Application Strategies and Drawbacks of Biomaterials in Ocular Implants

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Abstract
Eye is highly sensitive organs with primary role in vision and the main responsible parts for the vision are cornea, lens, and retina. Any refractory error leads to blurred vision or blindness. In order to rectify the disorders of each organ of our eye various biomaterials are used for the fabrication of implants. The present review mainly focuses on the criteria of selection of various types of biomaterials used for fabrication of implants which are used to rectify various ocular problems arise due to age, trauma and diseased condition.

Keywords: Contact lens; Corneal implants; PMMA; PHEMA; PVA; Hydrogel

Introduction

Table 1: Types of biomaterials used in ocular implants.

| Types of Ocular Implant | Explored Biomaterials |
|-------------------------|-----------------------|
| Contact lens            | Polymethyl methacrylate, Poly hydroxyl ethyl methacrylate, Trimethyl siloxy silane, N-vinylpyrrolidone, Polydimethylsiloxane |
| Intra Ocular Lens (IOL) | Polymethyl methacrylate, Poly hydroxyl ethyl methacrylate, Poloxamer |
| Corneal implants        | Poly Vinyl Alcohol, poly hydroxyl ethyl methacrylate, Polymethyl methacrylate, Polysulfones, Graphite, Hydroxyapatite, Bacterial cellulose |
| Scleral buckle          | Poly hydroxyl ethyl acrylate, Poly glyceryl methacrylate, Methyl acrylate hydroxy ethyl acrylate, Porcine skin, Soft silicones, silicone sponge |

Out of all the sense organs eye is considered as the most important and sensitive sense organ. It is not only sensitive but also equally complex system. Eye is a soft organ and most of the part is a vascular. It is housed in an eye socket, orbit. Light travels through the eye by crossing various layers, the outer most is tear layer and subsequent layers in order of appearance are corneal, aqueous humor, lens, vitreous humor, and retina. Finally image is formed at retina and it is sensed through lens optics which is connected to the brain through macular part. Any obstruction in any of the layer leads to blurred vision or blindness. The transplantation of the part is reported, but the supply is less than the demand. Therefore, there is great need of artificial support for the systems. A number of biomaterials has been tried for the purpose and many of the artificial transplants are been used successfully (Table 1). The current review evaluates all the biomaterials which has been explored for the applications with their drawbacks and advantages.

Contact Lens
Contact lenses are used to correct refractive error in eye. Therapeutic contact lenses are being used nowadays to deliver drug to treat various ocular diseases [1]. Leonardo da Vinci et al. [2], is the person who has invented the use of contact lenses for the first time in 1508 [2]. There are two types of lenses, hard contact lens and soft contact lens. Initially they were made up of glass taking moulds of rabbit or cadaver eyes. The discovery of polymethyl methacrylate (PMMA) led to the idea of usage of polymers for the development of contact lenses. However, PMMA lenses are hard and are difficult to wear for longer durations as these lenses do not permeate oxygen to pass through them. Wearing PMMA lenses obstructed oxygen diffusion hence there is a need for other alternative material [3,4]. To address this an attempt was made in the form of rigid gas permeable contact lenses which are made by copolymerising methyl methacrylate (MMA) with trimethyl siloxy silane (TRIS) which have been licensed to extended wear up to 7 days [5]. In subsequent years, the synthesis of poly hydroxyl ethyl methacrylate (PHEMA) led to the manufacturing of soft contact lenses in 1961 [6].
PHO gives excellent comfort and is having greater elastic modulus, higher water content up to 38% of water. In addition to this various hydrogel based lenses were also made from polymers like N-vinylpyrrolidinone and glyceryl methacrylate [7, 8]. Although these lenses were comfortable to wear the main drawback is that these hydrogel based lenses must be very thin and permeable of oxygen, but reduction in thickness led to loss in strength [9,10]. Another type of soft contact lenses were made up of polydimethylsiloxane (PDMS), it is having higher oxygen permeability. But the problem with PDMS is its low surface energy results in poor wetting [11]. Research is being carried out to increase the wet ability of the lens by grafting with hydrophilic polymers. Till date, PHEMA is most commonly used in contact lens with upto 90% water content for extended use.

Intra Ocular Lens

Cataract is one of the most dreadful diseases that lead to blindness by clouding of the lens. The removal of natural lens leads to withdrawal of cloudiness. Later, to reinstate the natural vision, an intra ocular lens (IOL) is placed. Typically IOL have two parts: optic and haptic [12]. Haptic may be made up of same material or different material. PMMA is the widely used material for manufacturing of IOL. It is selected because of its high bio-compatibility and less weight. Though PMMA has been used for 40 years it has its own disadvantages like less surface energy results to damage of corneal endothelium [13]. Polymeric coatings of NVP and HEMA are being coated to improve the bio-compatibility and to increase the surface energy [14,15]. In addition to PHEMA hydrogels, collagen fibers and acrylic polymers are used for manufacture of foldable IOL [16]. Recently, thermo sensitive polymer, polyoxamer hydrogel has been studied for IOL and the pilot study showed satisfactory results [17].

Concluding Remarks

There are many biomaterials has been for various types of ocular implants. Some have proven efficacy in in-vitro and preclinical studies. The materials must be scaled up to clinical level for human applications. Additionally, there is scope of newer polymer with nano materials approach. Moreover, these implants can be used as drug delivery depot for the treatment of various ocular diseases like age related macular degeneration, glaucoma, etc.

References

1. Costa VP, Braga ME, Duarte CM, Alvarez LC, Concheiro AG, et al (2010) Anti-glaucoma drug-loaded contact lenses prepared using supercritical solvent impregnation. J Supercrit Fluid 53:165-173.
2. Heitz R, Enoch J, Leonardo DV (1987) An assessment on his discourses on image formation in the eye. Advances in Diagnostic Visual Optics 19-26.
3. MacRae SM, Matsuda M, Yee R (1985) The effect of long-term hard contact lens wear on the corneal endothelium. Eye Contact Lens 11: 322-326.
4. Thean JH, Mchab BA (2004) Blepharoplasty in RGP and PMMA hard contact lens wearers. Clin Exp Optometry 97: 11-14.
5. Khoo C, Chong J, Rajan U (1999) A 3-year study on the effect of RGP contact lenses on myopic children. Singapore Med J 40: 230-237.
6. Wichterle O, Lim D (1960) Hydrophilic gels for biological use. Nature 185: 117-118.
1. Kunzler JF, Friends GD (1991) Polymer compositions for contact lenses. Google Patents.

2. Vanderlaan DG, Nuney IM, Hargiss M, Alton ML, Williams S (1999) Soft contact lenses. Google Patents.

3. Dohlman CH, Rejojo MF, Rose J (1967) Synthetic polymers in corneal surgery: I. Glycerol methacrylate. Arch Ophthalmol-Chic, 77: 252-257.

4. Evans CH (1980) Hydrogel contact lens. Google Patents.

5. Nicolson PC, Vogt J (2001) Soft contact lens polymers: an evolution. Biomaterials 22(24): 3273-3283.

6. Cumming JS (2009) Accommodating 360 degree sharp edge optic plate haptic lens. Google Patents.

7. Obstbaum SA (1992) The Binkhorst Medal Lecture Biologic relationship between poly (methyl methacrylate) intraocular lenses and uveal tissue. J Cataract Refr Surg 18: 219-231.

8. Yoo K, Huang XD, Huang XJ, Xu ZK (2006) Improvement of the surface biocompatibility of silicone intraocular lens by the plasma-induced tethering of phospholipid moieties. J Biomed Mater Res A 78(4): 684-692.

9. Lowe AR, Vamsikaki M, Wassall MA, Wong L, Billingham, et al. (2000) Well-defined sulfobetaine-based statistical copolymers as potential antibioadherent coatings. J Biomed Mater Res Part A 52(1): 88-94.

10. Feng Y, Borreli M, Reichl S, Schrader S, Geerling G (2014) Review of alternative carrier materials for ocular surface reconstruction. Curr Eye Res 39(6): 541-552.

11. Kwon JW, Han YK, Lee WJ, Cho CS, Paik SJ, et al. (2005) Biocompatibility of polyomac hydrogel as an injectable intraocular lens. J Cataract Refract Surg 31: 607-613.

12. Loughman MS, Robinson D, Sullivan L (1996) Mechanical methods in refractive corneal surgery. Curr Opin Ophthalmol 7(4): 41-46.

13. Grendhal DT (1986) Corneal inlay with holes. Google Patents.

14. McDonald MB, Mccarey BE, Storie B, Beuerman RW, Salmeron B, et al. (1993) Assessment of the long-term corneal response to hydrogel intrastral lenses implanted in monkey eyes for up to five years. J Cataract Refract Surg 19(2): 213-222.

15. Werblin TP, Peiffer RL, Binder PS, Mccarey BE, Patel AS (1992) Eight years experience with PermaLens® intrastranal lenses in nonhuman primates. Refrac Conal Surg 8(1): 12-22.

16. Mulet ME, Ailo JL, Knorz MC (2009) Hydrogel intraconal inlays for the correction of hyperopia: outcomes and complications after 5 years of follow-up. Ophthalmology 116(8): 1455-1460.

17. Liu K, Li Y, Xu F, Zuo YL, Zhang Li, et al. (2009) Graphite/poly (vinyl alcohol) hydrogel composite as porous ringy skirt for artificial cornea. Mater Sci Eng C 29: 261-266.

18. Sinha M, Gupte T (2017) Design and evaluation of artificial cornea with core-skirt design using polyhydroxyethyl methacrylate and graphite. Int Ophthalmol.

19. Wang J, Gao C, Zhang Y, Wan Y (2010) Preparation and in-vitro characterization of BC/PVA hydrogel composite for its potential use as artificial cornea biomaterial. Mat Sci Eng C 30(1): 214-218.

20. Alió JL, Salem TF, Artola A, Osman AA (2002) Intracorneal rings to correct corneal ectasia after laser in situ keratomileusis. J Cataract Refract Surg 28(9): 1568-1574.

21. Feldman BH, Kim T (2010) Enhanced effect of double-stacked intrastral corneal ring segments in keratoconus. J Cataract Refract Surg 36: 332-335.

22. Fraser S, Steel D (2010) Retinal detachment. BMJ Clin Evid.

23. Chen T, Janjua R, Modermott MK, Bernstein SL, steidl SM, et al. (2006) Gelatin-based biomimetic tissue adhesive. Potential for retinal reattachment. J Biomed Mater Res B Appl Biomater 77(2): 416-422.

24. Tsui I (2012) Scleral buckle removal: indications and outcomes. Surv Ophthalmol 57(3): 253-263.