Journal of Pharmaceutical and Biological Sciences 2021;9(2):88–94

Content available at: https://www.ipinnovative.com/open-access-journals

Journal of Pharmaceutical and Biological Sciences

Journal homepage: https://www.jpabs.org/

Review Article

Ocular drug delivery system (ODDS): Exploration the challenges and approaches to improve ODDS

Suraj Mandal[1,*], Km. Shiva[2], K Pavan Kumar[1], Sweta Goel[3], Ramesh Kumar Patel[1], Shital Sharma[1], Renu Chaudhary[4], Arti Bhati[4], Netra Pal[4], Ashwani Kumar Dixit[1]

[1]*Dept. of Pharmaceutics, Pt. Rajendra Prasad Smarak College of Pharmacy, Puranpur, Uttar Pradesh, India*
[2]*Dept. of Pharmacy, N.K.B.R. College of Pharmacy and Research Centre, Phaphunda, Uttar Pradesh, India*
[3]*Dept. of Pharmacy, IIMT College of Medical Science, Meerut, Uttar Pradesh, India*
[4]*Dept. of Pharmacy, Mahaveer College of Pharmacy, Sardhana, Uttar Pradesh, India*

ARTICLE INFO

Article history:
Received 11-09-2021
Accepted 11-10-2021
Available online 19-11-2021

Keywords:
Ophthalmic drug delivery
Ocular bioavailability
Anterior and posterior segment
ODDS

ABSTRACT

The remarkable life structures and physiology of the eye presents huge difficulties to researchers in the field of visual medication conveyance frameworks. Nearby infusion is the most fitting and proper medication organization technique for the treatment of foremost front sickness. There are two kinds of hindrances in ophthalmic medication conveyance frameworks: static boundaries and dynamic obstructions. Static lamellae contain corneal, dermal, retinal, and retinal vessels while dynamic lamellae contain placental blood stream, conjunctiva, tear evacuation, and lymphatic seepage. These limitations influence the bioavailability of the medication. This article examines the limits of customary ophthalmic practice and the central point affecting the pharmacokinetics of the eye. Likewise, eye salves, gels, prodrugs, intranasal infusions, thickeners, entrance energizers, liposomes, microparticles, nanoparticles, visual infusions, inserts, nanoparticles, nanostructures, microemulsions, gels and periocular infusions. It guarantees the bioavailability of the medication and the controlled and constant control of the medication in the foremost and back alveoli.

1. Introduction

Ophthalmic medication conveyance frameworks are perhaps the most thrilling and testing challenge confronting drug specialists. The natural chemistry, life systems, and physiology of the eye make this organ extremely delicate to unfamiliar items. The ophthalmic medication conveyance framework can be partitioned into foremost and back. Traditional techniques, for example, eye drops, balms, and suspensions, can't be utilized to treat eye-compromising eye conditions. 90% of the medication is as eye drops. Eye drops are essentially used to treat the front of the eye. Skin meds don't leave direct view.[1] The back eye (retina, glassy humor, and choroid) is treated with high dosages of medications intravenously or into the eye, or embeds or infusions around the eye. The objective of medication treatment is the proceeded with treatment of the sickness. The greatest test is to eliminate the eye block without harming the tissue. The impact of a medication relies upon its focus. The objective of the treatment plan is to expand the centralization of the dynamic fixing in the careful focus inside a sensible measure of time. The properties and discharge of ophthalmic medications rely upon the life systems and

physiological properties of the eye, just as on the physical and substance properties of the medication. As displayed in Figure 1, the focal point of movement of anti-

* *Corresponding author*.
E-mail address: sk8006721807@gmail.com (S. Mandal).

https://doi.org/10.18231/j.jpbs.2021.012

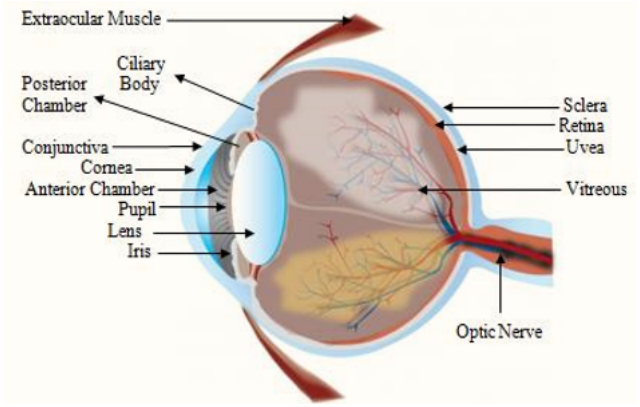

Fig. 1:

microbials, antivirals, and steroids is the focal point of disease and aggravation prior and then afterward the eye. The requirement for a solitary treatment somewhere else in the eye (Patel PB, 2011).

1.1. Normal eye infection

Bacteria are the most widely recognized reason for eye diseases. Infections, growths, and parasites can likewise cause eye contaminations. The eyes are defenceless to numerous sicknesses, however the most widely recognized are:

1. Conjunctiva
2. Blepharitis
3. Cataracts
4. Keratitis
5. Glaucoma
6. Uveitis (front uveitis) (Kumar K, 2013).

1.2. Physiological considerations

The rate at which a medication is assimilated into the eye is exceptionally restricted because of physiological limits.[2–7] Notwithstanding factors restricting the ingestion of the impermeable corneal obstruction of the eye. The cornea essentially comprises of three layers: epithelium, endothelium and stroma, which are the principle adsorption hindrances for particle transport measures. The tight bond of the corneal epithelium goes about as a particular boundary for little atoms, forestalling the dissemination of huge particles through the entry of nearby cells. The subepithelial grid is the hydrophilic layer that makes up 90% of the cornea. The corneal endothelium is liable for keeping up with the cornea's regular dampness. Subsequently, the more fat in the oil, the more safe it is to the section of substrates, and the abundance water becomes medication. It is the different physical and synthetic properties of medications that adjust the level of porousness, like solvency, steatosis, atomic size and shape, charge and level of ionization, and the pathway through the cornea (Sampath K, 2012).

1.3. Pharmacokinetic contemplations

This is the underlying phase of medication control and eye conclusion. For instance, a few courses are connected.

1. a) The tear liquid goes through the cornea and enters the primary compartment.
2. b) Non-corneal medications enter the foremost uvea through the conjunctiva and dermis.
3. c) Medication conveyance from the circulation system to the main fluid embolism chamber.
4. d) The medication is delivered from the circling liquid in the initial chamber into the trabeculae and congenital fissure.
5. e) Removal of medications from body liquids in the protected pathway because of nobility embolism.
6. f) Blood development to the back eye because of impediment of retinal hematopoiesis.
7. g) Drug association of glassy humor.
8. h) Medication discharge from the back glassy lot due to hematogenous retinal impediment.
9. i) Medications are infused posteriorly through the foremost chamber in the glassy (Marmer MF, 1985).

When using topical ophthalmic medications, they are first mixed with tears. The duration of contact with the drug is shortened (1-2 min) due to the sustained release of tears (0.5-2.2-L/min). Then, at this point, about half of the drug passes through the upper tube and the other half through the lower tube into the lacrimal sac and nasal cavity. When the heart (all 12) beats toward the nasal cavity, tear damage quickly removes the traditional interstitial structure. It enters the choroidal retina through a cycle of epicorneal or conjunctival sclerosis.[8–16] The iris and ciliary body are probably irrigated by both corneal and extracorporeal routes (Borlazis et al.,1998).

1.4. Difficulties in ophthalmic drug delivery system

Specific tests to design complex reconstitution regimens for ophthalmic medication conveyance frameworks discover ideal medication bunches in unique locales and give high recuperation potential to visual conveyance frameworks. The basic construction, physiology and occlusive limit of the cornea compromise the quick ingestion of the medication. Eye drops ought to be ingrained consistently to keep a sufficient portion in the tear film or dynamic region. Normal utilization of profoundly focused grids can make poisonous incidental effects and harm cells of visual surfaces. The unprotected bioavailability of the medication in the visual vehicle medium is primarily because of previous components, including angle filtration, lacrimal components, fistulas, tear inversion, desensitization, conjunctival resorption, and short home occasions. The

overall impermeability of the epithelial layer of the cornea presents a significant issue for the vehicle of medications from the foremost portion to the skin tissues. These are sensible cut-off points, they are not difficult to apply in medication, they address under 1% of the increase and are outwardly saved. Clinically compelling. A compelling definition is to keep a harmony among lipophilicity and hydrophilicity for a more drawn-out contact time (Patel P. B, 2011).[17–20]

1.5. Anterior segment drug delivery challenges

The problem is to survive through segmentation. In ocular conditions, it is generally preferable to select the effective tissue over the underlying tissue. Because the drug is injected visually, it must cross the border of the forehead before it reaches the physical barrier of the cornea. It is the first barrier that slows down the diffusion of the functional components of the eye; it is part of the tear film and conjunctiva. The bioavailability of the unprotected drug in the visually measurable structure is mainly due to the main orbital factor. In addition, continued use of eye drops is very important to maintain the level of drug available in the tear film or active site. However, in general, the use of deep and well-designed arrays can cause harmful side effects and damage to the cells of the visual surface (Steinfeld A, 2004).

1.6. Posterior segment drug delivery challenges

Skin visual solutions don't accomplish the back fragment drug centers in view of the incredible ability of the blood-retinal hindrance (BRB). The presence of solutions to the back section of visual tissue is denied by the very factors that are committed for the unprotected visual bioavailability. Moreover, the blood-retinal impediment bound the reasonableness of the intravenous course in back drug development. The decent intersection points of the blood-retinal impediment confine the piece of commonly organized solutions in to the retina. A high vitreal drug fixation is needed in the treatment of back region illnesses. Blood-retinal impediment is unequivocally permeable to extra lipophilic particles fundamentally controls the passage of medication particles into back section of the eye. Habitually relationship of medication prompts fundamental unintentional effect.

One more test for back part is to stay aware of the therapeutic medication place over conceded periods and diminishing the measure of blends. Medication is disposed of through the front course, that is, to the watery humor then, at that point killed by the absence of the humor in the chief chamber point. Various medications are likewise disposed of through back course through the blood-retinal deterrent to the focal dispersing (Myles M. E, 2005).

1.7. Optimal characteristics of ophthalmic drug delivery system

These are the distinctive ideal ascribes of ophthalmic drug transport system, for instance,

1. a) Extraordinary corneal infiltration.
2. b) Most outrageous visual drug absorption through haul out contact time with corneal tissue.
3. c) Clear instillation for the patient.
4. d) Cut-off the repeat of drug association.
5. e) Work on tireless consistence.
6. f) Reduces the hurtfulness and coincidental impact.
7. g) Reduce the pre corneal drug hardship.
8. h) Should not cause clouded vision.
9. i) To some degree nongreasy.
10. j) Fitting rheological properties and groupings of the thick structure (Gadbey R. E, 1979).

1.8. Approaches in ophthalmic drug delivery system

Early methods can be divided into two main categories. One is to increase bioavailability and the other is to transport a controlled release product. This method can be used to increase bioavailability. According to the degree of the positive effect of visual preparations, two categories can be distinguished. One relies on the use of thickenings and enhancers, prodrugs, gels and liposomes to increase drug retention in the cornea and reduce damage to the foreskin. The following is based on the use of a compatible drug delivery structure that allows the regular and controlled administration of ophthalmic drugs such as additives, nanoparticles, small particle implants, colloids, etc.

Traditional methods such as consistency enhancers, gels, dispersion enhancers, prodrugs and liposomes, increase the bioavailability of drugs right before your eyes. Modern techniques such as in situ gels and implants increase the bioavailability of the drug in the eye and control the entry of the drug into the eye in the most developed part of the eye.

In addition, approaches such as intravitreal injection, iontophoresis, subconjunctival injection, and the periocular cycle are used to deliver eye drops to the back of the eye (Patel P. B, 2011).

1.9. Approaches to manage or improve ocular bioavailability

1. **Gel-** This definition is intended to improve consistency with increasing thickness with a slight delay over the previous start time. The gel-based structure reduces the basal absorption capacity. Thicker gels can alter bioavailability, reducing reuse to once a day. Although this is a very concentrated gel, it is usually not suitable for patients due to dark eyelids. Polymers such as polyvinyl alcohol

(PVA), polyacrylamide, poloxamers, HPMC, carbon monomers, thermal poly-methylvinyl anhydride, and hydroxy-propyl-ethyl-cellulose are commonly used in liquid gels. Water-insoluble swellable polymers called hydrogels, or polymers with inhomogeneous aqueous dispersion properties, provide a controlled drug delivery structure. The composition of this system is created by transferring substances that are soluble in the polymer structure and are especially important for growth. Recent developments include dispersing solutes in reinforcing polymers to facilitate their degradation (Ali M, 2017).[1]

2. **Eye ointments-** These are for the most part ready by using a blend of semisolid and solid hydrocarbons (paraffin) which have a condensing and progressing direct close toward inner warmth level and are non-irritating to the eye. Treatment may be fundamental bases, where the emollient constructions one is the continuous stage, or mix bases where a two-phase system like emulsion. The helpful substance is incorporated the base as game plan or as a finely micronized powder. Ointments separate in to minute drops and stay as a stop of the medicine for complete periods. These are significant in further develop drug bioavailability and in supporting prescription release. Treatment is ensured and all around suffered by the eye, medicine suffer with comparably diminished patient consistence due to clouding of vision and aggravation (Raghava S, 2004 and Ashaben P, 2013). The hitter bioavailability of drugs from analgesic bases is an immediate consequence of a couple of components likes: (I) higher feasible obsession (ii) impediment of debilitating by the tears (iii) extended tissue contact time and security from nasolachrymal leakage (Shell J, 1984).[18]
3. **Penetration enhancers-** Increasing the permeability of the corneal epithelium can increase the commercial autonomy of the entire cornea. The typical epithelial lining of the cornea is a strong molecule that moves tissue. One of the methods used to increase the bioavailability of ophthalmic drugs is to rapidly increase the credit score of corneal permeability using appropriate substances known as invasive enhancers or admission enhancers. These are disorders such as visual impairment and toxicity. Transporting the drug from the cornea to the receptor site is the rate limiting step. Gait enhancers increase corneal absorption by altering the originality of the corneal epithelium. cetroid chloride, benzalkonium chloride, ionophore (for example, razaroside), tween 20, parabens, saponins, suspension 35, suspension 78, suspension 98 interact with ethylenediaminetetraacetic acid, bile salts and bile acids (such as sodium). destructive, fusidic acid, azone, saponins, hexamethylene tanamide and decylmethyl sulfoxide radically increase the absorption of corneal agents under various conditions (Gadbey RE, 1979).
4. **Microsomes -** This is reliable scatterings of water and oil worked with by a blend of surfactant and co-surfactant in a manner to decrease interfacial strain. Microemulsion upgrades the visual bioavailability of the remedy and diminished rehash of the affiliation. This design is routinely depicted by higher thermodynamic tenacity, little spots size (100 nm), and clear appearance. Oil and water framework containing pilocarpine drug utilizing lecithin, propylene glycol (surfactant), PEG 200 (co-surfactant), and isopropyl myristate as the oil stage has been orchestrated. It is nonirritating to the eye. An especially two or three definitions give maintained solution discharge, hence lessening the rehash of medication affiliation (Leucuta S.E, 1989).
5. **Liposomes-** These are tiny vesicles composed of one or more concentric lipid bilayers separated by a space containing water or liquid. It has therapeutic potential for vision because it has the ability to adhere to the conjunctival surface of the cornea. These limitations are especially attractive for drugs that burn ineffectively, have a slow packaging rate, low solubility, or have a medium to high load on the inner core. Obviously, highly charged liposomes were obtained aberrantly on the antagonistically charged surface of the cornea in the form of differentiated, undistorted, or reversely charged liposomes. Naturally biodegradable and biocompatible. This reduces the ability to destroy the drug and allows for continuous and rapid site transfer. Aseptic delivery is difficult. These are such limitations as the amount of drugs and lack of water (Peyman G.A., 1995).
6. **Nanosuspension -** It is described as a submicron colloidal structure containing a water-insoluble drug suspended in a suitable dispersion medium coated with a detergent. Colloidal carriers such as polymer juices are usually latent in nature. It's all about the visual bioavailability of drugs by increasing the time spent at home. The outer layer of nanoparticles pulls on the cornea, causing it to stress (Leucuta S.E, 1989). Relief Nanosuspension is best suited for high energy drug compounds that are highly insoluble in conventional (lipophilic) or hydrophilic media. These carriers do not alter the cornea, iris, or conjunctiva and can be opaque carriers for ophthalmic preparations (Harikumar S, 2011).
7. **Viscosity enhancers -** Thickness enhancer polymers are typically remembered ophthalmic drug courses of action for the standard that an extended vehicle consistency. Should contrast with an all the more lethargic ejection from the preocular area, which

lead to redesigned precorneal home time, and along these lines a more conspicuous transcorneal dispersal of the drug into the front part of the eye. It has least effect similar to progress in bioavailability. Polymers used fuse polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), methylcellulose, hydroxyethylcellulose, hydroxypropyl methylcellulose (HPMC) and hydroxypropylcellulose. PVA was more fruitful. This is an aftereffect of its concrete properties and its capacity to overhaul the thickness of the precorneal tear film. Shown that the upkeep of drug in the precorneal tear film isn't completely associated with the thickness of the vehicle, and the limit of a polymer to steady water as the vehicle spreads over the visual surface with each bink (Gadbey R.E, 1979).

8. **Niosomes**- These are bilayer vesicles containing nonionic surfactants. Excellent personalization of lipophilic and hydrophilic materials. Niosomes decrease alkaline drainage, encourage more time at home, and alter visual bioavailability. It is inherently non-biodegradable and non-biodegradable. It was used to transport cyclopentrate and was given the definition of nios. Take medication regardless of pH. This represents a fundamental improvement in visual bioavailability. Niosome levels are coated with polymer Carbopol and chitosan (Peyman G.A., 1995).
9. **Prodrug -** Prodrugs also increase the permeability of the drugs to the cornea by altering the drug's characteristic hydrophilic and lipophilic properties. After intracorneal or corneal infiltration, prodrugs are applied artificially or enzymatically to enhance the action of the substances. Therefore, the ideal prodrug would be more lipophilic and have a higher modulus of elasticity, and also have a serious disadvantage during movement. Visually clear structure of tissue protein, including esterase, ketone reductase and steroid-6-hydroxylase. The prodrug is another component of the drug. Therefore, proper disposal requires extensive pharmacokinetic and pharmacological information. Several cases of susceptible prodrugs have been associated with the antiviral drugs ganciclovir and acyclovir. The acronym for ganciclovir, an acyl ester-producing drug, is a drug with an almost low packing ratio, which greatly increases the amount of drug that can enter the cornea. The redesign of the patent is directly related to the additional disadvantage that ganciclovir esters induce hydrolysis of esterase in the cornea (Sultana Y, 2006).
10. **Nanoparticles / Nanospheres-** Nanospheres produce colloidal particles ranging in size from 10 nm to 1 mm. The drug is separated, trapped, adsorbed, or exposed to these particles. Drug incidents lead to drug changes. Nanospheres are used as ophthalmic carriers. Also described as nanospheres (small, center-seated compartments wrapped in plastic wrap) or nanocapsules (solid metric circles). Nanocapsules are more efficient than nanospheres. Nanocapsules are a direct result of their bioadhesive properties, which balance indoor residence time and natural response. This increases the visual bio availability of the drug and decreases dose relapse (Peyman GA, 1995).
11. **In situ-forming gel -** Gel drops are liquid and incorporate a phase progress measure with the advancement of a viscoelastic gel that causes changes in the environment. Work on steady tirelessness. This defers the home time and constructs the bioavailability of the medicine in the eye. Limits that can cause a phase progress of a gel with falling join pH, temperature and ionic strength (Ali M, 2017).[1]

1.10. Approaches to deal with controlled and continuous ocular drug delivery

1. **Ocular inserts-** Occular augmentations give more controlled, upheld, and continous drug transport by keeping a suitable medicine center in the goal tissues. It reduces the essential maintenance of the prescription. It causes careful dosing of the prescription. Different visual augmentations were arranged using various systems to make dissolvable, hydrogel, nonerodible, and erodible enhancements (Anita K, 2010).
2. **Implants-** The purpose of the placement of the intraocular insert is to delay movement through the continuous drug delivery system made of the polymeric material for placement. For minor surgeries, an eye implant is required. Ultimately, they are located inside the vitreous humor of the eye. Nutritional supplements benefit from- (a) Visual prevention of blood entry and sustained delivery of prescribed drug levels.(b) Reduce the side effects associated with ongoing essential and intravitreal grafts.(c) Several prescriptions are required during treatment. Visual aids are called biodegradable and biodegradable devices. Non-biodegradable dietary supplements reliably control the release of active ingredients and have a longer transit time than biodegradable polymers (Anita K, 2010).[2]
3. **Microparticles -** These are polymer particles of the micro-meter range containing a drug suspended in a liquid medium. The recipe can be dispensed onto a polymeric tissue or covalently attached to a polymeric column. Before the skin evaporates, the particles are present in the visual medicine motor system. They also release drug from particles through association, association reactions, or polymer degradation potential. The microparticles act during the previous appearance, allowing the drug to appear continuously and consistently. From now on, work on visual prescription bioavailability and reduce

repeated doses. Biodegradation, bio-adhesiveness and biocompatibility are properties that help create microparticle polymers for ophthalmic use.

1.10.1. Example

1. a) Model with methylprednisolone microspheres artificially coupled with hyaluronate.
2. b) Egg whites are packed with pilocarpine or gelatin microspheres.
3. c) Acyclovir folded with chitosan microspheres (Peyman GA, 1995).[21]

1.11. Approaches to deal with posterior segment drug delivery

1. **Periocular route -** Periocular course is the guideline course for directing remedies to back eye portion. Periocular is the area close to the eyes. Remedy strategies are applied in closeness to the sclera, which accomplish high retinal, vitreal fixations. These are benefits like expansion the solution absorption over from an overall perspective and topically passed on informed authorities. This development is guaranteed to the back piece of the eye ball, then, at that point the fundamental affiliation (no essential perniciousness), drug transport to the objective site of the eye. Implantation show first requesting energy (quickly increment the medication level might cause the remedy destructiveness) (Sultana Y, 2006).[20]
2. **Iontophoresis -** Visual iontophoresis is of particular interest because upward and backward eye movements are non-invasive. Film transfer of ionized drugs is a non-invasive method. The drug penetrates through the layer through two scaffolds: transport and electric (Sultana Y, 2006).[20]
3. **Intravitreal injections -** In this strategy, the implantation of prescription course of action is directly injected into lustrous through pars plana utilizing a 30G needle which grows the drug maintenance over topically and essentially passed on subject matter experts. This communication is use to assigned medication transport system. It has greater security drug movement to the back part to the eye then key association (no fundamental hurtfulness). Various courses, intravitreal implantation give high prescription obsessions in shiny and retina. End of medicine depends upon its sub-nuclear weight. Intravitreal implantation conveys high drug obsessions in retina. Other than patients should be meticulously seen in intravitreal implantations. These are obstacles like implantation show first solicitation dynamic (rapidly increase the medicine level may cause the drug hurtfulness) (Sultana Y, 2006).[20]

2. Future Aspects

In the future, most nutritional supplements will be offered as long-acting non-invasive drugs for treating two-component eye problems. The ideal structure should provide a reasonable long-term immobilization of the active ingredient in the target tissue while reducing central absorption. In addition, the design should be comfortable and convenient. In the future, patient identification will remain an important component of the transport structure for prescription ophthalmologists. A useful way to avoid deficiencies in personal development is to participate in development. The main model is liposomes and nanoparticles coated with bioadhesive polymers, liposomes and nanoparticles in gel form. Future challenges for cutaneous transport systems in visual medicine include: 1. Visual bioavailability should be changed from less than 1% to 15-20%. 2. Most of the advertised visual recipes are created for non-visual applications without getting a real ID. In this sense, we need to open up new possibilities for visual medicine. Rational placement and packaging of this transport system requires further research. There have been some thoughtful and creative developments that are driving progress in this area. In particular, advances in nanotechnology and biomaterial science can adapt advances in ophthalmic drug delivery to new acute events (Joshi A, 1994).[6] Below are the various visuals shown in the Market Directions section of Table 1.

Table 1: Available ocular product

S.N.	Dosage Form	Active Pharmaceutical Ingredient	Company Name
1.	Eye Drop	Fluorometholone and Neomycin Sulphate	Cipla
2.	Eye Ointment	Ciprofloxacin	FDC
3.	Eye Gel	Dexpanthenolum	Bausch & Lomb

3. Conclusion

Extensive research has been done on the structure of the drug's visual movements. An increase in the initial duration of action of a topical prescription in the cornea and conjunctiva is normal. Several new medical approaches are in early stages of development, such as liposomes, nanoparticles, collagen screens, visual enhancements, field-approved gel schemes, propagation routes of non-corneal visual compositions, nanoparticle-based polymer schemes, and gels. build. Patient confidence is essential for the implementation of a convenient ophthalmic drug delivery system. Significant improvements are needed across all structures, including delayed release of improved recipes, large scale collection, and reliability.

4. Source of Funding

None.

5. Conflict of Interest

The authors declare that the review was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest

6. Acknowledgment

The authors are thankful to his/her parents.

References

1. Alhalafi AM. Applications of polymers in intraocular drug delivery system. *Oman J Ophthalmic*. 2017;10(1):3–8. doi:10.4103/0974-620X.200692.
2. Kumari A, Pramod K, Vipin K, Garg G. Ocular inserts Advancement in therapy of eye diseases. *J Adv Pharm Technol Res*. 2010;1(3):291–6. doi:10.4103/0110-5558.72419.
3. Patel A, Cholkar K, Agrahari V, Mitra AK. Ocular drug delivery systems: An overview. *World J Pharm PMC*. 2013;2(2):47–64. doi:10.5497/wjp.v2.i2.47.
4. Bourlais L, Acar L, Zia H, Sado P, Needham T. Ophthalmic drug delivery systems–recent advances. *Prog Retin Eye Res* . 1998;17(1):34–52. doi:10.1016/s1350-9462(97)00002-5.
5. Gadbey RE, Green K, Hull DS. Ocular preparations: the formulation approach. *J Pharm Sci*. 1979;68:1176–84.
6. Harikumar S, Arora S. Nanotechnological approaches in ophthalmic delivery systems. *Int J Drug Dev Res*. 2011;3(4):9–19.
7. Henry F, Edelhauser CL, Rendleman MR, Robinson DG, Dawson GJ, Chader HE, et al. WongCurr Drug Deliv.Sultana YJain RAqil MAli A. Ophthalmic Drug Delivery Systems for the Treatment of Retinal Diseases: Basic Research to Clinical Applications. *Invest Ophthalmol Vis Sci*. 2010;51(11):5403–20.
8. Joshi A. Recent developments in ophthalmic drug delivery. *J Ocul Pharm Ther*. 1994;10:29–45.
9. Kumari A, Pramod K, Garg VK, Garg G. Ocular inserts — Advancement in therapy of eye diseases. *J Adv Pharm Technol Res*. 2010;1(3):291–6.
10. Kumar KPS, Srivastava S, Bhowmik D, Paswan S. Recent Challenges and Advances in Ophthalmic Drug Delivery System. *Pharm Innov*. 2012;1(4):1–15.
11. Raghava S, Hammond M, Kompella UB. Periocular routes for retinal drug delivery. *Expert Opin Drug Deliv*. 2004;1(1):99–114. doi:10.1517/17425247.1.1.99.
12. Shastri PB, Shelat DH, Shukla PK. Ophthalmic Drug Delivery System: Challenges and Approaches. *Syst Rev Pharm*. 2011;1(2):382–423.
13. Myles ME, Neumann DM, Hill JM. Recent progress in ocular drug delivery for posterior segment disease: emphasis on transscleral iontophoresis. *Adv Drug Deliv Rev*. 2005;57(14):2063–79. doi:10.1016/j.addr.2005.08.006.
14. Marmor MF, Negi A, Maurice DM. Kinetics of macromolecules injected into the subretinal space. *Exp Eye Res*. 1985;40(5):687–96. doi:10.1016/0014-4835(85)90138-1.
15. Leucuta SE. Microspheres and nanoparticles used in ocular delivery systems. *Int J Pharm*. 1989;54:71–9.
16. Kumar K, Bhowmik D, Harish G, Duraivel S, Kumar P. Ocular Inserts: A Novel Controlled Drug Delivery System . *Pharma Innov J* . 2013;1(12):1–16.
17. Sasaki H, Igarashi Y, Nagano T, Yamamura K, Nishida K, Nakamura J. Improvement of the ocular bioavailability of timolol by sorbic acid. *J Pharm Pharm*. 1995;47:17–21.
18. Shell J. Ophthalmic Drug Delivery Systems. *Surv Ophthalmol*. 1984;29:117–28.
19. Steinfeld A, Lux A, Maier S, Süverkrüp R, Diestelhorst M. Bioavailability of fluorescein from a new drug delivery system in human eyes. *Br J Ophthalmol*. 2004;88(1):48–53. doi:10.1136/bjo.88.1.48.
20. Sultana Y, Jain R, Aqil M, Ali A. Review of ocular drug delivery. *Curr Drug Deliv*. 2006;3(2):207–17. doi:10.2174/156720106776359186.
21. Peyman GA, Ganiban GJ. Delivery systems for intraocular routes. *Adv Drug Deliv Rev*. 1995;16(1):107–30. doi:10.1016/0169-409X(95)00018-3.

Author biography

Suraj Mandal, Assistant Professor

Km. Shiva, Student

K Pavan Kumar, Associate Professor

Sweta Goel, Associate Professor

Ramesh Kumar Patel, Assistant Professor

Shital Sharma, Assistant Professor

Renu Chaudhary, Associate Professor

Arti Bhati, Associate Professor

Netra Pal, Assistant Professor

Ashwani Kumar Dixit, Assistant Professor

Cite this article: Mandal S, Shiva K, Kumar KP, Goel S, Patel RK, Sharma S, Chaudhary R, Bhati A, Pal N, Dixit AK. Ocular drug delivery system (ODDS): Exploration the challenges and approaches to improve ODDS. *J Pharm Biol Sci* 2021;9(2):88-94.