Editorial

Nanomedicines for dental applications-scope and future perspective

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Abstract

Nanotechnology is directed at manipulating matter at the nanometer level and the application of the same to medicine is called nanomedicine. Over the past few years researchers have developed various nanomedicines for diagnosis, prevention as well as cure of various ailments both locally and systemically. In dentistry, drug loaded nanopharmaceuticals based on nanomaterials have been utilized extensively over the past few years to cure dental problems and facilitate attainment of a near-perfect oral hygiene. Although various drug delivery systems have already been investigated for treating periodontitis, research is currently focused on nanodelivery systems for efficient targeted delivery of drugs to the periodontal pocket. In this context a few nanodelivery systems explored include nanocomposite hydrogels, nanoparticles, nanoemulsion etc. A number of herbal and synthetic drugs examples of which include trichlosan, tetracycline, Harungana madagascariensis leaf extract, minocycline, metronidazole, chlorhexidine have been encapsulated into nanodelivery systems for treating periodontitis. A few examples of polymers investigated as matrices for the delivery of drugs to the periodontal pocket include chitosan, Poly lactic-co-glycolic acid copolymer, poly e caprolactone, polylactic acid, polypropylene, cellulose acetate propionate and ethyl vinyl acetate. In the near future also nanotechnology is expected to find its application in all the specializations of dentistry ranging from diagnosis and treatment of oral cancers to development of colloidal suspension containing millions of active analgesic micron-size dental robots resulting in anesthesia in patients. In the light of the above facts the current editorial focuses on the applications of nanotechnology based nanomedicines which cannot be undermined in the improvement of dental health and hygiene both, in the current as well as in future scenario.

Key words: Dental, nanoemulsions, nanomedicines, nanoparticles

INTRODUCTION

Nanotechnology is directed at manipulating matter at the nanometer level and the application of the same to medicine is called nanomedicine.[1] The concept of "nanomedicine" was first put forward in 1993 by Freitas and was defined as observing, controlling, and treating the biological systems of the human body at the molecular level using nano-structures and nano-devices.[2] Over the past few years researchers have developed various nanomedicines for diagnosis, prevention as well as cure of various ailments both locally and systemically.

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In dentistry, drug loaded nanopharmaceuticals based on nanomaterials have been utilized extensively over the past few years to cure dental problems and facilitate attainment of a near-perfect oral hygiene. Nanomaterials are defined as materials with components <100 nm in at least one dimension, including clusters of atoms, grains <100 nm in size, fibers that are <100 nm diameter, films <100 nm in thickness, nanoholes, and composites that are a combination of these.[3]

NANODELIVERY OF DENTAL THERAPEUTICS

Among the nanoceuticals studied and developed for the treatment of dental ailments, majority are directed towards the treatment of periodontitis. Although various drug delivery systems have already been investigated for treating periodontitis, a few of which include dental fibers, gels, films, strips and compacts,[4] research is currently focused on nanodelivery systems for efficient targeted delivery of drugs to the periodontal pocket. In this context a few nanodelivery systems explored

include nanocomposite hydrogels,[5] nanoparticles (NPs),[6] nanoemulsions.[7] etc.

A number of herbal and synthetic drugs examples of which include trichlosan, tetracycline, Harungana madagascariensis leaf extract, minocycline, metronidazole, chlorhexidine have been encapsulated into nanodelivery systems for treating periodontitis. A few examples of polymers investigated as matrices for the delivery of drugs to the periodontal pocket include chitosan, poly lactic-co-glycolic acid copolymer, poly e caprolactone, polylactic acid, polypropylene, cellulose acetate propionate and ethyl vinyl acetate.

Recently tetracycline NPs loaded calcium sulfate composite beads prepared exhibited antibacterial activity against *Staphylococcus aureus* and *Escherichia coli* and were concluded to be beneficial in periodontal management to reduce the bacterial load at the infection site.[8] Earlier, results of the study conducted in dogs induced with periodontal defects and treated with triclosan-loaded NPs (thiolated chitosan [TCS]-loaded NPs) prepared by the emulsification-diffusion process using poly (D,L-lactide-co-glycolide), poly (D,L-lactide) and cellulose acetate phthalate suggested that TCS-loaded NPs penetrate through the junctional epithelium.[9]

Besides this, nanopharmaceuticals have also been utilized for periodontal tissue engineering and regeneration therapy. A novel approach utilised trapping of tetracycline hydrochloride — loaded particles in polycaprolactone nanofibers for the regeneration processes of periodontal tissue at the gum interface. Chitosan NPs loaded with different levels of tetracycline hydrochloride (up to 5% wt) were prepared by solution nebulization induced by electrical forces (i.e., electrospraying). The authors demonstrated that trapping tetracycline hydrochloride — loaded particles with submicrometer diameters into a polycaprolactone fiber network contributed to slowing the release of tetracycline hydrochloride from the NPs, thus providing a more prolonged release in the periodontal pocket during clinical therapy. Preliminary studies on human mesenchymal stem cells confirmed the viability of cells up to 5 days after culture, thereby validating the use of NP-/nanofiber-integrated systems in periodontal therapies.[10]

OTHER APPLICATIONS OF NANODELIVERY IN DENTISTRY

A study reported that compared to the other NPs, silver NPs had an antimicrobial effect on *Streptococcus mutans*, which is the main causative microorganism of dental caries, in lower concentrations and with lower toxicity.[11]

Besides the therapeutic advantages, advances in digital dental imaging techniques are also expected with nanotechnology. In digital radiographies obtained by nanophosphor scintillators, the radiation dose is diminished and high-quality images are obtained.[12]

Nanocomposites have also found wide application in dentistry. These systems provide a more stable and natural interface between the mineralized hard tissues of the tooth and the nanosized filler particle used by enhancing continuity between the tooth structure and these advanced restorative biomaterials. Nonagglomerated coatings to produce nanocomposites have been successfully manufactured by Nanoproducts Corporation. Aluminosilicate powder with a mean particle size of 80 nm and a 1:4 M ratio of alumina to silica and a refractive index of 1.508 was used as the nanofiller with advantages of superior hardness, superior flexural strength, modulus of elasticity, and translucency with 50% reduction in filling shrinkage and excellent handling properties.[13]

PATENT PERSPECTIVE

A number of patents have been granted based on the applications of nanotechnology in dental sciences a few of which include the US patent No. 8,889,196 assigned to University of Maryland, Baltimore which claimed dental composites comprising NPs of amorphous calcium phosphate with improved mechanical properties, and improved antibacterial properties and the US patent No. 6,593,395 assigned to Kerr corporation which claimed that the invention provided a dental composite which had the high strength required for load-bearing restorations, yet maintains a glossy appearance, even after substantial wear. The composite was useful in stress bearing restorations and in cosmetic restorations.[14,15]

FUTURE PERSPECTIVE

In the near future also nanotechnology is expected to find its application in all the specializations of dentistry. A few of its applications as reported in the literature, would include improved diagnosis and treatment of oral cancers, nanorobotic manufacture and installation of a biologically autologous whole replacement tooth, in production of subocclusal-dwelling nanorobotic dentifrices delivered by mouthwash or toothpaste which would patrol all supragingival and subgingival surfaces at least once a day, metabolizing trapped organic matter into harmless and odorless vapors and performing continuous calculus debridement and in production of a colloidal suspension containing millions of active analgesic micron-size dental robots to be instilled on the patient's gingiva resulting in anesthesia.[13]

Besides this, new potential treatment opportunities in nanodentistry as foreseen and documented by researchers could also include, local anesthesia, dentition renaturalization which would revolutionarize cosmetic dentistry, permanent hypersensitivity cure, complete orthodontic realignments during a single office visit, covalently bonded diamondised enamel, and continuous oral health maintenance using mechanical dentifrobots.[16,17]

CONCLUSION

In the light of the above facts the application of nanotechnology based nanomedicines cannot be undermined in the improvement of dental health and hygiene both, in the current as well as in future scenario. Although, it is proved beyond doubt that comprehensive oral hygiene as well as health can be easily maintained using nanodentistry supported by the principles of biotechnology and genetic engineering, the risk and toxicity associated with the use of such nanotherapeutics need more extensive investigation and understanding. Besides this, the cost effectiveness should also be considered as an important parameter by researchers for enhancing patient acceptance of such nano-devices.

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