

History of Ophthalmic Photography

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"Probably it has occurred to every ophthalmoscopist to wish that he certainly knew, whether an appearance now deemed of great significance, was, or was not, present at the time of earlier examination; or that, to trace the progress of this case, he had the fundus a month ago to compare with the fundus of today."

These opening remarks were made by Edward Jackson, M.D., in the introduction to his paper titled "Blanks for Recording Lesions and Anomalies of the Fundus" published in 1886. His solution to the problem was supplied in the form of a small tablet laid out in much the same manner as the forms used by today's retinal specialists in producing their clinical drawings of retinal lesions. However, in that same year, Dr. Howe produced the first photographs of a living human retina.² Until this time ophthalmic photography had been restricted to photographs of the ocular adnexa and photomicrographs of ocular pathology. While Dr. Howe's retinal photograph was a major breakthrough, retinal photography was not regarded for some time as a routine procedure because of the limitations involved with his method. The exposure was extremely long, ten minutes, and the picture contained a severe artifact in the center which obscured a large portion of the retina. These problems were attacked over the next twenty years by many ophthalmoscopists and improvements slowly advanced the technique.

To further understanding of the beginnings of the field of ophthalmic photography, a brief introduction to the history of photography should be given. It was a fortunate coincidence that the greatest advance in photography and the invention of the ophthalmoscope were in the same year. Though Nicéphore Niépce and Louis Jacques Mande-Daguerre had perfected the daguerreotype by 1839, its limitations made the daguerreotype useless but for landscape and studio photography.³ Even reproducing a daguerreotype was difficult. William Fox Talbot was undaunted by the patented daguerreotype process and continued to pursue a more favorable method to produce a permanent image through a photographic system. Fox Talbot struggled with many chemical combinations and though he was successful at recording an image as early as 1835, he continued to perfect his process, often using the advances made by others working in the same field. In 1844, Fox Talbot produced the first work to use photographic illustrations, "The Pencil of Nature."

In 1851, two major occurrences advanced both photography and ophthalmology. Frederic Scott Archer successfully produced a method to coat a glass plate with a photographic surface, and Dr. Helmholtz invented the ophthalmoscope. It was an 1846 discovery of "guncotton" by Prof. Schonbein that Scott Archer used to impregnate with nitrate, or nitrocellulose, and soaked in ether or alcohol, thereby producing a viscous solution which dried to a tough transparent plastic film. Schonbein was using this compound as a bandaging material for surgery. Scott Archer applied this collodion technique to photography by dissolving potassium iodide in the collodion, poured the viscous solution over the plates and while they were still tacky bathed the plates in silver nitrate solution. Silver iodide was precipitated and a very effective photographic surface was now in use. Although these plates had to be used wet they were far better than the daguerreotypes and they rapidly replaced the older method.⁵

It was with such "wet plates" that Dr. Noyes produced in 1862 the first fundus photograph of a rabbit and in that same year Dr. Rosenbrugh obtained a retinal photograph of a cat.⁶ Aside from these two researchers apparently no one attempted photographing the retina in living subjects for over twenty years. There were two obstacles to overcome before Dr. Howe took his famous human retinal photograph. First it would be necessary to replace the wet plate with a photographic plate that could be used dry. As Dr. Howe's exposure was ten minutes long, the wet plate could not stay sufficiently moist to the end of the exposure. The wet plate was superseded by the photographic emulsion in 1871. Dr. R.L. Maddox, a physician and microscopist who was also an amateur photographer, replaced the collodion with a gelatin. The emulsion, a solution of soluble halide and silver nitrate was mixed with warm gelatin and poured over

the glass plate.⁷ Since the gelatin would swell and absorb chemicals when immersed in solutions, it was possible to use this photographic material in a dry state and still process it in the usual manner. Until this time photographers produced and processed their own plates; however, by 1880 there were many small companies that produced and sold photographic plates and chemicals. This enabled photographers to spend more time producing pictures and drew a large number of people into photography. The second obstacle to overcome was a strong belief among ophthalmologists that exposing the eye to a constant source of even moderately high illumination would permanently damage any vision the eye had; this belief kept many physicians from attempting to photograph the human retina. Help in allaying this fear came in 1869 when Dr. Jefferies of Boston presented a case of a fifteen year old boy who had been kicked in the head by a horse and was subsequently blind in the right eye. He was able to examine the eye with an ophthalmoscope using a mirror to reflect the sun's light onto the retina. This unique combination of a blind eye and the use of sunlight as the illumination source "gave me the most beautiful view of the fundus oculi I ever remembered to have obtained." His purpose in presenting his case was stated as follows:

"We here had a perfectly normal fundus oculi entirely destitute of sensation to light, and with a transparent media in front of it. From not being able to communicate in time with Dr. Noyes, of New York who possesses the necessary skill and apparatus, an opportunity was lost to achieve a scientific triumph, namely the photographing of the interior of the normal human eye, which, I believe, has not yet been done." ⁸

Though this patient's eye had no visual perception, it was noted that a light as bright as the sun could be directed into the eye with the proper focusing and diffusion devices without completely destroying the eye, as many physicians of that day felt would happen. This led to the use of lamps of higher and higher intensity for the purpose of photographing the retina. Early sources of illumination for this purpose were kerosene lamps and gas burners; later, reflectors and condensing lenses were added to increase the amount of light reaching the eye. In 1886, Drs. Jackman and Webster used an Argand gas burner with a reflector and orthochromatic plates to produce retinal photographs. Their camera was attached to a Carter demonstrating ophthalmoscope; the exposure needed was now only six to ten seconds.⁹ But the reflex was still a problem. Dr. Oswald Gerloff was able to eliminate the corneal reflex through the use of a cap or coverglass over the cornea in 1891. He chose an atrophic human eye for his subject; however, the results were so poor that the disc could be recognized only with difficulty. The vessels were barely discernable.

In 1888, Professor Cohn and Dr. Claude du Bois-Reymond in Wiesbaden exhibited photographs of the exterior of the eye taken with "lightning" illumination, a light source invented by Herman J. Goedicke and A. Mieth. This controlled illumination

"is so sudden and fleeting that when it occurs in a chamber in previous absolute darkness, the pupil has not time to contract, and thus absolute dilatation can be represented as photograms. It is hoped that it will be possible to photograph the retina during life by this process."¹⁰

It can be assumed by this statement that routine dilatation of the pupil was yet to come.

The state of ophthalmic photography remained an area of interest for ophthalmoscopists, but the reflex produced by the illumination source continued to be a deterrent; therefore another medium, that of the artist, became the preferred method of recording retinal findings. Ophthalmic artists had been practicing and improving their field since Helmholtz invented the ophthalmoscope in 1851. Their drawings were able to demonstrate areas of the eye the photographer often could not reach. They were able to use colors closely resembling the actual eye grounds (color

photography was still to come) and for clinical purposes were able to produce accurate enough drawings in a relatively short period of time. For these reasons the photographic methods were looked upon with much scrutiny. By 1899, Dr. Walter Thorner had partly solved the reflex problem with an ophthalmoscope manufactured by F. Schmidt and Haensch in Berlin. The Thorner ophthalmoscope was later modified to be used as a camera objective. The small photographs produced by the Thorner ophthalmoscope-camera still contained a severe artifact, but it was now in the lower portion of the picture rather than in the center.¹¹ In 1905, Dr. Dimmer, working with the Zeiss Co. in Jena, designed a large retinal camera which produced reflex-free photographs of the retina. Dr. Dimmer's camera, from an illustration of it published by him, occupied an entire table top, and according to the author only one such camera was ever produced. Dr. Thorner accused Dr. Dimmer of retouching his negatives to eliminate the reflex.¹² Another pioneer in fundus camera design was Dr. Nordenson in Stockholm. He too worked with the Zeiss Company and in 1925 produced the Zeiss-Nordenson camera which became a widely-used fundus camera.¹³ It was Dimmer's camera, however, which produced the photographs contained in the first atlas of retinal photographs. The atlas was produced in 1927 by Dimmer's associate, Pillate, two years after the death of Dr. Dimmer.¹⁴ Dr. Bedell, using the Zeiss-Nordenson camera, produced his original atlas in 1929.¹⁵ The Zeiss-Nordenson camera used the Gullstrand principle of illumination and has undergone many modifications through the years. It also used a carbon arc for the illuminating source, and was later modified to incorporate a high intensity incandescent lamp by Hartinger.¹⁶ The illumination produced by the carbon arc was an extremely bright and constant light. The exposure was controlled by a mechanical shutter placed in the light path to allow only the proper amount of carbon arc light to reach the retina. This proved to be a rather risky method as any failure of the mechanical shutter to close could produce retinal burns and some did indeed occur. The optical system was altered by Boeghold by the addition of a black spot in the lens system to eliminate the small reflex remaining.

1931 to 1950, the taking of retinal photographs slowly gained favor and was performed in many eye clinics in Europe and in major eye departments in the United States.

During this twenty year period, many new advances were achieved. Both the Thorner and the Zeiss ophthalmoscopes were attached to an Exacta Varex camera and were used to photograph the retina.¹⁸ Color film was used to record the true colors as well as the fine details of the retina. Dr. Bedell was presenting color photographs during the 1940's at the AAO meetings. The Retinaphot camera was produced during this time. Perhaps the most valuable device invented during this period and suggested in 1950 by Halberg was the electronic flash. While Halberg suggested using the electronic flash in 1950, Dr. Meyer-Schwickerath did use the illuminating source at that time, and Rucker and Ogle published the first paper mentioning the actual use of the new illuminant in photographing in color the interior of the eye in 1953.²⁰ The year 1955 brought the Zeiss-Littmann camera, a fully updated fundus camera with electronic flash, better optics, and a price affordable to eye departments all over the world.

Some rather unique uses for retinal photography were attempted; for instance, in 1925, Pincus theorized that retinal photographs could serve as evidence in a murder investigation by showing the assailant's image preserved in the victim's retina. He concluded that the possibility of the retina maintaining this image might be in error and that perhaps only whether the victim died in darkness or light could be determined (this by whether the pigment epithelium had been displaced or not).²²

Along with the development of the fundus camera came various clinical and diagnostic methods of using it. It was used in its very early stages for occasional external photographs. In 1950 Lee Allen and Dr. Duvas presented a paper on anterior segment photography with the Nordenson camera.²¹

Methods were derived to achieve satisfactory results by various means. Thorner apparently was the first to report achieving stereo photographs of the retina in 1909.²³ Von Der Heydt demonstrated stereo retinal photographs in 1927.²⁴ His method, which involved having the patient shift his gaze horizontally was incorrect however, and Mr. Lee Allen demonstrated that cornea-induced parallax shift would yield true stereo photographs of the retina. His original stereo separator was manually operated. Later the Zeiss Co. used his idea and made it an integral part of their camera.²⁵ Dr. Donaldson designed a retinal camera which produced consistent simultaneous stereo photographs. However, since many cases do not require

stereo photographs for clinical records or teaching uses, it is preferable to produce them only when needed through the shifting of the camera axis or by the stereo separator method. Some have placed markers on the camera base to serve as movement limits to achieve stereopsis.

In addition to routine color photographic examinations performed with the fundus camera, fluorescein retinal angiography has become a useful diagnostic technique performed by the ophthalmic clinician and researcher. The use of dyes in examining the retinal circulation and ocular structures is not as new as most would think. In 1881, P. Ehrlich reports giving fluorescein dye intravenously and noticing the dye appearance in the anterior chamber.²⁶ In 1910, Dr. Burk reported mixing fluorescein dye in coffee and administering it to the patient orally. By this method, he was able to observe retinal and choroidal lesions.²⁷ In 1930, Dr. K. Kikai was using fluorescein dye in animals intravenously to study choroidal and retinal lesions with a filter of 366A degrees.²⁸ Dr. Arnold Sorsby in 1939 used several dyes, but not fluorescein, in an attempt to demonstrate retinal holes in detached retinas.²⁹ And in 1955, McLean and Maumenee reported using fluorescein to outline hemangiomas of the retina.³⁰ In 1957, Drs. Milton Flocks and Peter Chao were using Trypan blue to check cerebral circulation time in cats and timing the dye appearance in the retina by a stopwatch. In 1958, they changed to fluorescein and for the first time photographed, by use of a Zeiss-Nordenson camera and a Cine Special 16mm. motion picture camera, the retinal circulation.³¹⁻³² This was the first reported photographic technique of fluorescein retinal angiography. Drs. Flocks and Chao attempted their method on human subjects, but could not achieve enough illumination for satisfactory results. Though their method was described in the literature in 1957 and 1959, they omitted the term fluorescein in the title and thus have been overlooked as the first to use the technique. Drs. Novotny and Alvis published their paper in 1961 and have been cited as the originators of this method of examination.³³ Since that time a host of uses for fluorescein angiography, both diagnostic and research in nature, have evolved by various ophthalmologists and ophthalmic photographers.

Through the use of controlled wave lengths of light, retinal and choroidal lesions have been isolated photographically. Both black and white and color infra-red films are now used to reveal fundus lesions in detail that true black and white or color films cannot record. The perfection of color fluorescein retinal angiography has added a new dimension to fluorescein interpretation. Perhaps the latest technique involving the fundus camera is placing the picture on the television monitor. Both monochrome and color television are now employed in video taping retinal findings through the fundus camera.

Illustrations in the early ophthalmic journals consisted of woodcuts to depict external ophthalmic findings and occasionally an artist's drawing of the retinal pathology. It is interesting to note that journals used photomicrographs for several years before the first photograph of even an external eye finding, a child with unilateral hypertrophy and hypertrophic ptosis, in 1889 in an article by J.T. Thompson. The American Journal of Ophthalmology did not publish any photographs until 1896 when it printed a photomicrograph, and in 1897, the Journal published its first external photograph depicting a pre and post operative lid procedure. These two photographs were retouched to enhance the detail and therefore do not depict an accurate record of the case.³⁴ Since it was necessary to use daylight and later flash powder to expose the film, early photographs of eye surgery are non-existent and here again the woodcuts served their purpose.

Those early clinicians who did perform external photography of the eye were limited as to the amount of magnification they could achieve and therefore it is not uncommon to see head and shoulders or even larger photographs used to illustrate eye findings in the early literature. There were some who had much foresight and even used a macro-stereo camera such as Druner did in 1900. Dr. Druner's early paper contained a woodcut illustration of his camera, a modified binocular Zeiss biomicroscope, but no photographs taken with it are presented.³⁵ Robert von Der Heydt presented in 1927 a paper detailing his modification of the Druner-Zeiss camera and included two illustrations taken with it.³⁶ Improvements in photography of the anterior segment since the early 1900's have included higher magnification, improved lighting systems, slit lamp photography, surgical photomicroscopy, and iris fluorescein angiography. These advances have led the way to a variety of clinical, surgical and research uses of external photography.

To those early ophthalmologists who nurtured the growth of ophthalmic photography much is owed. The clinical, educational, and research

ophthalmologists have used their techniques, devices and inspirations in 'many ways. Through their initiative and foresight, a profession has emerged which has assisted the field of ophthalmology to reach a high degree of excellence in the recording and presentation of visual disorders. Ophthalmic photographers the world over are engaged in the task of producing quality photographic material for ophthalmologists in their area of concern.

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