CHAPTER 1

THE HISTORY OF CONTACT LENSES [1–3]

In his 1508 "Codex of the Eye", Italian inventor Leonardo da Vinci speculated that submerging the head in a bowl of water could alter vision. He even created a glass lens with a funnel on one side, so that water could be poured into it, but the device was impractical. His ideas far exceeded the technology of his time to implement them. However, he had correctly identified several key principles of contact lenses; neutralising the refraction of the cornea by means of an artificial surface; substituting the refractive powers of a curved clear lens in its place; and positioning that lens directly on the eye. In 1632, after reviewing Leonardo's work, French scientist René Descartes proposed another idea: placing a glass tube filled with liquid in direct contact with the cornea. Descartes' invention worked somewhat to enhance vision; however, using it made blinking impossible. Although his idea was not practical, placing the lens only over the cornea, instead of including the sclera was most perceptive. Improvements in the design of contact lenses would not be seen again for nearly two centuries.

In 1801, English scientist Thomas Young made a basic pair of contact lenses based on Descartes' idea. He changed Descartes' contact lens design by reducing the size of the glass tube to ¼ inch and then using wax to stick the water-filled lenses to his eyeballs. He was also the first to accurately describe astigmatism, greatly advancing the field of eye care. However, Young's device was not practical, nor was it able to correct vision problems. In fact, the idea of using contact lenses to correct the refraction errors that cause nearsightedness, farsightedness, and astigmatism wasn't suggested until 1845. English physicist Sir John Herschel was the first to hypothesise that taking a mold of the cornea might produce lenses that could correct vision. However, without the necessary technology, Herschel was unable to test his hypothesis and his theory remained mere speculation until nearly 100 years later.

The early 1880s were a revolutionary period for contact lenses. The development of anesthesia in 1884 allowed for the making of a mold of the anterior shape of the eye, as proposed by Herschel, and new glass production, cutting, and shaping technologies made thin lenses possible for the first time. Designs for glass contact lenses that fit in the eye, allowing the wearer to blink, were independently invented by three men: Adolf Fick, Edouard Kalt and Louis J. Girard. Credit for the discovery usually goes to Dr. Fick, a Swiss physician, who wrote a treatise entitled "A Contact Spectacle," in which he described the first contact lens with refractive power for visual improvement. The first physical example of the lens was made by artificial eye-maker F. A. Mueller in 1887. These types of contact lenses were called scleral lenses, and they covered the entire eye, not just the cornea. They were slightly convex, allowing room for tears or a dextrose solution, a liquid that creates the refractive power to correct vision, to fill the space between the lens and the eye much like Da Vinci's bowl of water. In 1888, Fick constructed and fitted the first successful contact lens (both corneal and scleral). However, there were two major issues with Fick's contacts: the lenses were made from heavy blown glass and were 18–21 mm in diameter. The weight alone made them uncomfortable to wear, but worse, the glass lenses covered the entire exposed eye. Unlike other bodily organs, which are oxygenated by the blood, the eyes get their oxygen directly from the air. So, covering your eyeballs with glass shields will suffocate them. Scleral lens wearers experienced excruciating eye pain after a few hours of use. Nonetheless, glass scleral

lenses were the main form of contact lenses used for pathological conditions, such as, keratoconus and other severe distortions of the cornea, where correction with spectacles was not possible for the next 60 years.

By the late 1920s, technological advances in both anesthesiology and materials finally allowed, Sir John Herschel's ideas, about creating molds of the cornea to be tested. In 1929, Dr. Dallos and Istvan Komàromy of Hungary, perfected a method of making molds from living eyes, proving Herschel's theories. For the first time it was possible to create contact lenses that conformed to the actual shape of the eye. In 1936 Feinbloom in the USA was the first to use plastic in contact lenses, he produced a scleral lens by bonding the glass corneal potion to an opaque molded resin scleral band. Orbig and Mullen in the USA followed Feinbloom and in 1938, using a new material, polymethyl methacrylate (PMMA), which is easy to shape to ultrathin dimensions and greatly superior to glass, in safety, lightness and workability, made the first all-plastic scleral lens. This "unbreakable", "scratch-resistant", malleable and easy to manufacture plastic, revolutionised the contact lens industry, making glass lenses obsolete. But even though the new lenses were plastic, they were still scleral lenses, covering the entire eye and only wearable for a few hours at a time.

In 1948, an English optical technician named Kevin Touhy was sanding down a plastic lens when the part that covered the white of the eye fell off. Rather than start over, he decided to try the smaller lens. He smoothed the edges and popped it in his eye. He was delighted to discover that the lens still worked and stayed in place, even when one was blinking. This happy accident was the birth of the corneal lens, the type most commonly used today. The discovery allowed wearers to leave their contacts in longer, as their eyes could breathe somewhat better and the corneal lenses were more comfortable than scleral lenses. After Touhy's invention became public, several other changes were rapidly introduced to these types of lenses. In 1950, George Butterfield came up with the idea of a curved, rather than flat, corneal lens design. Later in the 1950s, Frank Dickenson, Wilhelm Sohnjes, and John Neil created thinner lenses, of about 0.20 millimeters centre thickness. Even thinner lenses, of about 0.10 millimeters, were introduced in the early '60s. However, even with all these improvements, corneal lenses still hindered oxygen flow to the eyes and couldn't be worn for long periods or overnight.

That was soon to change, beginning in 1958. At that time, Czechoslovakian chemists Otto Wichterle and Drahoslav Lim was developing a new type of plastic, called hydrogel, that was soft and pliable when wet, yet could be shaped and molded. Together with Dr. Dreifus, an ophthalmologist, they began to research and formulate hydrogel contact lenses. The basic hydrogel plastic is hydroxyethyl methacrylate (HEMA) and absorbs water (as much as 85 to 90%) and becomes flexible in proportion to their water absorbency. An optometrist named Dr. Robert Morrison, of Pennsylvania, became aware of Wichterle's work and recognised its potential for contact lenses. Wichterle released his patents for worldwide use, and a manufacturing facility for hydrogel soft lenses was set up in Dr. Morrison's lab. In 1960, Bausch and Lomb were granted access to the hydrogel material and took the soft contact lenses to new levels. This included creating a refined casting technique that produced consistent lens surfaces, as well as, a process for mass production. Ciba Vision's introduction of silicone hydrogels in 1998, offered extremely high oxygen permeability. Both hard and soft contact lenses continued to improve over the next 25 years, especially in terms of oxygen permeability, allowing the eyes to breathe.

The history of contact lenses development is considerably more detailed and complex than is suggested by this discussion of its significant developments, or a chronological listing, of its highlights presented in Table 1. Today's wide range of precision made, carefully fitted, and extensively used contact lenses represents the contributions of many scientific areas such as, biology, physics, chemistry, precision glass making, plastics and polymers, precision tool making, ophthalmic science and their continually expanding theoretical and empirical foundations. Finally, many individual eye-care practitioners, technicians and scientists contributed to the development of contact lenses and its use in eye-care.

Table 1: Summary of the historical development of contact lenses

1508	Codex of the eye, Manual D. Leonardo da Vinci	Italian inventor Leonardo da Vinci speculated that submerging the head in a bowl of water could alter vision. He even created a glass lens with a funnel on one side, so that water could be poured into it, but the device was impractical.
1632–1636	René Descartes	Furthered the evolution of contact lenses with the suggestion of corneal lenses.
1801	Thomas Young	Based on Descartes idea, used a ¼ inch long glass tube with a microscopic lens at the outer end and the open end on his eye, filled it with water to correct his own vision.
1827	Sir John Herschel	Suggested grinding a glass contact lens to conform exactly to the eyes surface. He also suggested taking a mould of the eye to ensure accurate fitting. This became possible in 1884 with the development of anaesthesia. Sir Herschel was also the first person to describe the concept of cosmetic lenses.
1887	F E Mueller	Prosthetic eye manufacturer becomes the first to produce a glass eye covering that can be seen through and tolerated. The “glass lenses” were designed for protection and could be only worn for very short periods.
1888	A. Eugen Fick a Swiss Physician, Edouard Kalt a Paris Optician, and Louis J. Girard	Simultaneously reported the use of glass contact lenses to correct optical defects.
1929	Joseph Dallos a Hungarian Physician	Developed methods of taking moulds from living eyes, so that lenses could be made to conform to individual eyes. This enabled mass production of glass contact lenses which conformed to the actual shape of the eye.
1936	William Feinbloom a New York Optometrist	Manufactures the first American made contact lenses and introduces the use of plastic hard lenses.
1945	American Optometric Association (AOA)	Formally recognised the growing contact lens field by specifying contact lens fitting as an integral part of the practice of Optometry.
1948	Kevin Tuohy a California Optician	Filed a patent for the first corneal contact lens made entirely of PMMA – polymethyl methacrylate.
1950	George Butterfield a Oregon Optometrist	Designs a corneal lens that follows the corneal curvature, instead of fitting flat, increasing comfort and tolerability. The shape was paraboloid and used peripheral curves – precursor of all modern rigid lenses.
1957	John DeCarle	Developed simultaneous-vision bifocal contact lenses.
1960’s	George Jessen	Created the first Orthokeratology design, under the term “autofocus”.
1960	Otto Wichterle and Drahoslav Lim from the Institute of Macromolecular Chemistry - Czechoslovak Academy of Sciences Prague	Introduced water-swollen, hydrophilic, cross-linked polymers (PHEMA or Poly hydroxyethyl methacrylate) and “soft lenses”. PHEMA was made available in Western European markets from 1962.
1965	National Patent Development Corporation (NPDC)	Bought the licence covering soft contact lenses from the Czechoslovak Academy of Sciences.
1965	Bausch & Lomb	NPDC sub-licensed the patent for soft lenses to Bausch & Lomb. This initiated the soft lens industry in the USA.
1968	US FDA – Federal drug administration	FDA regulation of contact lenses is introduced.
1971	Bausch & Lomb	B&L received approval from the FDA for their spin cast PHEMA lenses.
1970’s	John DeCarle	Demonstrated that if the water content of soft contact lenses could be sufficiently increased, extended wear was possible.
1975	John DeCarle	The first extended wear lens was distributed in the UK – 71% water content “Permalens”.
1974	Norman Gaylord - Polycon laboratories	First siloxane-based rigid lens material – merging the properties of methyl methacrylate with the increased oxygen performance of silicone rubber.

1978		First toric contact lenses, with both spherical and cylindrical power correction is introduced in the USA.
1979		First rigid gas permeable (RGP) lenses appear.
1981	John DeCarle	“Permalens” received FDA approval for 30 day extended wear.
1982	Synoptic Group – Denmark	In 1982, the world’s first disposable contact lens was introduced, the MIA lens - marketed as the ‘Danalens’ by the Synoptic group. As the name implies, this came from Denmark. MIA stands for Michael, Inga and Annette (the inventor, his wife and daughter). The technology for the MIA/Danalens lens was subsequently bought by Johnson & Johnson who changed lots of it and renamed it.
1982		First commercially available bifocal lenses were introduced for daily wear.
1983		The first tinted RGP lenses introduced.
Later part of 1980’s and early 1990’s	Hydron	Non-spherical and diffraction progressive multifocal lenses were developed by Hydron (Echelon lens) and others.
1987	Johnson & Johnson	Johnson & Johnson launched their own disposable contact lenses in the USA in 1987, ‘ACUVUE’.
1987		First tinted cosmetic soft contact lenses were introduced.
1987		The first multipurpose lens care products were introduced.
1987		Fluorosilicone acrylate material introduced for RGP lenses.
1988	Johnson & Johnson	In 1988, Johnson & Johnson launched two products in the UK designed to suit different lifestyles. The daily wear, Acuvue, was taken out each night and required replacing every fortnight. The extended wear Acuvue, could be worn for longer but required replacing every week.
1989	Johnson & Johnson Bausch & Lomb Pilkington Barnes-Hind	The two big rivals to Johnson & Johnson were Bausch & Lomb and Pilkington Barnes-Hind. Both first issued competing lenses in 1989: Bausch & Lomb produced a polymacon lens, called the ‘Seequence’. The design was based on their ultrathin U4 Series and the lenses were packaged for either weekly or monthly replacement.
1992		Tinted soft contact lenses were introduced for commercial distribution.
1995	Ron Hamilton – Bausch & Lomb	Daily disposable lenses used just once, before throwing away, were made available in 1995. The first was the Premier Award lens, invented by Ron Hamilton in Scotland. The company was later bought by Bausch & Lomb and the product transmuted into the SOFLENS 1 day. Ron Hamilton went on to launch the Provis company.
1996	Johnson & Johnson	Johnson & Johnson added to their Acuvue range, a 1-day daily disposable lens. The ‘1-Day Acuvue’ is notable as the first soft disposable lens to be available throughout the world rather than, in just one or two countries. First lenses with UV absorber.
1997	Ciba Vision	Ciba Vision followed in 1997, with their Focus Dailies range. These were made with precision quartz moulds which meant that they were highly reproducible.
1998	Bausch & Lomb	In 1998 multifocal disposable soft lenses were made available. The first design was ‘Occasions’ by Bausch & Lomb.
1999	Bausch & Lomb Ciba Vision	New generation extended wear soft lenses were also introduced in 1999. Silicone hydrogel lenses were made available in disposable form, the first two products being the ‘PureVision’ by Bausch & Lomb and the ‘Night & Day’ lens by CibaVision.
2000	Wesley-Jessen	‘Freshlook’ was a soft toric monthly disposable contact lens, for astigmatism by Wesley-Jessen.
2000		The very first monthly disposable toric lens was the ‘Focus’ by Ciba Vision (45% vifilcon and 55% water).
2002	Ciba Vision	The first daily disposable Toric lens was launched by Ciba as part of the ‘Focus Dailies’ range in 2002. This added to their monthly disposable toric lens. Back then, Ciba Vision was the only manufacturer producing a multifocal daily disposable lens (31% nelfilcon, 69% water). They used a cast moulding process. There was also a progressive lens in the same range.
2002		Overnight, orthokeratology was approved by the FDA.
2010		Custom made silicone hydrogel lenses introduced.