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Review Article

Evaluation of Microneedle Drug Delivery System and Nanoparticles Use in COVID-19 Patients

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Abstract

Microneedle is a new form of a transdermal delivery system, which increases its potential for the delivery of drugs to the site of action. Nanoparticles can be used as a drug delivery system that provides both enhancement of drug efficacy and a decrease in side effects. In this review we focused on their use for prevention and treatment of coronavirus disease-2019 (COVID-19).

Key words: Coronavirus, COVID-19; Drug Delivery; Nanoparticles; Microneedle.

Introduction

At the end of 2019, a group of pneumonia patients of unknown cause emerged in Wuhan, China [1]. Subsequently, the World Health Organization (WHO) announced a standard format of Coronavirus Disease-2019 (COVID-19), according to its terminology, for this novel coronavirus pneumonia on February 11, 2020.

Nowadays, most methods used for the transdermal drug delivery system are topical creams, transdermal patches, hypodermic needles. The effect of most of the drugs and agents which used in this method are of low value due to the presence of stratum corneum layer in the skin which acts as barrier for molecules making few of them able to reach its site of action [2]. Therefore, the transdermal drug delivery system has been developed to appear another method which called microneedles.

Microneedle is a smart approach and a new form of a transdermal delivery system, which increases its potential for the delivery of drugs to the site of action. It is a needle that is micro-sized with a height of 10-2000 μm, and its width is 10-50 μm, which can penetrate to dermal tissue directly without pain. Microneedle can deliver molecules of different sizes and forms. It is considered as a device of drug and vaccine delivery. It can be capsulated with live or inactivated virus vaccine, DNA vaccine, or antigen. Hollow microneedle is used widely in influenza vaccinations. Microneedle has many advantages as its administration is feasible and painless and it increases penetration of the skin and delivers different size of drug and vaccine [3].

Nowadays, many studies have registered to study the effect of using microneedle in vaccinations of COVID-19 as the skin is an excellent site for immunization, as it is rich in antigen and accessory cells. Microneedle developed to physically breach the stratum corneum then rapidly dissolve in the epidermis and dermis. Therefore, the use of microneedle in delivery of vaccinations results in high-concentration delivery of the vaccine. The use of microneedle lead to a decrease in the required dose, decrease the toxicity and increase the efficacy of vaccines.

Kim and his colleagues reported the development of a vaccine against SARS-CoV-2 that seems to be effective in animal models [4]. They used a micro-needle system for vaccine administration; each one made of glucose and fragments of viral spikes proteins that penetrate through the skin and dissolve in the epidermis [4].

Nanoparticles (NPs) are the materials that have nano-scale in all dimensions. NPs have different and more attractive proprieties than bulker substances. By focusing on their achievements in medicine, we find numerous applications that include: (I) Body's imaging techniques before diagnosis, e.g., CT, MRI, SPECT, PET. (II) Laboratory biomedical analysis in-vitro identification of biological molecules and acting as biomarkers. (III) The revolution of utilizing NPs for drug delivery [5].

Advantages of Nanoparticles for Drug Delivery

NPs, as a drug delivery system, provide both enhancement of drug efficacy and a decrease in side effects. Making drugs in the nano-size or attaching it with nanocarriers can alter the physiochemical pharmacokinetic and pharmacodynamic properties of the drug. NPs introduction improves the absorption,

distribution, and penetration features of the drug. This allows the availability of different routes of administration (parenteral, oral, and inhalation) [6]. Site-targeting is a promising advantage either passively by the increased permeation or activated by attaching recognition elements and selective sensors to receptors in the targeted tissues. NPs have a high capacity for drug loading, which means a higher concentration of drug can be delivered to maintain the effective therapeutic dose of the drug. Controlled and sustained release by using the multilayer technique is available [7].

Classification of NPs

NPs may be formulated in numerous forms [5-7]:

- Liposomes: NPs which have both aqueous and lipid compartments so can entrap both hydrophilic and lipophilic agents as gene, protein, or vaccine.
- Dendrimers (the hyperbranched NPs) are used mainly in long-circulating and targeted therapies.
- Polymeric micelles are most important in improving the solubility of hydrophilic drugs and decrease their degradation and clearance from the body.
- Polymeric NPs contain both colloidal vesicular and matrix systems.
- Solid lipid nanoparticles (SLNs) are limited to drugs dissolved in solid lipid but have a high role in increasing the stability of easily degraded particles and targeting.
- Nanostructure lipid carriers (NLCs) overcome the limitation of SLNs to be wider applicable.

Unfortunately, some disadvantages are discovered upon applying nano strategies. The balancing between the benefit and the related danger of NPs can determine the scope of utilization. It is a challenge for responsible seeking to diminish these unwanted side effects. On the other side, Nanotechnology has been achieved noticeable success in the medical application.

Antiviral therapies, prophylaxis, or even immunostimulant adjuvants can be supported by the incorporation of nanostructures depending on their preferable properties. Hydrogels NPs have the ability to entrap the viral′s vital components as the Influenza virus and are expected to be modified to suit the other viruses [8].

The world, nowadays, is suffering from the pandemic coronavirus disease-2019 (COVID-19). Great efforts have been oriented by scientists and researchers as attempts to overcome this crisis. Fighting COVID-19 demands high peoples′ awareness. It begins with adequate protection and highly sensitive and quick diagnosis, which are of the same importance as the treatment of the already infected persons.

Nanotechnology can help in different stages.

- Forming highly protective masks with nano-attached filters and nano-dependant disinfectants is of far benefit.
- The selectivity, bioavailability and penetration′s ability of antiviral, vaccines and immune-stimulant drugs can be synergized by attaching with NPs
- Depending on the reports and the information published by the WHO about COVID-19, no official final protocol of treatment or even vaccination are available yet [9].

One of the aimed approaches is to decrease the severity of the life-threatening symptoms associated with COVID-19. Damage of many organs as lungs is motivated by the excessive release of inflammatory and immune cells as a response of the body against this viral infection. So, introducing a suitable anti-inflammatory agent is recommended. Methotrexate (MTX) is a suggested drug used mainly as an antineoplastic and antirheumatic drug [10]. Additionally, MTX affects the inflammatory mediators (e.g., interleukins, prostaglandins, cytokines, and others) either directly by alteration of their synthesis and degradation or indirectly by alteration of their response [11]. Currently, a clinical trial was registered and running in Brazil to evaluate the efficacy and safety of MTX-loaded nanoparticles to treat severe COVID-19 patients with three different doses [12].

Another study was registered in Australia to evaluate the immunogenicity and safety of the SARS-CoV-2 rS nanoparticle vaccine in healthy participants [13]. Further trials will be planned sooner to utilize the advantages of nanoparticles for prophylaxis against the infection and treatment of COVID-19 patients.

In conclusion, using the microneedle drug delivery system and nanoparticles for the development of COVID-19 vaccines or enhanced delivery of some medications seems to be effective and successful nearly.

Conflict of Interest

The authors state that there are no conflicts of interest.

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