigem Astigmatismus" (Concerning the Corrective Effect of Lohnstein's Hydrodiascope in Keratoconus and Irregular Astigmatism)</i>
1906	<i>Fater/Siegrist (Berne): "Hydrodiaskop und Keratokonus" (Hydrodiascope and Keratoconus)</i>

Table 14 - 1
Early communications and publications on hydrodiascopes (1896-1917).

In the course of the adaptation of the hydrodiascope for clinical use in the correction of keratoconus, several steps can be distinguished and these provide the framework for the source documents making up this chapter:

in 1896, *Lohnstein* described the hydrodiascope,
in 1898, *Majewski* adapted the hydrodiascope for binocular use,
from 1898 to 1916, *Siegrist* used the hydrodiascope for clinical purposes.

1.1 - Lohnstein's Hydrodiascopes (1896 -1897)

1.1.1 - First Description (1896)

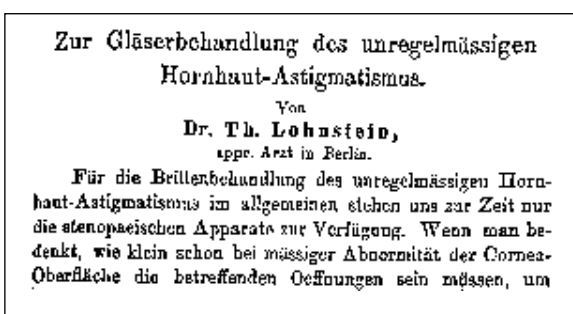


Figure 14-1
Title of Lohnstein's publication on the orthoscope.
Lohnstein's publication: "Zur Gläserbehandlung des unregelmässigen Hornhaut-Astigmatismus" (Concerning the Treatment of Irregular Corneal Astigmatism by Glasses). It is the first description of the therapeutic use in humans of a "water case" (Wasserkasten) equipped with a corrective lens.
(LOHNSTEIN Th., "Zur Gläserbehandlung des unregelmässigen Hornhaut-Astigmatismus", *Klinische Monatsblätter für Augenheilkunde*, 34, 1896, 405-420. - Page 405)

In 1896, the first description of the therapeutic use in humans of an orthoscope equipped with a corrective lens was not the work of an ophthalmologist but that of the general medical practitioner *Lohnstein* of Berlin, Germany. His published article had the innocuous and inoffensive title "**Zur Gläserbehandlung des unregelmässigen Hornhaut-Astigmatismus**" (Concerning the Treatment of Irregular Corneal Astigmatism by Glasses).

Lohnstein's Case History

Lohnstein was personally afflicted with bilateral keratoconus. The results of the operative procedures recommended at the time were extremely disappointing, whether cauterization of the corneal summit or optical iridectomy. *Lohnstein* noted also in his paper the flagrant contradiction between the success of the surgical techniques as proclaimed at the congresses and the sad reality. (5)

From Concept to Practical Realization

As a physician, *Lohnstein* recalled his practical studies in physiological optics while a medical student, notably those with *Czermak's* orthoscope. He had noted a temporary improvement in his visual acuity:

“Everybody knows how Thomas Young proved that the cornea did not participate in accommodation when he placed a water-filled vessel on his eye. Because the cornea has a refractive index similar to that of water and weak aqueous solutions, one must thus have very significantly reduced the influence of the irregular corneal curvature. Furthermore, several years earlier, I had established this with my left eye by using Czermak's orthoscope.”

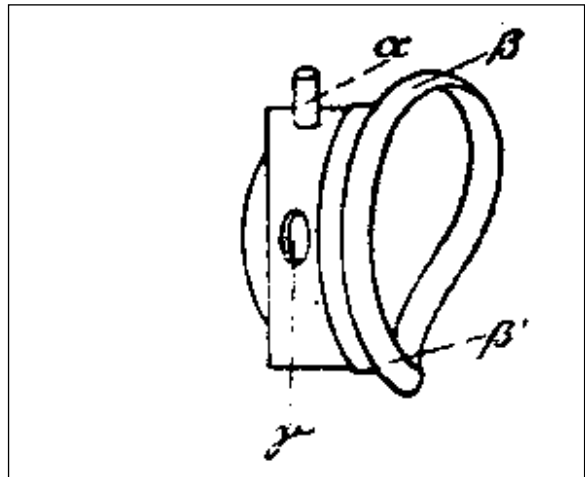


Figure 14-2
Lohnstein's hydrodiascope.
Schematic representation of the hydrodiascope constructed for Lohnstein by the optician E. Sydow (Berlin) in 1896. The hydrodiascope is fitted on the soft tissues of the orbital periphery.
α Filling tube,
β β' Soft rubber border,
Lateral fixation ring for ribbon tied behind head.
(LOHNSTEIN Th., "Zur Gläserbehandlung des unregelmässigen Hornhaut-Astigmatismus". *Klinische Monatsblätter für Augenheilkunde*, 34, 1896, 405-420. - Figure page 409).

“Bekanntlich hat Thomas Young die Nichtbeteiligung der Hornhaut bei der Accommodation dadurch bewiesen, dass er ein mit Wasser gefülltes Gefäss vor das Auge brachte. Da die Hornhaut in ihrem Brechungsindex vom Wasser und mässig concentrirten wässerigen Lösungen nicht viel verschieden ist, so muss man - was ich übrigens schon vor mehreren Jahren mit dem Czermak'schen Orthoskop an meinem linken Auge festgestellt hatte - in dieser Weise den Einfluss der unregelmässigen Hornhautkrümmung auf ein sehr geringes Maass herabsrücken können.” (6)

The challenge consisted in constructing a hollow frame and finding a liquid that the eye could tolerate for a lengthy period. *Lohnstein* approached *Sydow*, an optician in Berlin who was a supplier to the ophthalmological clinics, by which reason he had a collection of eyelid and orbital molds. Furthermore, he had already produced prosthetic frames from these models:

“I turned [...] to the well-known optician and mechanical engineer, Mr. Emil Sydow (Berlin N.W.), who was kind enough to place his experience and skills at my disposal. It worked out very conveniently that this individual was already in possession of a form of frame used for other orders from ophthalmologists that was sufficient for my requirements. My only remaining task was to determine the angle at which the lens should be inclined against the axis of the frame, as well as deciding on the depth of the frame and focal length of the lens.”

“Ich wandte mich [...] an den bekannten Optiker und Mechaniker Herrn Emil Sydow, Berlin NW., welcher mir in dankeswerther Weise seine bewährte Kraft zur Verfügung stellte. Es traf sich günstig, dass derselbe von anderen ophthalmologischen Aufgaben her bereits im Besitze einer Form der Fassung war, welche den zu stellenden Ansprüchen durchaus genügte. Meine Aufgabe bestand also nur darin, den Winkel zu bestimmen, in welchem die Linse gegen die Axe der Fassung geneigt sein musste (ca.20°), sowie nach Festsetzung der Tiefe der Fassung, die Brennweite der Linse zu bestimmen.” (7)

The optician furnished *Lohnstein* with a model similar to the closed orthoscope of *Hasner* and *Coccius*. This device consisted essentially of an oval monocular frame, the back edge of which was fitted, above and below, to the periphery of the eyelids, with the

temporal part wider than the nasal part. Soft rubber tubing covered the orbital border of the frame, providing a certain water-tightness when the device was forcibly applied against the skin. Two ribbons knotted behind the occipital protuberance held it there. Filling was achieved through an orifice pierced in the upper portion of the frame, above which there was a tube shut by an ebony stopper. The optician had set a plano-convex lens, tilted at 20 degrees with reference to the axis of the device with its plano-surface oriented towards the cornea.

The front convex surface of the hydrodiascope corresponded with the normal optics of an eye in the primary position, there being 15.00 mm of separation from the summit of the cornea to the back surface of the corrective lens. *Lohnstein* therefore chose a lens with a focal length of 37.50 mm and, for practical purposes, this gave him the expected visual correction. The visual improvement he achieved was accompanied by image enlargement through a magnifying loupe effect together with constriction of the visual field. A later improved model with the separation between cornea and corrective lens reduced to 10.00 mm and a larger diameter for the corrective lens remedied these undesirable features.

After five months of experimentation and the provision of a plano-convex lens of adequate power, *Lohnstein* obtained a visual acuity in his right eye that was sufficient for reading and for distance vision. The superposition of glasses with cylindrical lenses and the addition of a diaphragm of 3.50 mm in diameter produced an almost normal visual acuity for far and near vision.

Lohnstein, encouraged by these results in his first eye, went on to fit his more seriously affected left eye. The visual acuity in this eye progressed from 1/18 to 2/8 or even 1/2 if he added a plano-convex lens of 34.00-mm focal length. However, he noted the presence of cloudiness in the location corresponding to the corneal leucoma. Nevertheless, he was able to wear this device for periods of 30 to 90 minutes at a time and very occasionally reached two hours of wearing time.

Liquid used for Filling the Device

The choice of liquid for filling the device was the subject of considerable thought and the object of study in numerous trials. Physiological saline solution, at a temperature of 35 to 40 degrees, seemed the best tolerated of the available solutions and did not produce any irritation, whether the eye was open or closed at the time of filling. A cold solution was tolerated if one took the precaution of shutting the eyelids for several instants while waiting for the liquid to warm up. The temperature came into equilibrium after about an hour at 20° C, no matter whether it was poured in hot or cold:

“As far as the second point is concerned, i.e., the choice of liquid for filling the device, it is more or less self-evident that I adopted saline solution, warmed this up to between 35 and 40 degrees and then introduced it into the device. In doing this, there was no trace of irritation. Furthermore, it made no difference whether the eye was open or closed. Later on, I determined that cooler solutions were equally well tolerated, except that one has the same feeling as when cold water suddenly touches one’s skin. Furthermore, one can reduce the initial irritation to a minimum by keeping the eye shut for a fraction of a minute after the cold fluid contacts the upper lid. The liquid warms up at about 6° C an hour, as I determined through measurement, and thus the temperature rises from 20° to 26°. When the liquid reaches body temperature, it gradually cools down.”

“ Was den zweiten Punkt, die Wahl der Flüssigkeit anbetrifft, so erscheint es fast selbstverständlich, dass ich auf die physiologische Kochsalzlösung verfiel, die ich anfangs auf 35 bis 40° C erwärmt, in den Apparat brachte. Es erfolgt in der Tat keine Spur einer Reizung. Es ist hierbei sogar gleichgültig, ob das Auge bei der Einfüllung geschlossen ist oder nicht. Später stellte ich fest, dass kühlere Kochsalzlösungen genau ebenso gut vertragen werden, nur hat man im ersten Moment dasselbe Gefühl, das man hat, wenn kaltes Wasser plötzlich eine Hautstelle trifft. Uebrigens kann man den anfänglichen Reiz dadurch auf ein Minimum reducieren, dass man das Auge noch einen Bruchteil einer Minute, nachdem die kalte Flüssigkeit das obere Lid bespült, geschlossen hält. Die Flüssigkeit erwärmt sich, wie ich durch eine Messung feststellte, innerhalb einer Stunde um etwa 6° C, also von 20° auf 26°, während sie sich, bei Körpertemperatur eingebracht langsam abkühlt.” (8)

Lohnstein had tried saline solutions of various concentrations. Distilled water or strong saline solution was irritating. A saline solution of 0.85% seemed the best tolerated. Glucose solutions of up to 10% were well tolerated but had no advantage over saline solutions. The refractive index of the ideal solution would have to be close to that of the aqueous humor. Researching a solution of which the refractive index would be close to that of the cornea would require a 20% glucose solution. This would be intolerable and the beneficial effect illusory, as the optical power of a cornea is negligible when thinned by keratoconus.

Lohnstein noted Fick's error in claiming that a glucose solution of 2% possessed the same refractive index as the corneal tissues:

“Fick's statement that a 2% grape sugar solution had the same refractive index as cornea is therefore not valid. Only a 20% grape sugar solution could come close to the refractive power of the cornea.”

“Fick's Angabe, wonach eine 2% Traubenzuckerlösung die gleiche Brechung wie die Hornhaut hat, trifft also nicht zu. Erst eine etwa 20 %ige Traubenzuckerlösung dürfte an Brechkraft der Hornhaut gleichkommen.” (9)

The question regarding the toleration of the osmolarity of such a solution was also raised. The glucose solution would have to be isotonic with tears (310 mOsm/kg), and this was reached with a glucose solution of approximately 5.25% but not with a 2% solution (115 mOsm/kg).

Naming the Device

Lohnstein proposed to give his device the name “hydrodiascope,” this term being derived from *hydro* (water), *opsis* (to see) and *dia* (through):

“As everything requires a name, I must therefore be allowed to suggest the term ‘Hydrodiascope’ for my device, without attaching any special weight to this.”

“Da jedes Ding einen Namen haben muss, so möchte ich mir erlauben, für meinen Apparat die Bezeichnung ‘Hydrodiaskop’ vorzuschlagen, ohne indessen auf sie irgend welches Gewicht zu legen.” (10)

Comparison of the Hydrodiascope with Fick's “Contactbrille”

Lohnstein compared the properties of the hydrodiascope with those of Fick's “Contactbrille”. The two are based on the same principle of corneal optical neutralization through contact with water, in which a new refractive entity replaces the refractive power of the cornea that has been eliminated. However, according to Lohnstein, Fick's “Contactbrille” had the disadvantage of irritating both the eye and the

eyelids, as well as requiring assistance by another person to place these devices into the eye. *Lohnstein* insisted that he had never personally tried them out since they seemed to him to be too risky, especially with keratoconus, because the contact lens could touch the thinned corneal apex and cause ulceration:

“Optically, Fick’s ‘Contactbrille’ is based on the same principle as the hydrodiascope but has the disadvantage that it can be inserted into the eye only with the aid of another person and acts as a foreign body between the eyelid and eyeball. It may also produce inflammation in the latter. I state that I have never myself tried out the contact glass because it seemed too risky to me. Furthermore, this is especially true with keratoconus, in which the cornea is already markedly bowed forwards. This makes it especially unpleasant to wear a foreign body in front of the globe.”

“Optisch beruht Fick’s Contactbrille auf demselben Prinzip wie das Hydrodiaskop, hat aber den Nachtheil, dass sie nur mit Hilfe eines Zweiten angelegt werden kann und dass sie möglicherweise als ein Fremdkörper zwischen Lid und Bulbus einen Reiz auf den letzteren ausübt. Ich gestehe, dass ich selbst nie einen Versuch mit dem Contactglas gemacht habe, da mir die Sache zu riskant erschien ; übrigens scheint es mir gerade bei Keratoconus, wo die Cornea an sich schon stärker vorgewölbt ist, besonders unangenehm einen Fremdkörper vor dem Bulbus zu tragen.” (11)

Fick himself had tried out his “Contactbrille” only in one isolated case of keratoconus and the result was not encouraging. *Lohnstein* believed that a contact lens would not be tolerated by the eye any longer than a hydrodiascope.

Applications

Lohnstein finished by recommending applications other than the management of keratoconus for his hydrodiascope:

effecting optical correction of patients with irregular astigmatism would be easier than the correction of keratoconus and the result would be that much more beneficial because the cornea had a more regular thickness;

high myopes would profit from the visual correction and the enlargement of the image, though it was uncertain whether “the appropriate long-term use would arrest the development of myopia”; (12)

just as *Czermak’s* orthoscope, were the hydrodiascope to be used as a diagnostic device in the physician’s office, it could eliminate those corneal irregularities that interfere with the examination of the ocular media and fundus, thereby facilitating examination of retinal function. Above all, this could assist in making an early diagnosis in keratoconus in a situation, for example, where the diagnosis has not been made and a patient’s symptoms have either been underestimated or attributed to psychological problems. Within these limitations, the hydrodiascope would usefully replace *Czermak’s* orthoscope, which is not waterproof and therefore of limited practical usefulness.

In an addendum that was written in December 1896, in the interval between the submission of the paper and its publication, *Lohnstein* returns to the equipping of his second eye with the hydrodiascope. In this eye, the visual acuity was improved by combining high-powered cylindrical lenses with the hydrodiascope.

The reaction of ophthalmologists to the publication by this physician, who was not a specialist in ophthalmology, was quite muted and dwelt on such secondary points as the poor response of keratoconus to hyperbolic spectacles and *Fick’s* contact lenses.

1.1.2 - Modifications and Improvements to the Hydrodiaskope (1897)

In 1897, a year later, *Lohnstein* completed his research with the publication of a study on the optics of the corrective lens that needed to be placed on the front surface of the hydrodiaskope. In this article, entitled “*Die Berechnung der Planconvexlinse des Hydrodiaskops*” (*Calculation of the Plano-convex Lens of the Hydrodiaskope*), we learn that he has effectively pursued his promised studies on a new hydrodiaskope with the distance between the front corneal surface and the front wall of the hydrodiaskope reduced to 10.00 mm and fitted with a lens of 25.00 mm in diameter and a focal length ranging from 26.00 mm to 35.00 mm. This new model would provide a net enlargement of the visual field with reduced image magnification of 1.49. *Lohnstein* indicates that loss of elasticity and flattening of the rubber border reduces the axial depth of the hydrodiaskope by wear and that mild hypermetropia resulted, although this was easily compensated by accommodation. In another article, in response to criticism by *Fick*, *Lohnstein* mentions his interest in a hydrodiaskope that would be closed off by a plano lens and that would facilitate ophthalmoscopy:

Die Berechnung der Planconvexlinse des
Hydrodiaskops.
Von
Dr. Th. Lohnstein,
Berlin.

In meiner Mittheilung „Zur Gläserbehandlung des un-
regelmässigen Hornhautastigmatismus“ habe ich nur kurz
die Brennweiten der von mir benutzten des Hydrodiaskop-
vorne abschliessenden Planconvexlinsen angegeben. Genauer
auf die Berechnung einzugehen, hielt ich für unnöthig. In
der Annahme, dass jeder sich für den Gegenstand Inter-

Figure 14-3

*Supplement to Lohnstein's publication on his hydrodiaskope.
Lohnstein's publication: "Die Berechnung der Planconvexlinse des
Hydrodiaskops" (Calculation of the Plano-convex Lens of the
Hydrodiaskope) in which he completed his research with the
publication of a study on the optics of the corrective lens to be placed
on the anterior surface of the hydrodiaskope.*

(LOHNSTEIN Th., "Die Berechnung der Planconvexlinse des Hydrodiaskops" Klinische
Monatsblätter für Augenheilkunde, 35, 1897, 266-271. - Excerpt page 266)

“The hydrodiaskope possesses the advantage of being able to be used with a plano lens for ophthalmoscopy with an upright image. At maximum, two or three frames of different sizes at the most would be necessary, as the elastic rubber border easily adapts to the different shapes of orbital margin. Moreover, at the time of diagnostic examination, it does not matter much whether the device be hermetically sealed or not because the patient can lean on the instrument quite firmly during the brief time of examination”

“Das Hydrodiaskop hat den Vorteil, dass es mit einem Planglas in äusserst bequemer Weise zum Ophthalmoskopieren im aufrechten Bilde verwendet werden kann. Verschiedene Fassungen dürften höchstens 2 bis 3 benötigt werden, da der elastische Gummiring eine erhebliche Anpassungsfähigkeit an verschieden geformte Orbitaleingänge besitzt. Ueber dies kommt es bei diagnostischer Verwendung auf sehr dichten Schluss nicht an, da der Patient selbst während der kurzen Beobachtungszeit den Apparat ganz fest andrücken kann.” (13)

1.1.3 - The Lohnstein-Fick Controversies (1897)

Lohnstein also entered into a controversy with *Fick*. This is interesting from a historical point of view because of the descriptions given by *Fick* regarding the conduct of his experiments. (14) The controversy, as documented and following from one issue to the next, concerned essentially the respective advantages of the hydrodiaskope and contact lens for neutralization of corneal refractive power, correction of corneal anomalies and the type of solution used for filling the device.

For *Lohnstein*, an ideal saline solution for use with his hydrodiaskope would have a concentration of 0.85% to 0.90%. Concentrations stronger or weaker caused visual

clouding and the appearance of colored rings around lights, which he attributed to disturbances in osmotic pressure:

“Some time ago by mistake, I used a sodium chloride solution of only 0.45%. On another occasion, I used the same solution deliberately for experimental reasons. On each occasion, I experienced absolutely no burning sensation but rather the feeling of a peculiar and poorly localized pressure in the front of my eye. Then, an hour later, when I removed the hydrodiascope, I had a peculiar veil in front of the eye under consideration that I was easily able to distinguish from the indistinctness of the outside world caused by my diffusion images. This phenomenon disappeared in about 10 minutes. A flame, which I was observing during this time, showed weakly defined colored rings. There was thus true corneal clouding, which, furthermore, could not be objectively detected by one of my brothers, who was himself a medical doctor, and which, in any event, was minimal. I drew two conclusions from the experiment I describe: 1) that I am already in a position to detect very mild diffuse corneal disturbance of the cornea; 2) that such a disturbance of the corneal epithelium occurs because of water uptake by the corneal epithelium and consequently can be readily avoided through selection of the correct concentration of the fluid under consideration.”

“Als ich, einmal aus Versehen und ein anderes Mal experimenti causa, eine NaCl-Lösung von nur 0,45 % benutzte, empfand ich zwar noch kein Brennen, aber das Gefühl einer eigenthümlichen nicht näher zu lokalisierende Spannung vor dem Bulbus ; als ich das Hydrodiaskop nach einer Stunde absetzte, hatte ich einen eigenthümlichen Schleier vor dem betreffenden Auge, den ich sehr wohl von der durch meine Zerstreuungsbilder bewirkten Undeutlichkeit der Aussenwelt zu unterscheiden vermöchte, ein Phaenomen, das übrigens in etwa 10 Minuten abklang. Eine Flamme, die ich während der Zeit betrachtete, zeigte schwach angedeutete farbige Ringe. Das war also eine wirkliche Trübung der Hornhaut, die übrigens objektiv von einem meiner Brüder, einem Mediciner, nicht festgestellt werden konnte, jedenfalls also minimal war. Ich schliesse aus dem beschriebenen Experiment zweierlei: 1) dass ich schon eine sehr geringe diffuse Trübung der Hornhaut durch Selbstbeobachtung zu entdecken im Stande wäre; 2) dass eine solche Trübung durch osmotische Wasseraufnahme seitens der Hornhautepithelien zu Stande kommt, demnach durch richtige Wahl der Concentration der betreffenden Lösung mit Leichtigkeit vermieden werden kann.” (15)

In a footnote of the page the journal editor, Zehender, notes:

“Six or seven years ago, the editor of this journal carried out some experiments on the photography of the human fundus. In order to eliminate the disturbing corneal reflex, he used a hydrodiascope that was closed off by plano glass. [...] After removal of the device, the whole cornea appeared completely cloudy, to my not inconsiderable astonishment. The cloudiness quickly disappeared very shortly afterwards. This could only be explained as the result of edematous infiltration of the cornea in consequence of contact with the salt-free water.”

“ Vor etwa 6 oder 8 Jahren hat der Herausgeber dieser Zeitschrift sich mit dem Versuche beschäftigt, den Hintergrund des menschlichen Auges zu photographieren. Um den störenden Hornhautreflex zu beseitigen, wurde dabei ein mit physiologischer Kochsalzlösung gefülltes Hydrodiascop mit planparallelem Abschluss benutzt.[...]. Nach Abnahme des Apparates fand sich zu meinem nicht geringen Erstaunen die ganze Hornhaut vollständig trübe. Die Trübung verlor sich zwar bald wieder; sie konnte nicht anders als durch ödematöse Infiltration der Hornhaut in Folge des Contactes mit dem salzlosen Wasser erklärt werden. “ (16)

1. 2 - The Krakow Binocular Hydrodiastroscope (1898 - 1899)

About a year later, the idea of using *Lohnstein's* hydrodiastroscope for the correction of refractive errors was taken up again by *Majewski*, assistant to Professor *Wicherkiewicz* Ophthalmology Clinic of the University of Krakow. Experiments had been undertaken between March 13, 1898, and February 5, 1899, and were the subject of a preliminary publication by *Majewski* at the time of the inauguration of the new Ophthalmology Clinic (17). After completion, the article was published with the title **“Ueber corrigierende Wirkung des Hydrodiaskops Lohnsteins in Fällen von Keratoconus und unregelmässigem Astigmatismus”** (Concerning the Corrective Effect of *Lohnstein's* Hydrodiastroscope in Keratoconus and Irregular Astigmatism). The article describes how the author had connected two hydrodiascopes together and had thus obtained a form of ‘spectacles’ that guaranteed a binocular correction for him. *Majewski* used “silver alloy capsules” (Alphablech), an alloy consisting of nickel, copper and zinc that had a white color reminiscent of silver. The hydrodiastroscope capsules were fixed to the orbits with rubber drains of appropriate caliber that he set in a groove at the posterior border of the device. An adjustable copper thread, with a length determined from the inter-pupillary diameter, attached the capsules to each other. The choice of the diameter of the drain and the adjustment of the distance between the two capsules of these “water spectacles” (Wasserbrille) allowed the device to be fitted to every facial shape:

**Ueber corrigierende Wirkung des
Hydrodiaskops Lohnstein's in Fällen von Kera-
toconus und unregelmässigem Astigmatismus.**
(Aus der Universitäts-Augenklinik des Prof. Dr. B. Wicherkiewicz
in Krakau.)
Von
Dr. Casimir Vincenz Majewski,
klinischem Assistenten.
Die Leser dieser Zeitschrift sind wohl der regen Dis-
cussion, welche durch die Arbeit des Herrn Dr. Lohnstein¹⁾

Figure 14-4

Majewski's publication on the binocular hydrodiastroscope. *Majewski's* publication: “Ueber Corrigierende Wirkung des Hydrodiaskops Lohnsteins in Fällen von Keratoconus und unregelmässigem Astigmatismus” (Concerning the Corrective Effect of *Lohnstein's* Hydrodiastroscope in Keratoconus and Irregular Astigmatism). The article describes how the author had connected two hydrodiascopes together and had thus obtained a form of ‘spectacles’ for binocular correction.

(MAJEWSKI Casimir Vincenz, “Ueber corrigierende Wirkung des Hydrodiaskops Lohnsteins in Fällen von Keratoconus und unregelmässigem Astigmatismus”, *Klinische Monatsblätter für Augenheilkunde*, 37, 1899, 162-167 - Excerpt page 162)

“I have made use of two capsules made from a thin alloy (Alphablech) for my experiments. These capsules are joined to each other by means of a flexible copper wire in such a way that their separation and position relative to each other can be changed at will. The free border of each metal chamber is provided with a groove, into which one can press drainage tubing of various calibers. On the temporal side of each chamber, there is an eyelet through which a small band can be passed and tied behind the head. In this way, if you select a tube of appropriate size on the one hand and, on the other hand, bend the connecting wire and tie the small band just the right amount, you can finally use one and the same ‘Wasserbrille’ (water spectacles) to suit various shapes of orbit.”

“Ich habe mich bei meinen Experimenten zweier Kapseln aus dünnem Alphablech bedient. Diese Kapseln sind miteinander mittels eines nachgiebigen Kupferdrahtes verbunden, so dass man ihre Entfernung und gegenseitige Lage nach Belieben ändern kann. Der freie Rand jeder Blechkammer ist mit einer Rinne versehen, in welche man Drainröhrchen verschiedenen Kalibers hineinpressen kann. An jeder Kammer ist schläfenwärts eine Öse angebracht zum Durchführen eines Bändchens, welches am Hinterhaupte zusammengeschnürt wird. Auf diese Weise, indem man einerseits ein passendes Drainrohr wählt, andererseits den Verbindungsdraht zwecksmässig einbiegt und endlich das Bändchen mehr oder weniger stark zusammenschnürt, kann man eine und dieselbe “ Wasserbrille “ verschiedenartig gestalteten Augenhöhlen anpassen.” (18)

Majewski arranged to fix a plano-convex lens of +33.00 diopters and 27.00 mm in diameter to the front wall of the device. An opening in the top allowed instillation of approximately 15.00 cc of a solution of warm physiological saline. The total visual correction was obtained by superpositioning additional spectacles with spherical lenses that also allowed partial concealment of the device:

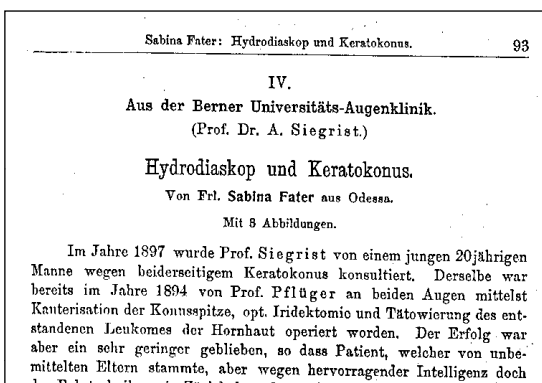
“In front, every metal alloy chamber has a circular opening (27 mm in diameter) that is closed off with a strong plano-convex lens (+33.00 D). The device, thus equipped, is then filled with lukewarm sterilized physiological salt solution through an opening set in the upper wall. After the device has been filled with water, the subject opens his eyes.”

“Vorn trägt jede Blechkammer eine runde Oeffnung (27 mm Durchmesser), welche mit einem starken planconvexen Glase (+33 D) abgeschlossen ist. Der auf diese Weise angepasste Apparat wird nachher mittels eines Tropfglases durch eine in obereer Wand angebrachte Oeffnung mit lauwarmen, steriliarter, physiologischer Kochsalzlösung gefüllt, in welcher der Untersuchte seine Augen öffnet.” (19)

Majewski confirmed the limits of wearing time as described by *Lohnstein* without however, providing the actual numerical results for the number of hours achieved. He described excellent visual results reached in 15 subjects (21 eyes): five with keratoconus, seven with irregular astigmatism complicated by corneal nebulae, five with unilateral aphakia and four with high astigmatism. Except for the last-mentioned, not one patient had been improved by lenses alone using cylindrical, hyperbolic or stenopeic glasses. He insisted, however, that he had not prescribed hydrodiascopes for everyday use.

In conclusion, *Majewski* recommended a series of improvements, e.g., by providing the shell with a plano lens and a groove into which corrective lenses would be slipped. *Lohnstein* had already described this idea that *Siegrist* was to take up again and put into practice in the years that followed:

“Instead of the powerful plano-convex lens (+33 D), I would recommend closing off the anterior opening of the device with a plano glass. In the lower half of this opening, a half-moon-shaped metal groove, in which the requisite plano-convex lens might be placed, could be connected with its flat surface obviously directed towards the glass plate. For this purpose, a series of plano-convex lenses (from +20 to +40 D) must be made available.”



“Statt der starken, planconvexen Linse (+33 D) möchte ich die vordere Oeffnung des Apparats mit planparallelen Glasscheiben absperren. Unterhalb dieser Oeffnung könnte man eine halbmondförmige Metallrinne anschliessen, in welche das eben nothwendige planconvexe Glas eingelegt würde, selbstverständlich mit der flachen Seite dem Glasscheibchen zugewendet. Zu diesem Zwecke müsste man über eine Reihe von planconvexen Linsen (von + 20 D bis + 40 D) verfügen.” (20)

Figure 14-5

Fater's publication concerning the Berne hydrodiaskope. Fater's publication: "Hydrodiaskop und Keratokonus" (Hydrodiaskope and Keratokonus) in which she presents the retrospective claims of Siegrist's first "water case" (Wasserkasten) (and new improvements for the hydrodiaskope.

(FATER Sabina, "Hydrodiaskop und Keratokonus", Klinische Monatsblätter für Augenheilkunde, 44, 1906, 93-109 - Excerpt page 93).

1.3 - The Berne Hydrodiascopes (1897-1906)

In 1906, *Fater*, an assistant at the University

Eye Clinic of Berne, published, at Professor *Siegrist's* urging, a significant paper and a "Inaugural-Dissertation" describing the refractive correction of patients with keratoconus. The title was "*Hydrodiascop und Keratoconus*" (*Hydrodiascope and Keratoconus*). According to *Siegrist's* retrospective claims, as documented by *Fater*, the experiments had commenced after 1897 and would therefore have been contemporaneous with those of *Lohnstein*.

1.3.1 - Siegrist's "Wasserkasten" (water case) (1897)

In 1897, *Siegrist* asked the optician *Strübin* of Basle (Switzerland), to construct a "water case" (Wasserkasten) that was inspired by *Czermak's* orthoscope for a young male patient with bilateral keratoconus. At this time, *Siegrist* was not aware of *Lohnstein's* publication and also ignored the papers of other earlier authors, notably those of *Hasner* (1851) and *Gerloff* (1891).

For the construction of the device, *Siegrist* provided *Strübin* with a plaster mold of the orbito-nasal region. The water-tight case had a depth of 15.00 mm, the distance from the front surface of cornea to the anterior wall of the device, and it was fitted outside the orbital margin with a strip of rubber. Its anterior wall was pierced by an orifice in front of which a convex lens of high power was mounted. This device was destined to permit a useful but very transient improvement in the patient's visual acuity.

1.3.2 - Siegrist's Hydrodiascopes (1898).

By the time at which the construction of the device was complete, *Siegrist* was aware of *Lohnstein's* publication. He arranged for *Sydow* of Berlin to deliver an original hydrodiascope, which was worn by the patient from March 1898 and which was better tolerated and produced a significantly better visual result than the earlier model. The Berlin hydrodiascope was equipped with

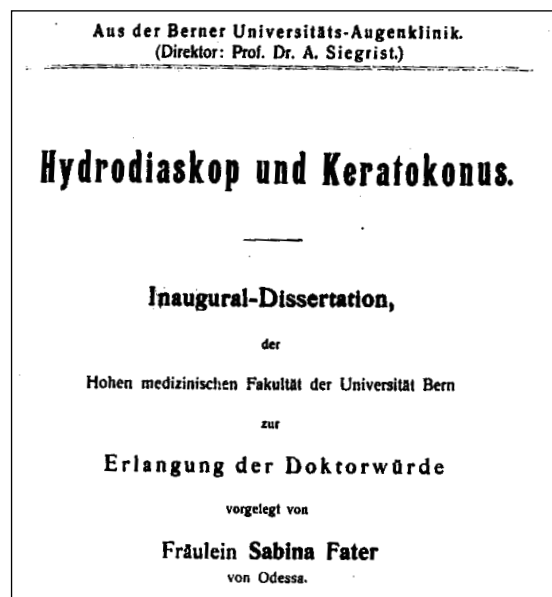


Figure 14-6
Fater's "Inaugural-Dissertation" concerning the Berne hydrodiascope.
Front page of Fater's "Inaugural-Dissertation" for M.D.: "Hydrodiaskop und Keratokonus" (*Hydrodiascope and Keratoconus*) in which she presents the retrospective claims of Siegrist's first "water case" (Wasserkasten) (and new improvements for the hydrodiascope).
(FATER Sabina, *Hydrodiascop und Keratokonus*, Inaugural-Dissertation Fakultät Bern, Hoffmann, Stuttgart, 1906)

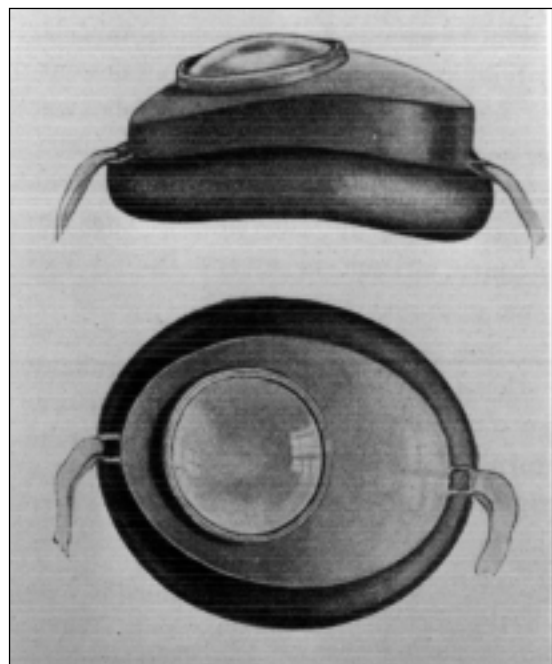


Figure 14-7
The prototype of the Berne hydrodiascope (1897).
Lateral and front views of the "water case" (Wasserkasten) constructed for Siegrist by Struebin, an optician in Basle. Modeled on Czermak's orthoscope, this container was applied outside the orbital rim to the face, thus explaining its broad dimensions:
30.00 mm in vertical diameter.
40.00 mm in horizontal diameter.
A 20.00-mm diameter plano convex lens is mounted on the front surface.
(FATER Sabina, "Hydrodiaskop und Keratokonus", *Klinische Monatsblätter für Augenheilkunde*, 44, 1906, 93-109 - Figure 1 page 94).

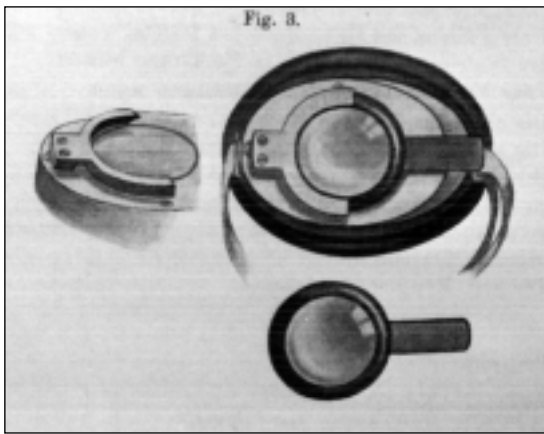


Figure 14-8

The first model of the Berne hydrodiascope.

Earliest version of Siegrist's modified hydrodiascope constructed by the Bischhausen Brothers, opticians in Berne. After taking into account Lohnstein's and Majewski's data, Siegrist reduced the size to 25.00 mm in vertical diameter and 35.00 mm in horizontal diameter. The front side is shut by a 15.00-mm plano glass, anterior to which a screw system allows a corrective plano-convex lens to be fixed to it.

(FATER Sabina, "Hydrodiaskop und Keratokonus" *Klinische Monatsblätter für Augenheilkunde*, 44, 1906, 93-109 - Figure 2 page 96).

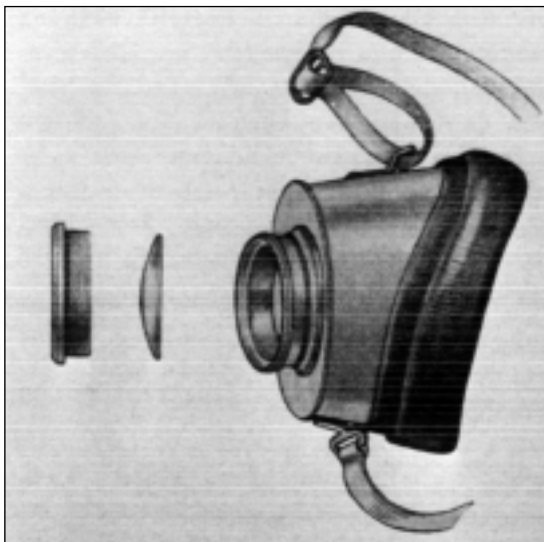


Figure 14-9

The second model of the Berne hydrodiascope.

Second version of Siegrist's modified hydrodiascope constructed by the Bischhausen Brothers, opticians in Berne. The dimensions remain unchanged relative to the previous model. The plano-convex lens is placed in a slide, allowing easier exchange and adaptation for far and near vision.

(FATER Sabina, "Hydrodiaskop und Keratokonus" *Klinische Monatsblätter für Augenheilkunde*, 44, 1906, 93-109 - Figure 3 page 97).

a +26.00 diopter lens. This could be supplemented by glasses for near vision and could be worn for up to eight hours per day, notwithstanding the disconcerting appearance that exposed the patient to jests from his fellow workers. Fater provided great detail regarding the history of this patient, a bank employee for whom successes alternated with failures up to the time of his suicide by hanging:

"The patient was so extraordinarily happy with his hydrodiascope that, without asking Professor Siegrist's advice, he became a bank employee where he carried out written assignments with the help of his 'Wasserkasten' (water case) 6-8 hours a day. Unfortunately, his previous state of depression could not be completely eliminated, this probably being exacerbated by the mocking of his female fellow worker, which the patient had to put up with on account of his odd-looking glasses. When, about six months later, as the result of a misunderstanding, he came to believe that his younger brother had passed away in another country, he committed suicide by hanging himself."

Patient war nun mit seinem Hydrodiaskop so ausserordentlich zufrieden, dass er, ohne Prof. Siegrist weiter zu fragen, als Angestellter in ein Bankgeschäft eintrat und dort täglich 6-8 Stunden schriftliche Arbeiten mit Hilfe seines Wasserkastens verrichtete. Leider konnte die einmal ausgebrochene Melancholie, welche noch neue Nahrung durch den Spott erhielt, welchen der Patient von seiner jüngeren Mitangestellten ob seiner eigentümlichen Brille zu ertragen hatte, nicht völlig gebannt werden. Als Patient ein halbes Jahr später aus Missverständnis glaubte, sein jüngerer Bruder sei im Ausland gestorben, machte er seinem Leben durch Erhängen ein Ende." (21)

The modifications in the hydrodiascope that were proposed by Lohnstein and Majewski led the way to perfecting a new generation of hydrodiascopes that were manufactured by the Berne opticians the *Bischhausen Brothers*. This device was closer to the eye, rested on the periphery of the eyelids and was equipped with a lens of smaller diameter. The lenses of the first models were fixed by a screw in front of a glass plate and could therefore be changed if necessary. In subsequent models, the corrective lens was able to slide within a groove, which made it both removable and interchangeable:

"To this end, plano glass only was riveted in the front wall of the device, onto which any

desired strong plano-convex lens could be screwed in on its plano side, or, as in Professor Siegrist's most recent modification of the hydrodiascope, could be set in a type of spectacle frame. It was thus also possible to unscrew a second convex lens positioned in front for close work and to replace it with little difficulty through an increase in power of the first plano-convex lens."

"Zu diesem Zwecke wurde in die vordere Wand des Apparates nur ein Planglas eingenetet, auf welches nun mittelbar ein beliebiges starkes Plankonvexglas mit seiner planen Seite aufgeschraubt oder wie in der neuesten Modifikation des Hydrodiaskopes von Prof. Siegrist ähnlich wie in ein Brillengestell aufgesetzt werden konnte. Auf diese Weise wurde es auch möglich, dass bei der Nahearbeit vorzusetzende zweite Konvexglas auszuschalten und dasselbe nun einfach ohne viel Mühe durch eine Verstärkung des ersten Plankonvexglases zu ersetzen." (22)

In the interface between the plate glass and the lens, diaphragms of various diameters could be interposed. The esthetic appearance of the device was improved by removing the filling pipes. The method of application was simplified: the liquid was poured directly into the hydrodiascope that was held horizontally, and then the eyes were submerged into the liquid before fixing the device at the occiput.

1.3.3 - Fater's Observations (1906)

The case reports described by *Fater* show considerable improvement in the visual acuities of patients affected by late-stage keratoconus, which was previously considered to be incurable. *Fater* deals at length with those questions that seemed to her to be fundamental for these devices, such as the composition of the liquid used for filling, image enlargement, and disturbances of accommodation.

The filling solution that was best tolerated and the one most popular at Berne was *Ringer's* solution (23). A 13.90% physiological saline solution, equivalent to tears, was intolerable in its sensation compared with saline solutions of 7.50% and 8.80%.

The enlargement of the retinal image due to the magnifying loupe effect resulting from the lengthening of the optical system was appreciated, studied and explained both for patients affected by keratoconus and for healthy persons who had tried out the hydrodiascope.

Lohnstein had previously described paresis or even apparent paralysis of accommodation while using the hydrodiascope. *Fater* confirmed the variable presence of accommodation, depending on age. The experiments, those carried out both on healthy persons (essentially physicians at the clinic) and on actual patients did not supply any consistent conclusions that would explain this phenomenon. It seemed, nevertheless, that accommodation was essentially lost with the deepest hydrodscopes, the lenses of which were furthest from the eye, and that the phenomenon varied proportionally with the length of the optical system (24).

The inevitable comparison of the hydrodscopes with the "*Fick-Sulzer* contact shells" (this was how *Siegrist* referred to them at the time) was significantly in favor of the hydrodscopes. This was because they could be worn for six to eight hours a day without ocular problems and always brought visual acuity back to normal. The patients tolerated the esthetic unsightliness of these devices because of the visual improvement that it gave them.

Fater concluded that the use of the hydrodiastroscope with improvements by *Siegrist* was really indicated for the correction of keratoconus. The modifications contributed by the Berne Clinic, especially the possibility of intercalating black paper diaphragms between the plano glass and the plano-convex lens also made it a useful device for research purposes:

“Based on the studies we performed, we can strongly recommend Lohnstein’s hydrodiastroscope. This is, as you know, Majewski’s modification both for the management of keratoconus and especially for measuring the range of accommodation in eyes affected by keratoconus. With an iris diaphragm consisting of black paper that can be interposed between the plate glass and plano-convex lens, as recommended in Professor Siegrist’s modification, the hydrodiastroscope represents a device that will certainly find application even in the most diverse of experimental studies.”

“Wir können also, gestützt auf die angeführten Untersuchungen, das Lohnsteinsche Hydrodiaskop, das ja eine Modifikation durch Majewski erfahren hat, sehr zur Behandlung des Keratokonus und speziell zur Bestimmung der Akkommodationsbreite bei Keratokonusaugen empfehlen. In der von Prof. Siegrist angegebenen Modifikation mit einschaltbaren Irisblenden aus schwarzem Papier zwischen Planglas und Plankonvexglas stellt das Hydrodiaskop einen Apparat dar, der sicherlich zu den verschiedensten experimentellen Untersuchungen noch wird Verwendung finden.” (25)

1.4 – Other Hydrodiastroscope Users

Year	Publication
1908	Lorenz (Leipzig) <i>"Ueber Keratokonus" (Concerning Keratokonus)</i>
1909	Terson (Paris) : <i>"Note sur la Pathogénie et le Traitement du Kératocône" (Note on the Pathogenesis and the Treatment of Keratoconus)</i>
1909	Lauber (Vienna): <i>"Randatrophie der Kornea mit hochgradiger Kerectasia peripherica" (Marginal Corneal Atrophy with Advanced Peripheral Corneal Ectasia)</i>
1909	Uthoff (Breslau): <i>"Ueber einen Fall von Keratokonus mit Sektionsbefund" (Concerning a Case of Keratokonus with Histopathologic Examination)</i>
1909	Parisotti (Rome) : <i>"Le Kératocône" (Keratoconus)</i>
1909	Antonelli (Naples) : <i>"Quelques Remarques sur le Traitement Optique du Kératocône" (Several Comments on the Optical Treatment of Keratoconus)</i>
1909	Wicherkiewicz (Krakow): <i>"Discussion" on Parisotti's report</i>
1923	Lauber & Kraemer (Vienna): <i>"Ueber die Maßnahme gegen Keratokonus mit besonderer Berücksichtigung der optischen Hilfsmittel, spez. der Hyperbolischen Gläser" (Concerning the Measures against Keratoconus with Particular Emphasis on Optical Means of Treatment, notably Hyperbolic Glasses)</i>

Table 14 - 2
Publications by hydrodiastroscope users (1908-1923).

After the landmark studies by *Siegrist*, the hydrodiastroscope had acquired “city rights” in ophthalmological practice, and other authors used it sporadically with more or less conviction and success even outside of German-speaking circles.

1.4.1 - Helmbold (1906 / 1913)

In 1913, *Rudolf Helmbold*, an ophthalmologist from Danzig (Germany), reports how a trial experiment was carried out at the Koenigsberg Eye Clinic in a patient affected by keratoconus. *Helmbold* demonstrated better visual acuity with the hydrodiastroscope than with spectacles equipped with stenopeic holes. (26)

1.4.2 - Lorenz (1908)

Case	Spectacle	Correction	Hydrodiascope	Correction
	OD	OS	OD	OS
1 (Lorenz) Self-observation	5/6	6/12	6/5	6/5
2	Counts Fingers at 3 meters	6/24	6/12	6/5
3	Counts Fingers at 3 meters	6/36	6/6	6/9
4	6/125	6/125	6/6	6/6
5	6/24	6/125	6/9	6/9

Table 14 - 3

Visual Improvement obtained with the hydrodiascope (Maria Lorenz, Inaugural Dissertation Leipzig, 1908)

On the April 30, 1908, *Maria Lorenz* presented her "Inaugural Dissertation" entitled "*Ueber den Keratoconus*" (Concerning Keratoconus) to the Faculty of Medicine in Leipzig. She did this on the initiative of Professor *Sattler*. She herself suffered from the same condition (keratoconus) and she noted improvement in her vision with the hydrodiascope. In her study, she emphasizes the need for the corrective lenses slipped in the front the instrument to be well centered. *Lorenz* describes the loss of accommodation due to the effect of the hydrodiascope. In her experience and in the experience of other patients, *Ringer* solution is better tolerated than 0.75% and 0.88% saline.

Lorenz concluded that, if there were no other alternative, the hydrodiascope constituted an excellent means for the optical correction of keratoconus:

"From the experience acquired on my own eyes with the hydrodiascope and in eyes affected by keratoconus that I have examined, it appears that there exists here an exceptionally suitable means for correcting keratoconus. Furthermore, the literature shows that there is no means other than the hydrodiascope to improve visual acuity in such an impressive manner or even to correct it completely. The hydrodiascope that I used has a depth of 1.5 cm, which is significantly too deep, and I think that if the customary depth of 1 cm could be further diminished, accommodation would be improved."

"Aus den an meinen eigenen Augen und an den übrigen von mir geprüften Keratoconusaugen mit dem Hydrodiaskop gemachten Erfahrungen erscheint mit dieses als ein außerordentlich gutes Korrektionsmittel für den Keratoconus, und aus der Literatur ist ersichtlich, dass es kein zweites Mittel gibt, das die Sehschärfe in dem Masse verbessert, oder sogar vollkommen korrigiert, wie es eben das Hydrodiaskop tut. Das von mir benutzte Hydrodiaskop besitzt eine Tiefe von 1,5 cm, das ist entschieden zu tief, und ich glaube auch, dass sich die sonst übliche Tiefe von 1 cm noch verringern ließe." (27)

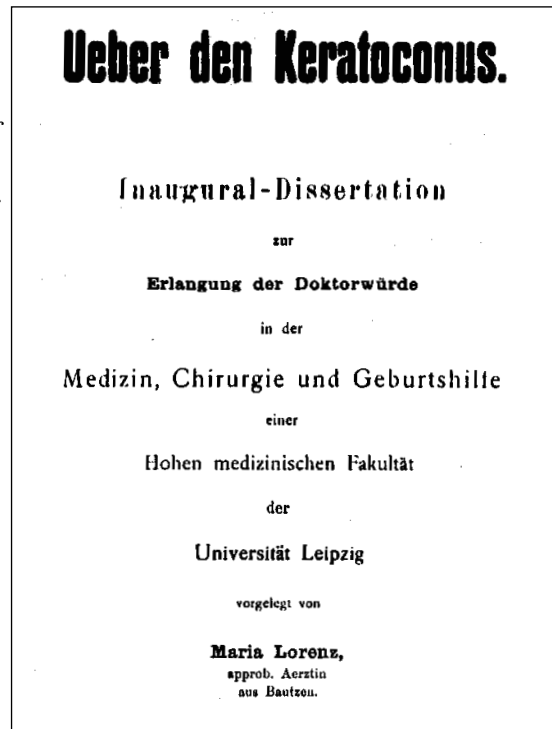


Figure 14-10

Title Page of Inaugural Dissertation "Ueber den Keratoconus" (Concerning Keratoconus) by Maria Lorenz (1908)

In April 1908, *Maria Lorenz*, herself afflicted with keratoconus, defended her "Inaugural dissertation" to the Faculty of Medicine in Leipzig. In her dissertation, she describes the optical correction of this condition by the hydrodiascope.

(LORENZ Maria, Ueber den Keratoconus, Inaugural-Dissertation Fakultät Leipzig, B. Georgi, Leipzig, 1908)

1.4.3 - Terson (1909)

In 1909, *Terson*, a French ophthalmologist, makes no reference to any personal experience with hydrodiascope, but in a “*Note sur la Pathogénie et le Traitement du Kératocône*” (*Note on the Pathogenesis and Treatment of Keratoconus*) he mentions: “*Contact lenses and the hydrodiascope are prostheses to be tried systematically.*” (28)

1.4.4 - Lauber (1909)

On May 12, 1909, *H. Lauber* presented a male patient at the *Vienna Ophthalmological Society*, whose hydrodiascope improved the visual acuity of an eye affected by advanced peripheral corneal ectasia and marginal corneal ectasia associated with pronounced myopia:

“Lauber presented a 64-year-old male with bilateral peripheral corneal atrophy and advanced peripheral corneal ectasia. The consequence of this condition was myopic astigmatism of high degree with reduction of visual acuity to 1/80. However, using the hydrodiascope produced a 2/3 rise in visual acuity.”

“Lauber stellt einen 64 jährigen Mann vor mit beiderseitiger Randatrophie der Kornea und hochgradiger Keratectasia peripherica. Die Folge davon war ein hochgradiger myopischer Astigmatismus mit Herabsetzung der Sehschärfe auf 1/80. Mit dem Hydrodiaskop jedoch liess sich die Sehschärfe auf 2/3 heben.” (29)

1.4.5 - Uthhoff (1909)

In 1909, in an article entitled “*Ueber einen Fall von Keratokonus mit Sektionsbefund*” (*Concerning a Case of Keratoconus with Histopathological Examination*), *Uthhoff*, of the *University Eye Clinic of Breslau*, Germany, presented corneal histopathology in a patient from whom this tissue had been excised by reason of keratoconus. He included some more general comments on the correction of keratoconus with the clinical history of the patient. He expressed his disappointment with the glass-blown contact shells of the *Müller Brothers* of Wiesbaden, described his interest in stenopeic glasses, and expressed surprise at the visual improvement right up to normal vision obtained with a hydrodiascope. Patients were able to wear the device for several hours when they used *Ringer's* solution. In spite of that, the hydrodiascope was useful only for short periods and in a single eye:

“A proportion of the cases showed a surprisingly great improvement in visual acuity (of up to a visual acuity of 1) as the result of the application of Lohnstein's hydrodiascope. Furthermore, the correction was relatively well tolerated for hours at a time because of the employment of Ringer's solution. And, yet, this accessory device can be considered usable only for short periods of time. Besides, we have in our possession up to this time no practically useful hydrodiascope such as could be used for both eyes simultaneously in the same way as a pair of spectacles. In unilateral keratoconus, with a healthy second eye, the correction of the cone does not have any great importance. If, however, the patient is dependent on only one eye only and that eye is affected by keratoconus, then this method of treatment can occasionally render great service.”

“Ueberraschend war in einem Teil der Fälle die Verbesserung der Sehschärfe (bis zu S = 1) durch Verwendung des Lohnsteinschen Hydrodiaskops, auch wurde unter Verwendung der Ringerschen Lösung

diese Korrektion stundenlang vom Auge relativ gut vertragen, doch kann dieses Hilfsmittel auch nur als temporär benützbare angesehen werden. Übrigens besitzen wir bisher keine praktische verwendbare derartige hydrodiaskopische Vorrichtung für beide Augen gleichzeitig, welche etwa im Sinne einer Brille benützt werden könnte; Bei einseitigem Keratokonus aber und bei gesundem zweiten Auge hat die Konuskorrektion keine grosse Bedeutung; ist aber ein Kranker lediglich auf ein Auge mit konischer Hornhaut angewiesen, so kann ihm gelegentlich mit dieser Methode ein grosser Dienst geleistet werden.” (30)

1.4.6 - Parisotti (1909)

In 1909, *Parisotti*, Professor of Ophthalmology in Rome (Italy), was commissioned to present the annual report to the *French Society of Ophthalmology* on the subject “**Le Kératocône**” (*The Keratoconus*). *Parisotti* noted that the hydrodiascope allowed effective optical correction of patients with keratoconus but that the device still had to be perfected, towards which end “clinicians in Germany and Switzerland were currently striving”. His presentation is a collection of stereotypes without relationship to historical facts.

“In a more recent times, Lohnstein has recommended a contact lens with interposition of liquid, which he has named hydrodioscope [sic]. He described his device in the December 1896 issue of the Klinische Monatsblätter für Augenheilkunde. He conceived it for a case of irregular astigmatism. But it is very easy to understand that he has ended up using it for keratoconus. [...]. In order to achieve this goal, Lohnstein uses his device to surround the whole anterior portion of the eye with liquid and replaces the static corneal and anterior chamber refraction with a plano-convex lens consisting of the anterior surface of the liquid chamber of the device. [...]

This spectacle is worn like any ordinary spectacle, by means of a ribbon tied behind the head and a rubber border that adapts perfectly to the orbital margins and prevents the loss of liquid. The lukewarm liquid is poured into the device through a small filling tube. [...]. The need for further improvements is quite apparent because it is clearly the most rational approach that has been conceived up to the present time. The advantages that Majewski and other clinicians in Germany and Switzerland recognized in this approach need not surprise us. Miss Sabine Jater [sic], from Odessa, has suggested an improvement in the construction of the hydrodiascope.”

“A une époque encore plus récente, Lohnstein a conseillé un verre de contact avec interposition du liquide qu’il a appelé hydrodioscope (sic). Il a décrit son appareil dans le numéro de décembre 1896 du Klinische Monatsblätter für Augenheilkunde. Il l’a imaginé à vrai dire pour un cas d’astigmatisme irrégulier. Mais il est bien facile de comprendre qu’il en soit venu à l’utiliser pour le k ratoc ne. [...]. Pour atteindre ce but, Lohnstein entoure de liquide au moyen de son appareil toute la partie ant rieure de l’ il, et remplace la r fraction statique de la corn e et de la chambre ant rieure par un verre plan-convexe qui forme la face ant rieure de sa chambre   liquide.

Cette lunette se porte comme une lunette ordinaire, par un ruban qui se noue derri re la t te, et un rebord en caoutchouc s’adaptant parfaitement aux bords orbitaires, de mani re   emp cher la sortie du liquide. Celui-ci est vers  ti de dans un petit tube d’introduction. [...] Le besoin de perfectionnements nouveaux se fait grandement sentir, car il est certain que c’est l  le moyen le plus rationnel qu’on ait imagin  jusqu’  pr sent ; les avantages que lui reconnaissent Majewski et d’autres cliniciens de l’Allemagne et de la Suisse ne doivent pas nous  tonner. Mlle Sabine Jater (sic), d’Odessa, a propos  une am lioration dans la construction de l’hydrodioscope.” (31)

From the 23 contributors to the discussions that followed this presentation, only two expressed an opinion on the hydrodiascope, *Antonelli* and *Wicherkiewicz*

1.4.7 - Antonelli (1909)

At the time of the discussion of *Parisotti's* report, *Antonelli* gave a paper describing the last model of the Berne hydrodiascope in which he documented its faults: its lack of cleanliness, its deficient water-tightness, the escape of liquid through the lacrimal passages and the blurriness of the vision. He concluded that, unlike *Sulzer's* contact lenses, the hydrodiascope had reached a stage of development beyond which it could not be perfected and that patient acceptance was problematical. In the same year, he published his own contribution under the title "***Quelques remarques sur le traitement optique du k ratoc ne***" (*Several Comments on the Optical Treatment of Keratoconus*):

"I have demonstrated in the course of the observation reported a moment ago how useful contact lenses can be, in that they are perfectly tolerated and give absolutely normal visual acuity back to the patient. I would not be able to say as much for Lohnstein's hydrodiascope. Thanks to the cooperation of the manufacturers (the Bischhausen brothers, Opticians in Berne), I was able to demonstrate Siegrist's modified instrument before the Congress, such as is described in the thesis of his pupil, Miss Sabine Fater. I have tried it out a sufficient number of times to be able to say that I feel a certain repugnance to sticking the eye into a liquid-filled device that is difficult to clean satisfactorily and of which the water-tightness is necessarily imperfect. Furthermore, the movements of the facial muscles are sufficient to disrupt the water-tightness and to allow the liquid to run down the cheek and, unless there is obstruction of the lacrimal system, this eyebath causes a flow of fluid down the nose that is most disturbing. Finally, the considerable distance between the plano-convex lens and the retinal screen makes the point of sharpest focus particularly delicate and variable. [...] It is sufficient to state the opinion that the hydrodiascope will be difficult to accept as a veritable means of managing patients suffering from keratoconus and that, following the same logical development of ideas, one can claim for contact lenses only a really practical application."

"J'ai montr  au cours de l'observation rapport e tout   l'heure, combien les verres de contact peuvent  tre utiles,  tant parfaitement support s et redonnant une vision absolument normale. Je ne saurais en dire autant de l'hydrodiascope de Lohnstein. Gr ce   l'obligeance des constructeurs, les fr res Bischhausen, opticiens   Berne, j'ai pu montrer au Congr s le mod le de l'instrument modifi  par Siegrist, tel qu'il est d crit dans la th se de Mlle Sabine Fater, son  l ve. Je l'ai suffisamment essay , pour pouvoir dire qu'il y a une certaine r pugnance   plonger son  il dans un liquide qui baigne un objet difficile   nettoyer id alement; que l' tanch it  ne peut pas  tre parfaite, et, du reste, les mouvements des muscles de la face suffisent   la troubler et   laisser couler le liquide sur la joue; qu'  moins d'obstruction lacrymale, ce bain oculaire donne un  coulement nasal des plus g nant ; qu'  enfin la distance consid rable entre le verre plan-convexe et l' cran r tinien rend la mise au point particuli rement d licate et variable. [...] C'est assez pour affirmer que l'hydrodiascope sera difficilement accept  comme un v ritable moyen de soulagement pour les malades de k ratoc ne, et que, dans le m me ordre d'id es, seuls les verres de contact peuvent pr tendre   une application vraiment pratique." (32)

1.4.8 - Wicherkiewicz (1909)

Wicherkiewicz recalled finally that after 1898 the hydrodiascope had produced significant improvements in visual acuity in the hands of his former assistant, *Majewski*: "*Lohnstein's hydrodiascope as perfected by my former assistant, Professor Majewski, considerably improves the visual acuity up to 6/10 or even 8/10.*" (33)

1.4.9 - Lauber - Krämer (1923)

Many years later, in June 1923, the hydrodiascope was recalled once again to mind by two Viennese ophthalmologists, *Krämer* and *Lauber*, during a discussion at the *Viennese Ophthalmological Society*. The former strongly recommended the return to hyperbolic spectacle lenses, the manufacture of which had been discontinued, whereas *Lauber* made the comment “that he recommended the hydrodiascope above all to demonstrate to patients how much could be achieved by appropriate therapy for this eye disease”. This recommendation caused *Krämer* to express the following reservations: “*It seems risky to me to wish to demonstrate to the patient by means of the hydrodiascope how well he is going to see after the operation because the results of the operation were far from being satisfactory and the fact that the numerous failures were usually not published in the literature*”. (34)

1.4.10 - Krämer (1923)

Some time after that, *Krämer* published his lecture entitled: “**Über die Maßnahme gegen Keratokonus mit besonderer Berücksichtigung der optischen Hilfsmittel, spez. der hyperbolischen Gläser**” (*Concerning the measures against keratoconus with particular emphasis on optical means of treatment, notably hyperbolic glasses*). In his plea for hyperbolic spectacle glasses, *Krämer* gave a glowing description of the favorable results obtained with the hydrodiascope:

“*We have already seen that no other method can measure up to the hydrodiascope, as far as optical effectiveness is concerned. This water chamber, placed in front of the eye, completely eliminated corneal refractive power while producing ‘an underwater eye’ and was applied by Lohnstein for his own use in the year 1896. It was also invented independently by Siegrist a year later. [...] Unfortunately, because of its impossible shape, the use of this wonderful device is limited to the ‘charity room,’ and only in desperate situations will a patient come to the point of using it on himself in public.*”

“*Wir haben schon erkannt, daß sich kein anderes Mittel an optischer Wirksamkeit mit dem Hydrodiaskop messen kann. Dieser vor das Auge zu setzende Wasserkasten, der die Hornhautrefraktion vollständig ausschaltet, indem er ein « Auge unter Wasser » erzeugt, wurde im Jahre 1896 von Lohnstein zu eigenem Gebrauch erdacht, ein Jahr später von Siegrist selbständig gefunden. [...] Leider bleibt aber dieses glänzende Hilfsmittel wegen seiner unmöglichen Form auf die Arbeit in camera caritatis beschränkt und nur in ganz verzweifelten Fällen wird ein Kranker dahin zu bringen sein, sich seiner öffentlich zu bedienen.*” (35)

1. 5 – The Hydrodiascope: a Bygone Evolutionary Step in the Optical Correction of Keratoconus

Year	Publication
1916	<i>Siegrist (Berne) "Die Behandlung des Keratokonus" (The Treatment of Keratoconus)</i>
1917	<i>Lüdemann (Berne) "Hydrodiaskop oder Kontaktglas zur Korrektur des Keratokonus" (Hydrodiascope or Contact Glass for the Correction of Keratoconus)</i>

Table 14 - 4
Last publications on hydrodiascopes (1916-1917).

1.5.1 - Siegrist (1916)



Figure 14-11

Illustration describing the esthetic superiority of the Müller brothers' blown contact shells with respect to the hydrodiascope.

Patient suffering from keratoconus.

On the right: with Siegrist hydrodiascope.

On the left: with a blown Müller Brother's contact shell (worn in the right eye).

(SIEGRIST August, "Die Behandlung des Keratokonus", Klinische Monatsblätter für Augenheilkunde, 56, 1916, 400-421 - Figure 8 & 9 of pages 414 & 415).

(Figures 14 – 11 & 14 - 12)

In 1916, Siegrist provided a new and comprehensive account of the modern treatment of keratoconus under the title "*Die Behandlung des Keratokonus*" (*The Treatment of Keratoconus*). In his 21-page article, he reviews the theoretical arguments regarding the etiology of the trophic corneal defects responsible for keratoconus and enumerates the various optical methods for correcting keratoconus available at the time:

hyperbolic and conical lenses that were practically useless for visual improvement in the cases studied, the blown contact lenses used by Fick, as well as the ground contact

lenses used by August Müller and Sulzer, but which no optician is able to produce on a large scale,

finally, the hydrodiascopes, regarding which he quotes Lohnstein's publications and also those of Majewski and Fater, the latter being directly inspired by her own studies at the Berne Eye Clinic.

It turns out that the improved Berne hydrodiascope easily normalizes the visual acuity of nearly all patients affected by keratoconus. It can be worn without exception for 6 to 8 hours a day without producing lesions or significant ocular symptoms. The unsightly appearance of the patient is the main disadvantage, which, however, is tolerated with difficulty and resignation in the absence of any therapeutic alternative:

"Like Lohnstein, I too discovered that the visual acuity of nearly all keratoconus patients can be easily raised to normal through the use of this water case. [...] It has also been demonstrated that these hydrodiascopes can easily be worn for 6 to 8 hours using physiological saline solution or Ringer solution without damage to or inflammatory reactions in the ocular globe. Ringer's solution proved itself to be the best."

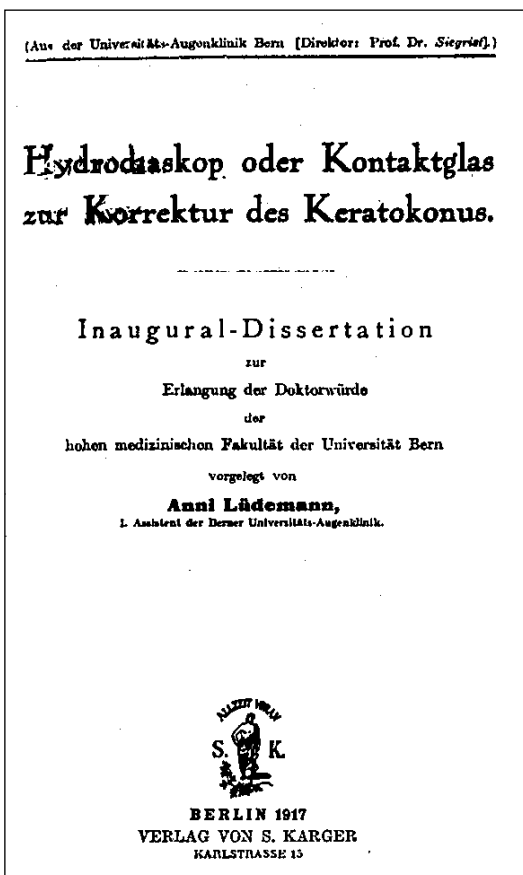


Figure 14-12

Title Page of Inaugural Dissertation "Hydrodiaskop oder Kontaktglas zur Korrektur des Keratokonus" (Hydrodiascope or Contact Glass for the Correction of Keratoconus), by Anni Lüdemann (1917).

In his "Inaugural-Dissertation", Anni Lüdemann published the results of an experimental comparison of successive fitting of a hydrodiascope and a Müller Brothers contact shell in ten patients with keratoconus.

(LÜDEMANN Anni, Hydrodiaskop oder Kontaktglas zur Korrektur des Keratokonus, Inaugural-Dissertation Fakultät Bern, S. Karger, Berlin 1917).

“Wie Lohnstein, so fand auch ich, dass durch diesen Wasserkasten die Sehschärfe fast aller Keratokonuspatienten ohne Schwierigkeit zur Norm erhöht werden kann. [...]. Es hat sich auch gezeigt, dass diese Hydrodiaskope mit physiologischer Kochsalzlösung oder mit Ringerscher Lösung mit Leichtigkeit 6-8 Stunden getragen werden können ohne Schädigung oder Reizungen des Augapfels. Am besten hat sich die Ringersche Lösung bewährt.“ (36)

And further on:

“It cannot be denied that the hydrodiascope possesses a great advantage when compared with the Fick-Sulzer contact glasses, namely the advantage that this device can be worn without exception for 6-8 hours daily without lesions or significant disturbance to the eye and that it almost always brings grossly reduced visual acuity back to normal. The major disadvantage of the hydrodiascope lies in the disfigurement of its wearer. If one considers that there is no other means for a patient with bilateral keratoconus to raise his reduced visual acuity significantly, one has to conclude that the majority of keratoconus patients accept the price of this disadvantage but with no pleasure and a heavy heart.”

“Es ist nicht zu leugnen, dass das Hydrodiaskop im Gegensatz zu den Fick-Sulzerschen Kontaktgläsern einen grossen Vorteil aufweist, nämlich den Vorteil, dass dieser Apparat ausnahmslos nach einer gewissen Uebung täglich 6-8 Stunden ohne Schädigung oder wesentliche Belästigung des Auges getragen werden kann und dass er fast immer die hochgradig verminderte Sehschärfe zur Norm zurückführt. Der Hauptnachteil des Hydrodiaskops beruht in der Entstellung seines Trägers. Wenn man bedenkt, dass es für einen beidseitigen Keratokonuspatienten kein anderes Mittel gibt, seine meist stark verminderte Sehkraft wesentlich zu heben, so begreift man, dass dieser Nachteil von den meisten Keratokonuspatienten, wenn auch ungern und mit schwerem Herzen, in den Kauf genommen wird.“ (37)

However, for a short time, Siegrist used the glass-blown contact shells, namely the “Kontaktadhäsionsbrille” (adhesion-contact-spectacles) (38) of the ophthalmologists Müller Brothers of Wiesbaden. These were significantly superior to ground contact lenses of Sulzer. The experiments with these new contact lenses, described in detail by Siegrist, gave such conclusive results, as much by their good toleration as by their duration of wearing time reaching 9 to 10 hours, that it was necessary to admit that the hydrodiascope epoch was definitely a thing of the past:

“I am convinced that these modern contact glasses will make the hydrodiascope totally unimportant and dispensable, as it represents only one step in our attempts to perfect our optical devices against keratoconus.”

“Diese moderne Kontaktgläser werden nach meiner Ueberzeugung das Hydrodiaskop, welches nur eine Stufe in der Vervollkommnungsbestrebung unserer optischen Hilfsmittel gegen Keratokonus darstellt, vollkommen unnötig und entbehrlich machen.“ (39)

1.5.2 - Lüdemann (1917)

In 1917, the following year, the matter was again revisited, this time by

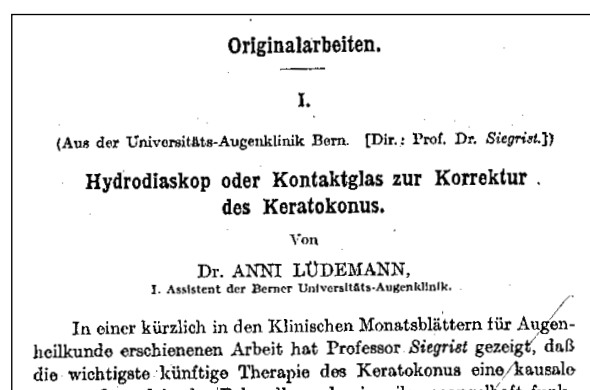


Figure 14-13

Publication of a comparison between the hydrodiascope and the Müller Brothers' contact shells.

In this study entitled "Hydrodiaskop oder Kontaktglas zur Korrektur des Keratokonus" (Hydrodiascope or Contact Glass for the Correction of Keratoconus Anni Ludeman, of the Berne Eye Clinic published the results of an experimental comparison of successive fitting of a hydrodiascope and a Müller Brothers contact shell in ten patients with keratoconus.

(LÜDEMANN Anni, "Hydrodiaskop oder Kontaktglas zur Korrektur des Keratokonus", Zeitschrift für Augenheilkunde, 36, 1917, 267-289. - Excerpt of page 267).

Lüdemann, Siegrist's first assistant at the *Berne Eye Clinic*, under the title "**Hydrodiaskop oder Kontaktglas zur Korrektur des Keratokonus**" (*Hydrodiastroscope or Contact Glass for the Correction of Keratoconus*). In this new study, as "Inaugural-Dissertation" and as a journal article, the Berne Clinic assistant published the results of an experimental comparison of the successive fitting of these devices, hydrodiastroscope and contact lens, in ten keratoconus patients.

According to this article, the hydrodiascopes had the advantage of excellent optical correction and all the patients achieved 20/20 or better. The magnifying loupe effect causing enlargement of the images was often an appreciable advantage:

"The principal advantage of the hydrodiastroscope is [...] the excellent correction of the refractive error and the resultant normalization of visual acuity. This result can be achieved only by using the hydrodiastroscope to place in position without difficulty a spherical non-astigmatic cornea of precisely the correct power."

"Der Hauptvorteil des Hydrodiaskopes ist, [...] die vorzügliche Korrektur des optischen Fehlers und die hierdurch erzielte Normalisierung der Sehschärfe. Dieses Resultat kann nur dadurch erreicht werden, daß es eben beim Hydrodiaskop möglich ist, eine sphärische nicht astigmatische Hornhaut von ganz beliebiger Brechkraft ohne Schwierigkeiten einzusetzen." (40)

The major disadvantages of the hydrodiascopes were the necessity of large quantities of saline solution for positioning them and the unsightliness that wearing them entailed. Even if this imposition was reduced with later models, it constituted a handicap for social life. Finally, certain patients complained of disturbances of accommodation:

"The disadvantages of the hydrodiastroscope are not insignificant. Above all, the positioning of the hydrodiastroscope always requires a certain quantity of saline solution, besides significantly disfiguring the person concerned much more than all other spectacle glasses. Thirdly, accommodative power is much impaired by wearing the hydrodiastroscope."

"Die Nachteile des Hydrodiaskopes sind nicht unbedeutend. Vor allem erfordert das Aufsetzen der Hydrodiaskopes stets eine gewisse Menge von physiol. Kochsalzlösung, ferner entstellt der Apparat den betreffenden Menschen ganz bedeutend, viel mehr als alle andere Brillengläser, drittens kommt beim Tragen des Hydrodiaskopes die Akkommodation nur noch ganz ungenügend zur Geltung." (41)

The blown contact shells of the *Müller Brothers* had the important esthetic advantage of being invisible. They still had the relative disadvantage of the insufficiency of the optical correction that was significantly inferior to that obtained with the hydrodiastroscope. Subjective symptoms limited the wearing time of contact lenses, even if certain patients reached records of 8 to 10 hours. The need for an assistant to put the contact shells in and to remove them was also noted. In comparing the two methods of correction, the author arrived at the conclusion that he had to decide in favor of the *Müller Brothers'* contact shells from now on: *"A nicely fitted contact glass can be worn in the human eye for hours and even for days at a time without disturbance or with only very minor irritation."* (42) Such was the end of the era of the hydrodiascopes.

2 - Discussion

The hydrodiascopes were in use only for a period of about twenty years and this occurred principally at Berne. One can justifiably wonder what caused their relative unsuccessfulness in spite of their having been shown to possess a certain technical, physiological and optical value.

2. 1 – Technical aspects

Lohnstein's Model

Lohnstein deserves the credit for having adapted *Czermak's* orthoscope for the optical correction of keratoconus. There is no doubt that *Lohnstein's* hydrodiascope was primitive, having an appearance and filling attachments that were hardly attractive. *Lohnstein* dared to do something that no other ophthalmologist had ever previously undertaken. He had the audacity to:

place a liquid in prolonged contact with the eye,
position a corrective lens on the front wall of an orthoscope,
fit the device inside the orbital margin, where it could rest on the eyelid periphery,
reduce the dimensions of *Czermak's* device, thus improving optical correction.

Majeswski's Model

Majeswski's model took its inspiration from *Lohnstein's* hydrodiascope and preserved the essential elements of the latter. *Majeswski* should nevertheless be given credit for introducing a connection between the two shells, thus creating, so to speak, "water spectacles" for binocular correction of refractive errors.

Siegrist's First Model

The basic *Siegrist* model was adapted from the orthoscope of *Czermak*, the deficiencies of which he retained by applying it to the exterior of the bony orbital border with the consequently imperfect water-tightness. *Siegrist* was apparently unaware of the modifications that *Hasner* had applied to *Czermak's* orthoscope with the intention to adapt the latter for prolonged use.

Siegrist's Ideal Hydrodiascope

The impetus given by *Lohnstein's* hydrodiascope had allowed the Berne researchers to develop a more perfect hydrodiascope equipped with an optical correction that could be used on a daily basis by patients affected by keratoconus.

The Orthoscope and its Priorities

We must remember that neither *Lohnstein* nor *Siegrist* cited the priorities of *Hasner*, *Coccius* or *Gerloff*, the orthoscopes of whom, after reduction of their diameters, as compared with that of *Czermak*, also lay on the palpebral periphery. These orthoscopes had water-tightness and functionality equivalent to those of *Lohnstein's* hydrodiascope. The merit of *Lohnstein* is that he inserted a corrective lens with adequate inclination and refractive correction into the apparatus of his predecessors and thereby disseminated the idea of optically correcting a deformed cornea.

2. 2 –Physiologic Aspects

Neutralization of Cornea by a Liquid

The idea of neutralizing the optical effect of the cornea by a liquid placed against it was known to the scientific and medical community since the diffusion of *Czermak's* idea by *Helmholtz* and its being put into practice for contact lenses by *Fick*. *Lohnstein*, nevertheless, asked himself the question of whether the refractive index of the liquid should approach that of the cornea or the aqueous. His response was hesitant, but trial and error demonstrated to him that corneal neutralization was reached under good conditions with physiologic saline. *Siegrist* did, however, refer to the principal work of *Fick*, from which he cited the paragraph on corneal neutralization by means of the interposition of an intermediate liquid between the contact lens or shell and the ocular globe.

The Quality and the Toleration of the Liquid

The episode of the hydrodiascopes allowed sufficient time for the clarification of those disputes regarding the quality and the properties of the liquid to be used for filling the hydrodiascope. Had *Lohnstein* asked himself the question of what the index of refraction should be, he would surely have quickly decided on the 0.85% saline solution, the refractive index of which was close to that of the aqueous humor and for which the ocular tolerance appeared the best: *“From an optics standpoint, namely with respect to refractive index, the saline solutions I have chosen correspond with the aqueous humor. [...] The aqueous humor approximates physiologic saline, its refractive index barely different from our filling fluid, only to the fourth decimal point at the maximum. I have deliberately avoided taking a refractive index of the latter identical to that of the cornea because, both in keratoconus cases and in various cases of irregular astigmatism, a better optical effect was achieved where the cornea has approximately the same thickness in the transparent areas [...]. Fick's statement that a 2% grape sugar solution has the same refractive index as the cornea is therefore not valid.”* (43)

Majeswski followed suit. *Fater* tried several saline solutions, namely 0.75%, 0.88% and 1.39 %, the last supposedly corresponding with the dilution of human tears, but all solutions proved to be intolerable. *Ringer's* solution was the best tolerated. *Lüdemann's* studies in the *Bern Eye Clinic* referred solely to the use of physiologic saline.

The Optical Quality of the Surface acting as Substitute for the Neutralized Cornea

The open orthoscope of *Czermak* and the closed version of *Hasner* were equipped with a plano lens. *Lohnstein* equipped his hydrodiascope with a non-removable corrective lens. *Siegrist* returned to the plano lens but added a detachable corrective lens, first fixed by a screw-in attachment, later slipping along a slide to allow easier insertion and removal. *Lohnstein* described his theory of the power of hydrodiascope lenses superbly after 1897, to the extent that his successors were content to refer to his account without questioning it. From that time on, it seems to have been accepted that the fundamental advantage of the hydrodiascope, the one that allowed it to compete with contact lenses and shells, consisted in the perfect correction of refractive errors and the resultant normalization of visual acuity. All authors noted that this result was reached from the fact that the hydrodiascope allowed the introduction of a new spherical surface of appropriate power and that astigmatism was eliminated from the optical system formed by the eye and the liquid.

Secondary Effects of the Hydrodiascope

Enlargement

The enlargement of the retinal image was generally noted by users of the hydrodiascope, who emphasized that this effect (related to the lengthening of the optical system) was a potential advantage for partially sighted persons.

Accommodation

The effect on accommodation had been noted from the first time that *Lohnstein's* hydrodiascopes were used. His successors referred to the effect without realizing that they were attributing something to paresis or paralysis of accommodation that depended on the optical system of an artificially elongated eye. The eye was thus furnished with an approximate optical correction that solicited accommodation. *Fater* provided a correct explanation for this phenomenon.

Corneal Edema

We learn that at the time of the controversy between *Fick* and *Lohnstein*, the latter had observed objective signs of corneal edema at the time of an experiment with a 0.45% saline solution: “*I had a peculiar veil in front of my eye; [...] a flame that I was observing during this time showed weakly defined colored rings.*” (44). This subjective sign of corneal edema described by *Lohnstein* in 1897 was to be rediscovered in 1935 by *Sattler* and to become “*Sattler's veil*”, indicating corneal anoxia.

Cosmetic Handicap

The most important disadvantage of hydrodiascopes, one described by all authors, resided in the difficulties encountered in positioning these devices on the eye with a large volume of liquid, in addition to their unpleasing appearance.

2.3 – Other Applications for the Hydrodiascope

Correction of High Refractive Errors

Aside from his use of the instrument for the correction of keratoconus, *Lohnstein* had proposed that hydrodiascopes could be used in patients for the correction of irregular astigmatism and high myopia. *Majewski* had also used them in unilateral aphakia and in severe regular astigmatism. *Lauber* found application for hydrodiascopes in the correction of high myopia produced by peripheral corneal ectasia. The *Berne School* appears to have restricted their application to patients with keratoconus.

Diagnostics and Research

The orthoscopes of *Czermak* and *Hasner* were used for diagnostics and research when there was a need to neutralize the refractive power of the cornea for a brief period of time. They were also used to eliminate reflections from the cornea in order to examine the anterior ocular segment. *Lohnstein's* hydrodiascope, equipped with a plano lens, could be said to have taken over the next lap of an imaginary relay race towards the finishing post of optical correction. In the course of his controversies with other ophthalmologists, *Fick* drew attention to the fact that his contact lenses could also be used for this purpose. Following the same line of thought, *Lohnstein* recommended his hydrodiascope for diagnostic differentiation between visual disturbances of retinal origin and those related to corneal irregularities in the assessment of retinal perception in a patient with a corneal disturbance and in the early diagnosis of keratoconus. *Lauber* used it in order to study the visual acuity of the eye after the elimination of corneal irregularities.

Hydrodiascopes, Neutralization of Corneal Refractive Power and Contact Lenses

Lohnstein and *Siegrist* used hydrodiascopes eight years after the invention of contact lenses and shells. Their application had the merit of provoking reflection and research studies in regard to two essential points that hydrodiascopes had in common with contact lenses. These were the neutralization of corneal refractive power by a compatible liquid and the replacement of the corneal dioptric power thus neutralized by a new optical structure.

The neutralization of corneal refractive power by a liquid was widely known within the scientific community, particularly since *Czermak's* orthoscope was described in *Helmholz's* treatise on physiological optics. Disagreement arose between the various authors related to the nature of the liquid and its properties, both optical and metabolic:

Was it preferable to advocate, as *Fick* did, a liquid with a refractive index close to that of the cornea or to follow *Lohnstein* and give precedence to the biological compatibility of the liquid and its metabolic effects?

Was it preferable to correct the refractive error of the eye by a liquid lens, or would it not be more appropriate to use a lens with refractive power situated within the body of the device?

Hydrodiascopes have the following features in common with contact lenses:

- immersion of the cornea in a liquid,
- maintenance of the liquid in position by a specific device,
- neutralization of the dioptric power of the anterior corneal surface,
- centration on the optic axis,
- correction of a refractive error by a new dioptric effect.

Hydrodiascopes are to be differentiated from contact lenses and contact shells essentially by nature of their being positioned far anterior to the eye and by their contact to skin as opposed to the cornea.

They also undoubtedly possess certain properties in common with contact lenses and merit, therefore, to be cited among their forerunners. (45)

3 - Historical Survey of the Citations and Misinterpretations

Usually, hydrodscopes are ignored by historians of contact lenses or referred to erroneously. (46) Even if these devices are not placed under the lids and are not in contact with the eye, they possess, nevertheless, all the other characteristics of contact devices and thus represent an important step forward in the history of neutralization of corneal dioptric power.

Certain historians considered that the experiments of *Young* inspired *Lohnstein* and *Siegrist*: “It is interesting that almost a century later [than *Thomas Young*], the same idea was taken up in the hydrodiascope of *Lohnstein* of Berlin (1896-97) and *Siegrist* of Switzerland in 1897 [...] at its best it was, of course, unwieldy and impracticable.” (47). And also: “It is nevertheless worth mentioning that the design of *Young* found application in refined form by *Lohnstein* and *Siegrist* [sic] around 1896 as ‘the hydrodiascope’ for the correction of patients with refractive errors, which derive from deformities or irregularities of the anterior surface of the cornea (regular and irregular corneal astigmatism and keratoconus).” (48) This link with *Young* is arguable, as the device used for the neutralization of his corneal dioptric power was not fixed to the head and he plunged his head into it with the head inclined to the horizontal. (49) While attributions of the priority of the concept of the hydrodiascope are generally ambiguous, one notes attributions of the description of the principle of the hydrodiascope for neutralization of corneal dioptric power to *Descartes*, *La Hire* and *Hershell*. In truth, *Lohnstein* declared that he was inspired by *Young*’s experiment and by *Czermak*’s orthoscope described by *Helmholtz*. The first instrument described by *Siegrist* recalls the closed orthoscope of *Hasner*. The similarities between the hydrodiascope and the orthoscopes of *Czermak*, their improvements by *Hasner*, *Arlt* and *Coccius*, and the citation by *Helmholtz* are very rarely mentioned in the literature.

Conclusion

The orthoscope of *Czermak*, equipped by *Lohnstein* with a corrective lens under the denomination of hydrodiascope, was completed by *Majewski* then perfected by *Siegrist*. It facilitated the optical correction of several patients with keratoconus.

The first “water case” (Wasserkasten), that of *Siegrist*, did not pass the stage of isolated clinical trials at the Berne Eye Clinic. Subsequently, very highly sophisticated hydrodscopes were manufactured by *Bischhausen* opticians in Berne, and their commercialization was exploited up until 1910.

It is not surprising that the blown scleral contact shells of *Müller Brothers*, ophthalmologists of Wiesbaden, were substituted for the unwieldy and esthetically displeasing hydrodscopes. This provides the greatest support for the conclusion that *Siegrist* gave in regard to his last endeavor: “I am convinced that these modern contact-glasses will make the hydrodiascope completely unnecessary and dispensable because it represents only one step in our attempts to perfect our optical devices for the management of keratoconus.” (50).

Notes

- 1 In this chapter, we use often the terms “contact lens” and “contact shell” as generic synonym (*ISO 8320: Contact lens: a generic term including any lens designed to be worn on the front surface of the eyeball.*) (See Appendix 10-1). According to current terminology, 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 The terminology used for similar devices consisting essentially of watertight goggles filled with water varies for different authors and eras, i.e., “Orthoskop” (orthoscope) for *Czermak* (1851), “Hydrodiaskop” (hydrodiascope) for *Lohnstein* (1896), “Wasserkasten” (water case) for *Fater & Siegrist* (1906).
- 3 *Czermak* 1851, *Hasner* 1851, *Coccius* 1852 & 1853. For the history of the orthoscope see chapter IX: *The Era of Orthoscopes*.
- 4 *Helmholtz*, “*Handbuch der Physiologischen Optik*” 1864, (first edition) p. 14-15.
- 5 On November 1, 1895, *Lohnstein* underwent cauterization of the summit of the cone in his left and more seriously affected eye. This was the usual procedure performed at that time. Then, on the December 8, 1895, four weeks after the operation, tissue retraction resulted in corneal perforation at the margin of the cauterized zone with loss of aqueous and a transitory flattening of the ectatic cornea. This ectasia allowed him several days of vision. This was followed by a positively disabling cicatricial leucoma, which reduced his visual acuity to 1/18. There was no longer any means available him to improve his visual acuity, and neither stenopaic nor hyperbolic spectacle glasses were beneficial to him. The effectiveness of the latter would have required perfect centration on that part of the cornea that remained transparent, and they would have functioned only while the corneal condition was evolving. In his right eye, the appearance of keratoconus occurred later, in 1893. This eye developed a myopia of -5.00 diopters. Without corrective glasses, the visual acuity in this eye also dropped to 1/18.
- 6 *Lohnstein* 1897, p. 408. *Lohnstein* cites *Young* and *Czermak*, but not *Hasner*, although *Lohnstein* borrowed the idea of the closed orthoscope from *Hasner*. This orthoscope rested on the soft tissue surrounding the ocular globe and was provided with a filling hole at the top that was closed by a stopper (see chapter IX: *The Era of Orthoscopes*).
- 7 *Lohnstein* 1896, p. 409.
- 8 *Lohnstein* 1896, p. 410-411.
- 9 *Lohnstein* 1896, p. 413. A 2% glucose solution has a refractive index of 1.335, which is approximately the same as that of tears and aqueous (1.337). Such a solution is perfectly compatible with neutralization of anterior corneal refractive power, excluding corneal thickness.
- 10 *Lohnstein* 1896, p. 417.
- 11 *Lohnstein* 1896, p. 417. *Lohnstein* also use the term “Contactglas”, as advocated by *Sulzer*, thereby demonstrating that he found it just as suitable as *Fick*’s “Contactbrille”.
- 12 “Vielleicht, dass man durch zweckmässigen zeitweiligen Gebrauch die Myopie zum Stillstand bringen kann.” (*Lohnstein* 1896, p. 418).
- 13 *Lohnstein* 1897, p. 133-134. *Lohnstein* reinvented the indications for *Hasner*’s (1851) and *Coccius*’s (1853) plane glass orthoscopes used for ophthalmoscopy. *Gerloff* (1891) also used this device for fundus photography (see chapter IX: *The Era of Orthoscopes*).
- 14 *Lohnstein*, 1897 & *Fick*, 1897. The elements of the controversy concerning *Lohnstein*’s criticism of *Fick*’s “Contactbrille” are analyzed in chapter XIII: *The Decades after the Invention*.
- 15 *Lohnstein* 1897, p. 133-134.
- 16 *Zehender* in *Lohnstein* 1897, p. 133 footnote 1.
- 17 The text of this initial presentation was printed for the occasion of the inauguration of the Krakov Ophthalmological Clinic (*B. Wicherkiewicz “Wiadomosci z Kliniki okulistyckiej”* Krakov, 1898). *Wicherkiewicz* referred again to this publication in 1909, when he took part in the discussion of *Parisotti*’s report to the *French Society of Ophthalmology*.
- 18 *Majewski* 1899, p. 162-163.
- 19 *Majewski* 1899, p. 163.
- 20 *Majewski* 1899, p. 164.
- 21 *Fater* 1906/a, p. 95-96 & *Fater* 1906/b, p. 5-6.
- 22 *Fater* 1906/a, p. 96 & *Fater* 1906/b, p. 6.
- 23 *Ringer*’s solution is an isotonic solution of chlorides of sodium, potassium, and calcium.
- 24 *Fater* was mistaken when she attributed accommodative weakness to deterioration from nonuse, following *Lohnstein*.
- 25 *Fater* 1906/a, p. 109 & *Fater* 1906/b, p. 19.
- 26 According to *Helmbold*, the hydrodiascope was used at the Koenigsberg University Eye Clinic in 1906. As *Helmbold* states: “*bei der Entlassung betrug die Sehschärfe rechts mit Siebbrille 2/35, links 5/25, mit Hydrodiaskop - +3 dpt sphär + 3dpt cyl, axe horiz 5/10*” (*At discharge, visual acuity reached 2/35 O.D. and 2/55 O.S. with stenopaic spectacles, 5/10 with the hydrodiascope (+3.00 D.S. +3.00 Cyl axis horizontal.*) (*Helmbold* 1913/14, p 77)
- This same patient was later one of the first to be fitted with contact lenses by *Helmbold* and wore these at least until 1920 (see chapter XV: *Early Blown Contact Lenses*).
- 27 *Lorenz* 1908, p. 23-24.
- 28 “*Les verres de contact et l’hydrodiascope sont des prothèses à essayer systématiquement.*” (*Terson* 1909, p. 343-344).
- 29 *Lauber* 1909, p. 210. Communication to the *Vienna Ophthalmological Society*, May 12, 1909.
- 30 *Uthhoff* 1909, p. 48. *Uthhoff* did not know that in 1899 *Majewski* had described and used a binocular hydrodiascope.
- 31 *Parisotti* 1909, p. 87-88. The spellings “hydrodioscope” (for hydrodiascope) and “Jater” (for *Fater*) are incorrect.
- 32 *Antonelli* 1909, p. 147-148. Discussion of the annual report on “*Keratoconus*” at the 26th *Annual Meeting of the French Society of Ophthalmology (Société française d’Ophthalmologie)* & *Antonelli* 1909, p. 252.
- 33 “*L’hydrodiascope de Lohnstein perfectionné par mon ancien assistant, le professeur Majewski, relève la vision considérablement et même donne une acuité visuelle de 6 à 8 dixièmes.*” (*Wicherkiewicz* 1909, p. 180). Discussion of the annual report on “*Keratoconus*” at the 26th *Annual Meeting of the French Society of Ophthalmology*.
- 34 “*Lauber empfiehlt vor allem das Hydrodiaskop dazu, um dem Patienten zu zeigen, wie viel durch die zweckmässige Therapie dieses Augenleidens zu erreichen ist.*” & *Lauber*, in discussion of *Krämer*’s communication: “*Es scheint mir gefährlich zu sein, dem Kranken mit dem Hydrodiaskop etwas demonstrieren zu wollen, was er nach der Operation sehen werde.*” (*Krämer* 1923, p. 372). Communication to the *Vienna Ophthalmological Society*, June 19, 1923.
- 35 *Krämer* 1923, p. 244-245.
- 36 *Siegrist* 1916, p. 408.
- 37 *Siegrist* 1916, p. 410.
- 38 *Siegrist* designated the blown scleral contact shells of the ocularists *Müller Brothers* first by the term recommended by the manufacturer, “adhesion-contact-spectacle” (Kontaktadhäsionsbrille). Later, he used the term “contact glass” (Kontaktglass).
- 39 *Siegrist* 1916, p. 420.
- 40 *Lüdemann* 1917/a, p. 284 & *Lüdemann* 1917/b, p. 20-21.

- 41 Lüdemann 1917/a, p. 285 & Lüdemann 1917/b, p. 21.
- 42 "Ein gut passendes Kontaktglas kann vom menschlichen Auge stundenlang, ja tagelang ohne oder nur mit ganz geringen Störungen getragen werden." (Lüdemann 1917/a, p. 288 & Lüdemann 1917/b, p. 24).
- 43 "In optischer Hinsicht, d.h. in Hinblick auf den Brechungsindex, entsprechen die von mir gewählten Kochsalzlösungen dem Humor aqueus. [...]. Da der Humor aqueus anähernd die physiologische Kochsalzlösung ist, so ist sein Brechungsindex höchstens in der vierten Stelle nach dem Komma von dem unserer Füllflüssigkeit verschieden. Absichtlich habe ich davon Abstand genommen, den Brechungsexponentens der letzteren gleich dem der Hornhaut zu nehmen, weil weder im Falle des Keratokonus noch in den sonstigen Fällen von unregelmässigem Hornhautastigmatismus, wo die Hornhaut an den durchsichtigen Stellen annähernd gleich dick ist, damit ein besseres optisches Effect erzielt würde. [...]. Fick's Angabe, wonach eine 2% Traubenzuckerlösung die gleiche Brechung wie die Hornhaut hat, trifft also nicht zu." (Lohnstein 1896, p. 412-413).
- 44 "Ich hatte einen eigenthümlichen Schleier vor dem Auge, [...] eine Flamme, die ich während der Zeit betrachtete, zeigte schwach angedeutete farbige Ringe." (Lohnstein 1897, p. 133).
- 45 The hydrodiascopes have more features in common with contact lenses than *Leonardo da Vinci*'s masks or the tube of *Descartes*, so often quoted by the historians of contact lenses.
- 46 Aside from mistakes in their patronyms: "Lohenstein" or "Loewenstein" (for *Lohnstein*) and "Giegrist" or "Sigrist" (for *Siegrist*).
- 47 Mackie in *Duke-Elder* 1970, p. 713. One finds other similar erroneous texts, e.g., in *Mamolli* 1931, p. 61-62.
- 48 "Es ist jedoch erwähnenswert, daß die Anordnung von Young in verfeinerter Form von Lohnstein und Sigrist (sic) um 1896 als 'Hydrodiaskop' zur Korrektion von Sehfehlern, die auf Deformationen oder Unregelmäßigkeiten der Hornhautvorderfläche (regelmäßiger und unregelmäßiger Hornhautastigmatismus, Keratokonus) zurückzuführen sind, Anwendung fand." (Baron 1981, p. 3).
- 49 See chapter VII: *Corneal Immersion* by Thomas Young.
- 50 "Diese moderne Kontaktgläser werden nach meiner Ueberzeugung das Hydrodiaskop, welches nur eine Stufe in der Vervollkommungsbestrebung unserer optischen Hilfsmittel gegen Keratokonus darstellt, vollkommen unnötige und entbehrlich machen." (Siegrist 1916, p. 420).

