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A brief history of contact lenses

[1]Ştefan Ţălu, [2]Mihai Ţălu, [3]Stefano Giovanzana, and [4]Rajiv D. Shah

[1]Department of Descriptive Geometry and Eng. Graphics, Faculty of Mechanics, Technical University of Cluj-Napoca, Cluj-Napoca, Romania; [2]Department of Applied Mechanics, Faculty of Mechanics, University of Craiova, Craiova, Romania; [3]DAUR – Laboratory of Design Tools and Methods in Industrial Engineering, University of Padova, Italy; [4]Massachusetts Eye Research and Surgery Institution, Boston, Massachusetts, USA
Corresponding author: Ş. Ţălu, stefan_ta@yahoo.com

Abstract. This paper presents a brief history of contact lenses in ophthalmology.
Key Words: contact lenses, ophthalmology.

Rezumat. Această lucrare prezintă pe scurt istoria lentilelor de contact în oftalmologie.
Cuvinte cheie: lentile de contact, oftalmologie.

Introduction. A contact lens, also known as a contact, is a corrective, cosmetic, or therapeutic lens usually placed on the cornea of the eye. Contact lenses remain on the cornea by means of the surface tension of the tear film that is composed by different living and dead cells as conjunctival, corneal, and keratinized epithelial cells; polymorphonuclear neutrophils; eosinophils; lymphocytes and plasma cells. The contact lens floats in the tear film, being a tear layer anterior and posterior to the lens. The contact lenses are pulls onto the corneal surface by the tear film on the anterior surface of the lens (Hom & Bruce 2006).

Contact lenses usually serve the same corrective purpose as glasses, but are lightweight and virtually invisible - many commercial lenses are tinted a faint blue to make them more visible when immersed in cleaning and storage solutions. Some cosmetic lenses are deliberately colored to alter the appearance of the eye. Some lenses have a thin surface treatment which is a ultraviolet coating; this helps to reduce ultraviolet damage to the eye's natural lens.

The history of contact lens has a long and complex history.

Leonardo da Vinci is credited with describing and sketching the first ideas for contact lenses in his 1508 Codex of the eye, Manual D. Leonardo da Vinci sketches and describes several forms of contact lenses (Heitz 2003).

In 1632, René Descartes furthered the evolution of contact lenses with a suggestion of corneal lenses (Bennett & Weissman 2004).

In 1801, Thomas Young on the basis of Descartes' idea and with a quarter-inch-long, water-filled glass tube and the outer end containing a microscopic lens used it to correct his own vision (Bennett & Weissman 2004).

In 1827, English astronomer Sir John Herschel suggests grinding a contact lens to conform exactly to the eye's surface. He also suggested taking a mould of the eye to ensure accurate fitting; and this was something that finally became possible in 1884 with the development of anesthesia (Bennett & Weissman 2004). Sir John Herschel was probably the first person to describe the concept of cosmetic lenses.

In 1887, F.E. Müller, a prosthetic eye manufacturer from Wiesbaden, Germany, produces the first eye covering designed to be seen through and tolerated. Muller's glasses were designed in the first place for protective purposes, but they were very

heavy and could only be worn for very short periods of time (Rugg-Gunn 1931; Bennett & Weissman 2004).

Two independent European researchers, A. Eugen Fick, a Swiss physician, and a Paris optician named Edouard Kalt, reported almost simultaneously in 1888 the use of contact lenses to correct optical defects.

In 1929, Joseph Dallos, a Hungarian physician, developed methods of taking molds from living eyes so that lenses can be made to conform more closely to individual sclera. His work enabled the mass production of contact lenses, conformed to the actual shape of the eye (Rabih 2002; Bennett & Weissman 2004).

William Feinbloom, a New York optometrist, in 1936 manufactures the first American made contact lenses and introduces the use of plastic. These ones were more convenient, although were still hard lenses.

The American Optometric Association (AOA), in 1945, formally recognizes the growing contact lens field by specifying contact lens fitting as an integral part of the practice of optometry.

In 1948, a California optician, Kevin Tuohy, filed a patent for the first corneal contact lens, which was made entirely of polymethyl methacrylate or PMMA. PMMA, as a hard contact lens material, had a high modulus of elasticity, acceptable surface wettability, excellent durability, but is not flexible. A great disadvantage of PMMA lenses is that no oxygen is transmitted through the lens to the conjunctiva and cornea, which can cause different adverse clinical effects. To overcome this, PMMA lenses are fitted to move freely up and down on the cornea with each blink (Zantos & Titus 1987).

Dr. George Butterfield, an Oregon optometrist, in 1950 designs a corneal lens, the inner surface of which follows the eye's shape instead of sitting flat, increasing comfort and eye tolerability. Butterfield's thinner contour was to approximate the shape of a paraboloid, being the precursor of nearly all rigid lenses (Bennett & Weissman 2004).

In 1957, DeCarle in London developed simultaneous-vision bifocal contact lenses that were free from the problem of rotation, which became the basis for current bifocal contact lenses (DeCarle 1989).

Hydrogel (or 'soft') lenses have had a great impact on the contact lens market since they were first introduced in the late 1960s. These lenses are termed 'soft' since they are made from water-swollen, cross-linked, hydrophilic polymers, being flexible. These hydrogels can be made by polymerising suitable monomers with a crosslinking agent, or less commonly, by the post treatment of noncrosslinked hydrophilic polymers (Tranoudis & Efron 2004).

In order to be suitable as a contact lens material, a hydrogel polymer must possess certain properties. These include: being optically transparent; having a refractive index similar to that of the cornea; being sufficiently oxygen-permeable; having sufficient hydraulic permeability; having sufficient dimensional stability; having adequate mechanical properties; being biocompatible in the ocular environment (Maldonado-Codina & Nefron 2003).

Hydrogel lenses were developed in the mid-1950s by Prof. Otto Wichterle and Dr. Drahoslav Lim of the Institute of Macromolecular Chemistry of the Czechoslovak Academy of Sciences in Prague. They experimented with contact lenses made of a soft, water-absorbing plastic they had developed - poly(hydroxyethyl methacrylate) or PHEMA. The water absorption helped with eye dryness problems that could determine discomforts as irritations, eye tiredness and focusing problems (Wichterle & Lim 1960).

PHEMA lenses were available on the market in Western Europe in 1962.

In 1965 the National Patent Development Corporation (NPDC) bought the licence covering soft contact lenses from the Czechoslovak Academy of Sciences and in 1966 sub-licensed it to Bausch & Lomb (B&L). This initiated the soft contact lens industry in the USA (Kopeček 2009).

B&L received approval from the Food and Drug Administration (FDA) for their PHEMA lenses in 1971. These lenses soon became much more convenient than rigid contact lenses, mainly due to their immediate comfort. Different companies developed their own PHEMA lenses, but clinical studies highlighted ocular complications from the

fact that the lenses caused hypoxia, or other problems relating to solution toxicity and lens spoliation (Maldonado-Codina & Nefron 2003).

George Jessen created what was probably the first orthokeratology design in the 1960's, under the term 'orthofocus'.

In the UK, in the early 1970s John de Carle demonstrated that if the equilibrium water content (EWC) of hydrogel lenses could be sufficiently increased, then these lenses could be continuous or permanent wear. He developed the first extended-wear lens to be distributed in the UK (1975) named Permalens™ with a EWC of 71 % made from a HEMA/VP/MAA copolymer. The Permalens was produced and marketed in the UK in 1975; it received approval from Food and Drug Administration in 1981, with a 30-day extended-wear indication (Maldonado-Codina & Nefron 2003).

Different companies manufactured other lenses that received approval for extended wear during the 1980s, but along with the increase in demand for these lenses clinical studies highlighted an increase in ocular complications.

In 1974 at Polycon Laboratories, Norman Gaylord designed the first siloxane-based rigid lens material – merging the properties of methyl methacrylate with the increased oxygen performance of silicone rubber (Maldonado-Codina & Nefron 2003).

In 1978, the first toric contact lenses, which have both spherical and cylindrical correction power, was approved for commercial distribution in the United States.

In 1979 rigid gas permeable (RGP) lenses appeared. These ones offer long-term comfort, excellent vision and durability relative to soft lenses. Some vision problems can be corrected using only RGP lenses (Agarwal et al 2002).

In 1981, FDA approved extended wear soft lenses of up to 30 days, but with unnoticed and unreported complications.

In 1982 were introduced the first commercially available bifocal contact lenses (daily wear). Bifocal contact lenses are specially designed to provide two corrections, one for distance and one for near (Zantos & Titus 1987).

In 1983, the first tinted RGP lens were introduced for commercial distribution and the extended wear RGP lens were available for commercial distribution, in 1986.

In the latter half of the 1980s to the 1990s, nonspherical progressive multifocal contact lenses and diffraction contact lenses were developed (Toshida et al 2008).

In 1987 were available for commercial distribution: soft contact lenses; a soft contact lens to change eye color; the first multipurpose lens care product and a new formulation of fluorosilicone acrylate material for RGP lenses.

In 1992, tinted contact lenses were introduced for commercial distribution.

In 1995, daily disposable lenses became available for commercial distribution.

In 1996, first disposable lenses using ultraviolet absorber were available in the market in USA.

In 1998, first multifocal disposable soft lenses were available on the market and new generation extended wear soft lenses were introduced in 1999.

In 2002, overnight orthokeratology was approved by FDA.

In 2010, custom-manufactured silicone-hydrogel contact lenses were introduced for commercial distribution in USA.

When compared with spectacles, contact lenses are less affected by wet weather, do not steam up, provide a wider field of vision, and are more suitable for some sporting activities and by theater and film performers. Although, all contact lens wearers must be made aware of the possible risks of contact lens wear, especially at corneal ulcers, because scratches on the edge of the contact lens can scrape the cornea and make it vulnerable to bacterial infections.

History of soft lens manufacturing. The manufacturing technology and material composition used determine the physico-chemical properties, mechanical properties, surface finish and clinical performance of the contact lenses. Contact lenses manufactured by different methods will undergo very different polymerisation conditions that may have an effect on the resultant material (Maldonado-Codina 2001; Maldonado-Codina & Efron 2003, 2004, 2005).

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Manufacturing techniques developed from the contact lenses being hand made and polished to contact lenses made with lasers and computer precision. Although, contact lenses are made through a complicated process, the most usual manufacturing methods of the contact lenses are: spin casting, lathe cutting, cast molding, or combinations of these (O'Brien & Charman 2006).

Contact lens technology grown rapidly after polymers introduction and most contact lenses are being mass produced. The manufacture method is chosen on the wear modality of the contact lens and commercial considerations (Maldonado-Codina & Efron 2005).

a) Spin – casting

The first contact lenses were manufactured by spin casting, a method that used a spinning mold to create the lens surfaces. The outside of the mold fixed the outer surface while the inner surface was generated by the action of centrifugal force on the liquid polymer (Agarwal et al 2002).

The spin casting permits to vary the lens optics by varying the speed of rotation, and/or the shape of the mold. Spin-casting usually takes place in anaerobic conditions in order to reduce the surface degradation effects which would otherwise take place in the presence of oxygen (Maldonado-Codina & Efron 2004).

Spin casting process can't produce the high volume of contact lenses as the cast moulding process, but the volume is much higher than the lathe – cutting process.

b) Lathe – cutting

Lathing was used in the manufacture of rigid lenses before it was used for manufacturing soft hydrogel lenses. This process is more expensive than the spin casting or cast moulding processes and involves the use of a special contact lens lathe to cut an anhydrous block of material according the required shape, and then hydrating this to form the final soft lens (Efron 2002).

This method permits to construct complex design such as toric contact lenses (Agarwal et al 2002).

Lathing can be used to make soft or rigid lenses from most types of contact lens material (Maldonado-Codina & Nefron 2003).

Usually the cuts are made with a laser, but in the past, actual knives were used.

c) Cast - moulding

This method is based by the placement of the monomer into a mold, the mold is then cast, and the monomer is polymerized. In order to obtain different lens parameters the change the shape of the anterior and posterior molds is used.

In 1980, American Hydron was the first contact lens company that received FDA approval for cast-moulding contact lenses.

In 1981 Johnson & Johnson, an American healthcare company, entered the contact lens market by purchasing a small contact lens manufacturer (Frontier Contact Lenses) in Jacksonville, Florida, USA and acquiring the rights to a Danish contact lens manufacturing technology termed "stabilised soft moulding" (SSM) in 1984.

This process is a variant of conventional cast-moulding process, with the main difference that the contact lenses are not allowed to dry after polymerization (Maldonado-Codina & Nefron 2003).

Toric and bifocal contact lenses can be manufactured using this method.

The cast - moulding, the dominant technology in high volume contact lenses manufacture, based on the injection molding and computer control, offers improved reproductibility, greater cost efficiency, being the common manufacturing technique.

These advanced manufacturing techniques are the basis of cost effective single use contact lenses (Agarwal et al 2002).

Conclusions. The development of contact lenses is still ongoing based on the new technology, which make the lenses more biocompatible, comfortable, safe and cheaper.

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Authors:
Ştefan Ţălu, Technical University of Cluj-Napoca, Faculty of Mechanics, Department of Descriptive Geometry and Eng. Graphics, B-dul Muncii Street, no. 103-105, 400641, Cluj-Napoca, Romania, e-mail: stefan_ta@yahoo.com
Mihai Ţălu, University of Craiova, Faculty of Mechanics, Department of Applied Mechanics, Calea Bucureşti Street, no. 165, 200585, Craiova, Romania, e-mail: mihai_talu@yahoo.com
Stefano Giovanzana, DAUR – Laboratory of Design Tools and Methods in Industrial Engineering, University of Padova, Padova 35100, Italy, e-mail: lol_740@hotmail.com
Rajiv D. Shah, Massachusetts Eye Research and Surgery Institution, Boston, Massachusetts, USA, e-mail: hersheymd75@yahoo.com

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