History of Vision Correction: Contact and Intraocular Lenses

Contact lenses differ from spectacles or eyeglasses in that the lenses rest directly on the eye's sensitive surface rather than being perched on the nose. Leonardo da Vinci described several possible designs in 1508, and René Descartes suggested a design of contact lenses of his own in 1632. The first working model based on Descartes' design, built by Thomas Young in 1801, consisted of a quarter-inch long glass tube with a lens on one end, filled with water. The open side rested on the surface of the eye whose moisture was maintained by the water in the tube. In 1887 a German glassblower designed and fabricated a contact lens to protect the eye of a patient whose eyelid had been removed. It covered the entire surface of the eye and only the central (corneal) section was transparent.

In the late 1880s a Swiss physician, Eugen Fick, developed glass contact lenses in collaboration with the Zeiss Optical Works in Germany. These lenses could be ground to a prescribed shape for vision correction. Fick worked both with scleral lenses, which cover the entire surface of the eye, and corneal lenses, which cover only the central portion. At approximately the same time, French optician Edouard Kalt developed glass corneal contact lenses meant to fit closely to the eye.

By the 1920s, Zeiss marketed a set of trial glass contact lenses that patients could try on to find a proper fit before placing an order. Methods were also developed to make molds of patients' eyes so that lenses could be custom-made. But the lenses were still too thick to be comfortable for all-day wear.

In 1936, New York optometrist William Feinbloom introduced the use of plastic in the making of contact lenses. While the corneal portion of his lens was polished glass, it was surrounded and supported by a scleral portion made of opaque plastic resin. In the same year, the plastic polymethl methacrylate (PMMA, trade name Plexiglas) was invented. Since that time, almost all "hard" (inflexible) contact lenses have been plastic rather than glass. Plexiglas lenses were found to retain their optical quality over time, and they were not prone to dangerous bacterial growth. But because the polymer is impermeable to oxygen and CO_2, many wearers experienced varying degrees of eye irritation and the lenses could not be used for overnight wear.

The more comfortable "soft" lenses were introduced in the early 1970s. They were invented by Czech chemist Otto Wichterle, who developed the water-absorbent polymer hydroxyethylmethacrylate (HEMA). While soft lenses provided improved gas permeability and increased ease of wear, a variety of materials-related problems remained to be solved. The polymer was susceptible to colonization by bacteria and a regime of daily disinfection was required, but even so, infection rates were high. Furthermore, the lenses were easily torn if mishandled and yellowed with age, requiring replacement every year or two.

By the mid-1970s, asymmetric "toric" soft lenses were marketed for the correction of astigmatism, and were manufactured using a computer-controlled lathe. Bifocal contacts were also developed but have not been successful with most patients. (Instead, some physicians suggest contacts that correct for good near-vision in one eye and good distance-vision in the other. Wearers learn to unconsciously switch from one eye's image to the other.) Starting in the mid-1980s, tinted soft contact lenses to change eye color were marketed.

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Rigid gas-permeable lenses were introduced in the late 1970s; these were made of copolymers PMMA and silicone, or silicone-acrylate, and combined the gas permeability of soft lenses with the infection-resistance of hard lenses. By the late 1980s, rigid gas-permeable lenses were available for round-the-clock wear up to a week at a time. The addition of fluorine to the polymer improved both gas transmission and moisture maintenance.

The problems associated with infection in soft lenses were finally solved in the late 1980s with the introduction of disposable soft lenses that can be worn continuously for up to two weeks before replacement. The lenses were essentially identical to those in use already, but innovations in manufacturing brought the price down far enough to make frequent replacement economically feasible.

The eye has a natural lens of its own, which may become clouded or entirely opaque, usually with age, in a condition known as cataract. The only known treatment is surgical removal of the damaged lens, which is said to have been practiced since ancient Egypt. "The history of the operation dates back to the Egyptians, who used sticks as crude tools for the removal of cataracts." In the modern era until the 1970s, the refractive power of the lost lens was normally replaced either with glasses or with contact lenses.

In 1949, London ophthalmologist Harold Ridley pioneered the surgical implantation of artificial plastic lenses to replace natural lenses damaged by disease or injury. Ridley came up with the idea of using Plexiglas lens implants from the experience of Allied doctors treating pilots involved in airplane accidents in World War II. When Plexiglas fragments from shattered airplane canopies were found to be embedded in an injured pilot's eye, it was found that the plastic was well tolerated by the body, so that in many cases it was actually better to leave the fragments in place rather than damage the eye further by removing them. Ridley theorized that a lens made of Plexiglas could be surgically inserted into the eye to provide permanent vision correction for a cataract patient whose opaque natural lens had been removed. Implants in current use are about one quarter inch in diameter.

In the present decade, 99% of patients undergoing cataract surgery choose intraocular implants. The clouded natural lens is emulsified by vibration and removed through a narrow incision, and then a flexible acrylic intraocular lens is folded and inserted through the same incision. The lens unfolds and restores vision to the eye. Materials issues include the possibility of stress fracture of the lens during folding, as the polymer's flexibility depends on moisture, temperature, and speed of folding. The procedure is performed routinely under local anesthesia on an outpatient basis and recovery is swift. YAG (yttrium, aluminum, and garnet) laser treatment is routinely used to restore clear vision if the artificial lens is clouded by the growth of natural tissue.

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FOR FURTHER READING: J. Anshel, *Healthy Eyes Better Vision*, (The Body Press, Los Angeles, 1990) and M. Speaker and K. Feiden, *Cataract and Other Eye Surgery*, (Dell Publishing, New York, 1991).