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Nanotechnology: Its Role in Restorative Dentistry and Endodontics

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Review Article

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ABSTRACT

Nanotechnology has made its way into various fields of medicine and dentistry in a positive way. The current communication gives an insight into the various applications of nanotechnology in restorative dentistry and endodontics.

INTRODUCTION

Nanotechnology has been creating its niche in various aspects of dentistry and restorative dentistry and endodontics are no exceptions [1,2]. Nanotechnology deals with nanostructures, which may assume the form of surface nanoroughness, nanopits, nanomountains or nanoparticles. The properties at Nano scale differ significantly from the properties at bigger scale because of the increased surface area and the so called "quantum effect" which is the deviation in properties of particles when they are smaller than a characteristic size scale, of the order of few to few hundred nanometers. Under this size do the particulate nature of fundamental matter (molecules, atoms, ions, electrons) start to emerge, due to confinement effects, especially in light-matter interaction[1]. Quantum effect is used to maximize the desirable properties of materials, and restorative dentistry and endodontics have not remained untouched by this trend.

From the use of nanotechnology in composite resins for better optical and mechanical properties to the use of nanoparticles for disinfection of the root canals and further to the use of surface nanostructuring of dental implants for better osteo integration [3], the possibilities for the use of nanotechnology in dentistry are limitless. This article describes in brief the various ways in which nanotechnology has had an impact on restorative dentistry and endodontics.

APPLICATION IN RESTORATIVE DENTISTRY

Nanotechnology has impacted restorative dentistry in the material aspect the most. The major areas of application in restorative dentistry are as follows.

Nano particle filled restorative composite resins

The interest in nanotechnology for restorative composites is because of the fact that addition of nanoparticles allows for greater filler loading thereby enhancing the mechanical properties of the composite resins and allowing their usage in stress bearing areas of the teeth, like occluso- proximal cavities. The other reason for incorporation of Nano fillers is that these particles are smaller than the wavelength of visible light which don't allow the human eye to detect the presence of fillers. This has positive

implications on the optical property of these composites. Not only do the optical properties of resin composite improve because of the incorporation of nanofillers but there is also an improvement in the mechanical properties of the resin composites, like wear resistance and polishability thus giving these composites a broader usability in most areas of the oral cavity [4].

These composite resins are the result of bottom up approach of nanotechnology in which two types of nanofillers are used: namely nanomeric particles (NM) and nanoclusters (NC). NM are non-aggregated nano silica particles with an average diameter of 20 to 75 nm, while the NC fillers contain zirconia silica (particle size 2 to 20 nm) and pure silica (particle size 75 nm) which are used along with resin matrix, cured and milled to a small average size of 0.6 μm [1]. When tested for various mechanical properties, it was found that nanofilled composites had equal or superior properties as compared to other commercially available composite resins. It is also claimed by the manufacturers of nanofilled composite resins that the fillers wear out at the same rate as the matrix and thus don't become rough over time and retain their smoothness.

Recently titanium oxide has been used as nanofillers with good results [5]. It is also mention worthy that nanostructured porous filler particles have been used which eliminate the need for coupling agent as the resin matrix penetrates the porous nanofillers causing mechanical interlocking [6]. Though this type of coupling agent free restorative composite is still in the experimental stage but they are an exciting area of research, which may come in the market in the near future.

Commercially available nano filled composites is Filtek supreme XTE universal restorative composite resins.

Nanofilled bonding agents

These bonding agents contain silica nanoparticles, which don't tend to cluster while in storage and allow better bonding with minimal loss of the inorganic part of the enamel resulting in a bond which is more resistant to degradation in the oral cavity [7]. Commercially available bonding agent, which uses this technology, is 3M Adper single bond 2 adhesives.

Nanofilled glass ionomer cements

Addition of nanofillers to resin modified glass ionomers has resulted in the production of nanofilled glass ionomer cements which are intended for use in the restoration of primary teeth and small cavities in permanent teeth. Commercially available examples of the same are, Ketac N100 from 3M ESPE.

In studies both nanofilled composites and nanofilled glass ionomers have been found to be as suitable as conventional composites and glass ionomer for bonding of orthodontic brackets [8].

Treatment of dental hypersensitivity and remineralization of tooth structure

There has been major progress in this area with the use of nanotechnology. From the use of Carbonate hydroxyapatite nanocrystals in the toothpaste for occlusion of dentinal tubules and formation of a surface mineral layer or dentin [9] for the treatment of dentinal hypersensitivity, to the use of Electrospun mats of PVP/ACP (poly(vinylpyrrolidone)/amorphous calcium phosphate) nanofibres for remineralization of enamel tooth surfaces *in vitro* [10] on to the use of Scaffold of CMC/ACP (carboxymethyl chitosan/amorphous calcium phosphate) Nanocomplexes for the remineralization of demineralized dentine *in vitro* [11] for the treatment of deep carious lesions with promising results.

APPLICATION IN ENDODONTICS

In endodontics the use of nanotechnology encompasses disinfection of the root canal and its use in endodontic sealer.

Root canal disinfection

Zinc oxide nanoparticles, chitosan nanoparticles and silver nanoparticles have been used for the disinfection of the root canal. The use of the mixture of Zinc oxide nanoparticulates, chitosan nanoparticulates with zinc oxide based sealer improved the ability to leach out antibacterial component of the sealers [12]. In 2014 Annie et al. studied the antibacterial efficacy of photosensitizer functionalized biopolymeric nanoparticles in the presence of tissue inhibitors in root canal. The results of the study showed that these nanoparticles exhibited significant antibacterial properties even in the presence of tissue inhibitors within the root canals [13].

The use of silver nanoparticles in the form of 0.02% gel had a significant disrupting effect on the structural integrity of the *E. Faecalis* biofilm though the same results could not be replicated with the use of 0.01% silver nanoparticles syringe irrigation [14]. It may be noted that *E. Faecalis* is known to be the most commonly found microbe in failed root canal cases [15].

Nanotechnology in endodontic sealers

Shvero et al. demonstrated that by addition of quaternary ammonium polyethylenimine nanoparticles in popular endodontic sealers at low concentration enhanced the antimicrobial characteristics of these sealers [16].

It was also demonstrated by Barros et al. that the addition of these nanoparticles did not adversely affect the relevant mechanical and physiochemical properties of these sealers [17].

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CONCLUSION

Use of nanotechnology in various fields is an evolving process and slowly but surely it is impacting restorative dentistry and endodontics in a positive way. It is sure to enhance the various prevailing dental procedures and more and more materials and procedures may be based on it in the future. More and more research in the field of restorative dentistry and endodontics should concentrate at a nanoscale for the possibility of finding better, finer techniques, products and procedures for the treatment of diseases in the oral cavity and the restoration and replacement of the lost tissues.

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