A History of Contact Lenses

Their evolution in the history of the healing arts.

Their eventual transition to medical devices and treatment for corneal diseases and abnormalities and their effect on the world, America, and our own community.

"The Beginning"

The development of contact lenses is an old story, dating back to 1500 - 1508.

The first insight into the treatment of optical defects of the cornea with a device is given to the great Italian, Leonardo da Vinci. Master Leonardo filled a bowl with water, then placed a man's face into it. It is said that for the first time the individual was able to see clearly. There are two very important factors about this discovery. Improved refraction and improved peripheral visual acuity.

Leonardo da Vinci also made a contact lens with a funnel on one side so that water could be poured into it. Of course, this was immediately discarded due to impracticality.

In 1636, after reviewing Leonardo's work, a French scientist, Renee Descartes, in a special medical treatise, Ways of Perfecting Vision, described a concept of a lens placed directly onto the eye. He developed a tube he could fill with water and place directly against the cornea. This was also impractical and discarded.

We must remember that early technology did not make it possible to develop and manufacture devices that would fit directly on the eye and produce good vision. That being the case, spectacle lenses were the only devices used to correct vision. Patient's with regular corneas and normal astigmatism had very good vision. Individuals with corneal astigmatism or diseases and abnormalities of the cornea had minimal visual improvement with glasses. Wearable contact lenses did not begin to evolve until the nineteenth century. In 1801,

Thomas Young described a neutralizing surface for the cornea that was the forerunner of contact lenses.

Sir John Herschel, the English astronomer and physicist, wrote and circulated an opinion that corneal contact lenses were, in fact, optically feasible. Herschel was also the first to suggest that an actual mould of the cornea might be taken.

These ideas though, lay dormant for approximately sixty years. His suggestions were theoretically sound but very problematic due to practical applications that were too difficult to overcome. One of the barriers was the need to make a mould of the sensitive corneal tissue. The cornea is totally avascular, with thousands of nerves, making a very sensitive tissue. With the introduction of anesthesia in 1884, contact lens technology advanced because moulding was made possible.

In the early 1880's, glass contact lenses that fit the anterior of the eye, called scleral lenses, were invented by Adolf Fic, Eugene Cult and August Mueller, independently. Dr. Fic was a physician in Zurich, Switzerland, who wrote a treatise entitled A Contact Spectacle, in which he described the first contact lens with a refractive power, to protect the eye and later for visual improvement. This first lens was made by F. A. Mueller in 1887, a manufacturer of artificial eyes.

Fic also recognized a method for correction of different types of irregular astigmatism other than spectacle lenses, which did not adequately correct the refractive power of irregular corneas. This device to neutralize the refractive power of the cornea, consisted of placing a small glass bowl directly on the eye, much like Leonardo had done 300 years prior. Later, Fic prepared a set of trial glass lenses. Fic selected the diagnostic lens that was most suitable for each of his experimental subjects. These original contact lenses were made of very thin glass.

Fic used these lenses quite successfully in treating patients with corneal disease and abnormalities. These abnormalities, such as keratoconus, can cause scarring and a definite obstruction to the refraction of light. Fic's lenses were quite successful compared to other applications but were still cumbersome and uncomfortable.

Cult, who was a glass blower from Wiesbaden, Germany, described another method by which keratoconus could be corrected by suppression of the cone and correction of the refraction with glass shells.

Over the course of about sixty years, scleral lenses made of glass were the major contact lenses used. Scleral glass lenses were primarily manufactured by Carl Zeiss Company in Jiena, Germany, as early as 1912.

Making Progress

In the 1930's, the availability of plastics produced lenses that were lightweight and very transparent. They were chemically consistent, stable, unbreakable, scratch resistant and much easier to manufacture. This eventually changed the course of contact lens technology.

In 1937, Theodore Obrig developed manufacturing techniques for making plastic lenses and suggested the use of fluorescein dyes to study the morphology of the lens fit against the patient's cornea. With the introduction of polymethylmethacrylate (PMMA) a flush fitting scleral lens was made possible. A few Labs still fit and manufacture these types of contact lenses for the treatment of severe keratoconus disease and Stevens-Johnson syndrome.

The therapeutic use of these lenses was developed by Woodly in England in 1954. These lenses also had desirable cosmetic effects. Innovations greatly contributed to the success of contact lenses, for both cosmetic and therapeutic use.

The Beginning of the Renaissance

An optician from England, Kevin Touhy, introduced the corneal lens, which covered only the transparent portion of the protective coating of the eye (the cornea) in 1947. The lenses, patented by Touhy in 1948, rested directly against the limbal margin of the cornea. These lenses had diameters of 10.80 to 12.50 mm. They were much more attractive and easier to wear than the glass and plastic scleral lenses that preceded them.

Many changes were rapidly introduced to these types of lenses until a product emerged that was safer and could be worn all day, had tremendous optical clarity and was invisible to the human eye. These changes allowed early contact lens patients to address the public with confidence. The new contact lenses could be worn in all kinds of weather and were useful for sporting activities of all kinds. Because the contact lens was large, but smaller than earlier scleral lenses, it was not easily dislodged or lost.

The Renaissance

At this point, the renaissance in the contact lens field was about to explode. The year was 1960. Celebrities, athletes, business executives, and political figures, all wanted these new contact lenses. Eventually these people, along with students and office workers formed the bulk of the contact lens consumers and popularized contact lenses. Although there were thousands and thousands of converts to contact lenses they really did not threaten to make spectacle lenses a historical footnote.

Remembering that the contact lens renaissance began in 1948, the world was just learning about these new and different contact lens designs. In 1950, George Butterfield introduced the concept of fitting the peripheral cornea.

The first corneal lenses to have widespread success were designed in the 1950's by Frank Dickenson, Wilhelm Sohnjes and John Neil. These lenses had a thickness of about 0.20 millimeters. Thinner lenses of about 0.10 millimeters were introduced in the early 1960's. These had rounded edges and a much smaller size that permitted greater metabolic transition of fluids.

Dr. Robert Morrison, of Harrisburg, PA, who Dr. Siviglia had the privilege of working with in the 1960's, introduced a small, thin MINNA lens. These lenses were better tolerated. No thought had ever been given to the fact that perhaps the contact lenses were uncomfortable and cumbersome after some time of wear because of the insufficiency of oxygen between the contact lens and the cornea. PMMA material, which is still in use and mostly produced by GlassFlex Corporation in New Jersey, was not oxygen transmissible. In the 1960's, Morrison postulated that after removal of these types of contact lenses, the cornea was definitely influenced in both a positive and negative way. At times, there was inconsistency in the performance of the lens. It produced very unpredictable results, both during and after wear.

In 1958, Otto Wichterle, who was in charge of the Macromolecular Institute of the Czechoslovakian National Academy of

Science, along with Dr. Drahoslav Lim, a polymer chemist, developed a new soft plastic that could be cut down or moulded into a variety of shapes. However, when this plastic was placed in water or any type of aqueous solution this tough, rigid plastic became very soft, pliable and increased in diameter. In the wet form it could be bent between the fingers until the edges met, but would snap back to its original shape. This material was subjected to rigorous biological testing and found to be inert and fully compatible with human tissue. It had extreme elasticity when wet, but was still strong and able to hold its shape.

Much credit is to be given to Morrison. He was an innovative and creative individual who was among the first to recognize the importance of the first soft hydrogel contact lens materials. In time they evolved into present day soft contact lenses. The original soft lenses were cut with a lathe, but the material could also be spun- casted into a contact lens with a precise radius of curvature. This new material and concept provided excellent possibilities for the future of more comfortable lenses. The harder and more stable contact lenses were hydrophobic, while the new soft lens materials, were hydrophilic. Dr. Wichterle was eventually persuaded to release the patents for worldwide use and a manufacturing facility for these soft lenses was set up in Dr. Morrison's hard contact lens laboratory where they researched the material and manufacturing techniques.

In 1960, the National Patent Corporation acquired the rights to this new, soft plastic and sub-licensed it to Bausch and Lomb for manufacturing purposes. Original problems with this material were that it was not oxygen transmissible, it was hydrophilic, and after some time clogged with impurities from the patient's lacrimal system. This lens material also was noted to have extreme reactions to different atmospheric conditions, such as increased humidity swelled the lens, while less humidity caused the lens to become contracted on the patient's cornea.

Significant to Lancaster County's role in contact history is the founding of Lancaster Contact Lens Lab in 1962, by Dr. Nick Siviglia, the only full service laboratory in the county. Now known as Lancaster Contact Lens, Inc., & Associates, it is still an active full service laboratory.

Contact Lens for Treatment of Medical or Ocular Disorders

With the advent of hard and soft lens materials and some idea of how to fit the lens, medicine could move forward with the application of treating eye problems.

In the early 1960's, Nick Siviglia, Ph.D., Sc.D., a contact lens designer, fitter and inventor, having previously been employed by Dr. Morrison, created and manufactured custom aphakic contact lenses for individuals who had cataracts removed from one eye. Before this modality was available, these patients became monocular, unable to see clearly with both eyes.

At a later date, Bausch and Lomb made popular the spun-casted soft lenses. Spun- casting produced a lens with very consistent, reproducible lens surfaces. Bausch and Lomb also introduced mass production. This made it possible for Siviglia and other practitioners to fit soft bandage lenses for therapeutic reasons, such as corneal erosion or other corneal traumas, in addition to fitting near and far sighted patients.

In 1968, The Food and Drug Administration classified soft lenses as a drug. Between 1954 and 1970, as soft contact lenses were improving and developing in design and materials, polymethylmethacrylate hard contact lenses were depreciating in their use. Practitioners came to discover that many patients who wore either PMMA hard or soft contact lenses developed central corneal edema. This affected the patient's visual acuity and their ability to tolerate these lenses. There was tremendous need for improved materials with more oxygen transmission for both hard and soft lenses.

In 1970, silicone and methacrylate combinations produced rigid gas permeable materials. Through time and research experience we found the need to improve designs and fitting techniques as well. Experts the world over worked feverishly to accomplish that goal.

In 1976, the Medical Devices Act declared that soft contact lenses were now classified as a medical device and no longer a drug. Later, in 1978, and after much research, the first rigid gas permeable lens materials made out of cellulose acetate butyrate were FDA approved. Because of its oxygen transmissibility, many more patients were once again being fitted with hard, (stable) oxygen transmissible gas permeable lenses. They produced better visual acuity than soft contact lenses because they did not flex

with blinking.

As years passed, soft lens designs improved. The general public was mostly fit in soft contact lenses that were more oxygen transmissible and able to be worn on a daily, as well as an extended wear basis. The need for stable or rigid contact lenses declined, but over the years maintained twenty-five percent market share. Soft contact lenses have not been able to satisfy patients with various diseases and anatomical distortions of the cornea. These patients were best served by a well fit, specially designed, gas permeable stable lens for visual and corneal rehabilitation. Improvement in materials gave the patients better comfort. However, designs with gas permeable lens materials for some corneal diseases were limited and produced unpredictable results. More knowledge and improved technology was needed.

In 1977, out of much frustration, Siviglia began research on new contact lens designs. With the advent of manual corneal topography and with use of specialized instruments, it was possible to obtain geometries from different quadrants of the patient's cornea. Corneal topography, gave evidence of various elevation levels and changes in the corneal surface. That led him to design several lenses, for keratoconus and corneal abnormalities, such as the Ni-Cone design. This design is a multiple back surface vaulting system based on Leonardo da Vinci's original concept. Remembering the part Leonardo overlooked when he put the man's face in the bowl of water, the water pushed back against the cornea. This is called fluid compression. With knowledge that the cornea's epithelium regenerates itself, it is possible to take advantage of the re-distribution of cells through the science of fluid compression when fitting a specially designed lens that applies pressure to specific areas of the cornea. Various Institutions such as Wills Eye Hospital Contact Lens Department, Schei Eye Institute and the Pennsylvania College of Optometry joined in research with this specially designed lens. It was found that not only can there be control of the corneas of patients with corneal disease and abnormalities, but also improve those surfaces. This U.S. Patent was approved in 1986, #4,601,556. This lens is used worldwide.

With the advent of improved soft contact lenses and new, better, more oxygen transmissible, stable lenses we now have millions of contact lens patients turning to this modality as a means of correction for visual disparities of all kinds. However, as scientific research evolved in the late 1970's, surgical procedures were introduced to the world by Drs. Baraquer of Bogota, Columbia, Sato from Japan, T.J. Lans from the Netherlands and later by Feodorof of the Soviet Union. These procedures, using incisions known as radial keratotomy, were developed with the goal of surgically correcting myopia. Myopia is either an elongated globe or an elongated globe plus an elongated cornea. When successful, the procedure greatly reduces the effective power of the eye and successfully treated patients no longer required eyeglasses or contact lenses. These procedures were eventually found to be unpredictable, and those patients with poor results could no longer wear normal soft contact lenses of any kind. This was because a soft contact lens would conform to the shape of their cornea, producing the same visual effect as with no lens on at all.

The clinical use of laser surgery began in North America at the Bochner Eye Institute in Canada, with training by Dr. Stephen Trokel, the inventor of the Excimer laser.

In 1984, Siviglia once again initiated research for the development of a new design. It began with a patient here in Lancaster, who is still alive and works at one of the local hospitals. This lens is a hybrid, a combination of Siviglia's two patented designs.

Meanwhile, there was a procedure introduced called photo-refractive keratotomy, which is the use of a laser to sculpt the front surface of the cornea. With that in mind and with radial keratotomy in full swing, another design was developed called the NRK lens. It was patented in 1986, U.S. Patent #856,077. NRK means to neutralize the refractive kurvature, by the science of fluid compression. It was the first of its kind. This design was presented to ophthalmology, optometric and opticianry meetings worldwide.

Another, more aggressive design, U.S. Patent #4,787,732, was granted in 1988, and was patented in nine other countries. It was the first deviation from standard geometries and mathematical formulas employed in hard contact lenses, gas permeable contact lenses and soft lenses.

This design was presented at the International Medical Contact Lens Symposium in Toronto Canada in 1994, the European

Contact Lens Society of Ophthalmic Medicine in Venice, Italy in 2003, and the European Contact Lens Society of Ophthalmic Medicine in Budapest, Hungary in 2004. The NRK design has led to more comfort and better vision with the least amount of risk and complication to the patient's post surgical cornea. It is also the first FDA approved design for the reduction of myopia without surgery.

Conclusion

Today, the world is researching different contact lens materials, and designs that will promote more comfort and better vision. This search for safer lenses and better designs will always exist. However, as we look to the future in ophthalmic sciences we may find that with advanced surgical procedures both eyeglasses and contact lenses as we know them will be used less and less. Gas permeable lenses of special designs will be used as a medical treatment for patients with diseases and abnormalities of the cornea. Various types of surgery for correction of common refractive errors is indeed a reality. But even that will be challenged, as perhaps solutions to present issues in ophthalmic science and visual correction may not be resolved with optical devices or surgery, but rather through genetic restructuring in the future.