Nanomed. J. 5(3): 121-126, Summer 2018

REVIEW PAPER

Applications of nanotechnology in endodontic: A Review

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ABSTRACT

Among the several available techniques to produce braided composite rods for the construction industry, nanotechnology is rapidly growing due to its favorable impacts on the properties of materials. Adding nano particles to a material can significantly affect its mechanical and physical properties. In recent years, nanotechnology has been applied in the field of medical sciences in order to enhance the quality of treatment procedures. This technology can be used in various aspects of dentistry. In the present study, a comprehensive literature review is conducted on the applications of nanotechnology in endodontics. It was concluded that nanotechnology can be utilized in fillers, irrigants and photodynamic therapy to achieve more beneficial results. Based on the reviewed studies, it is well acknowledged that antibacterial nano particles can be used for disinfection and have shown acceptable efficacy in elimination of bacterial cells. Moreover, nanotechnology is applicable to sealers used in endodontics. By using nano-sized materials, anti-leakage property of the sealer can be enhanced. In addition, nanotechnology can be applied in photodynamic therapy in endodontics. By using nanotechnology, it is possible to enhance the efficacy of this method.

Keywords: *Dentistry, Endodontic, Irrigant, Nanotechnology*

How to cite this article
Akbarianrad N, Mohammadian F, Alhuyi Nazari M, Rahbani Nobar B. Applications of nanotechnology in endodontic: A Review. Nanomed J. 2018; 5(3): 121-126. DOI: 10.22038/nmj.2018.005.0001

INTRODUCTION

Nanotechnology has been growing in recent years due to its ability to enhance the performance of various systems [1, 2]. There are several studies which have focused on the applications of nanotechnology in engineering fields [1, 3, 4]. In addition to engineering systems, nanotechnology can be applied in medical sciences [5, 6]. By applying nanotechnology, better treatment will be achievable [7, 8]. Nanotechnology provides the possibility of decreasing the size of devices [9, 10] and increasing the strength of materials [11, 12], which makes tools more appropriate for utilization in medical devices.

Various studies have been conducted on the application of nanotechnology in dentistry [13-17]. Nanotechnology can be applied in various areas of dentistry, such as diagnosis of diseases, treatment, and prevention [18-21]. For instance, Monfared et al. [22] conducted a study on the effect of nano particles on the filling composite used for restoration. It was observed that adding glass nano particles into the composite enhanced its mechanical properties. In another research, Kim et al. [23] investigated the influences of using nano-carbonate apatite on the re-staining after bleaching. Obtained results revealed that employing 10% nano-carbonate apatite led to lower color difference. Han et al. [24] carried out a study on the influences of nano-oxides on the stability of the color of pigmented maxillofacial silicone elastomer. Among nano particles tested in the study, including and , using resulted in the lowest color change.

Reviewing literature has demonstrated that Adding nano-sized materials to the toothpaste can augment toothpaste characteristics such as its remineralizing influence of artificial caries lesions [25]. Other specifications of toothpaste can also be improved by using nano materials. For instance, Santos Jr et al. [26] investigated a novel anti-caries

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Note. This manuscript was submitted on April 25, 2018; approved on May 15, 2018

agent, known as nano silver fluoride, in order to arrest caries in a group of children. The nano silver fluoride was used once a year in the study. The results indicated that, at seven days, 81% of investigated teeth in the group which utilized nano silver fluoride showed arrested caries, while there was no tooth arrested in the control group. As a consequence, it was concluded that the nano silver fluoride is appropriate for arresting dentine caries which were active.

In the present paper, the applications of nanotechnology in endodontics are focused. In order to get better insight into various applications, several studies are reviewed and the obtained results are presented. Furthermore, Summaries of the studies and their conclusions are pointed out.

Applications of nanotechnology in endodontic

As mentioned in the previous section, there are several applications for nanotechnology in the field of medical sciences. Since there are various nano materials which have antimicrobial properties [27], nanotechnology can be applied to endodontics in order to improve the quality of disinfection and treatment procedure [28, 29]. Fig 1 shows the various applications of nanotechnology in the field of endodontics being tested until now.

As shown in Fig 1, nanotechnology can be used in various fields of endodontics. For instance, Ibrahim et al. [30] investigated the effect of using antibacterial nano particles in endodontics. Obtained results showed that using antibacterial nano particles had significant impact on resistant pathogens, which was attributed to their physio-chemical properties. Moreover, it was observed that using nano particles as antibacterial had eliminated bacterial cells by applying multiple mechanisms [30].

Nano particles, such as silver, are able to stick to sections of the membrane of the bacterial cells which are negatively charged. As a consequence, the nano particles disturb cells' structure, break them and cause cytoplasm leakage, resulting in penetration of nano particles inside the cytoplasmic content. Afterwards, they interact with materials containing DNA and RNA such as sulphure, leading to higher destructive impact on the cells [30].

Several researches have focused on finding appropriate irrigants [31], and some studies have shown that it is possible to obtain good irrigants using nanotechnology .

Luna et al. [32] evaluated the effect of using silvernanoparticles as final irrigant on E. faecalis.

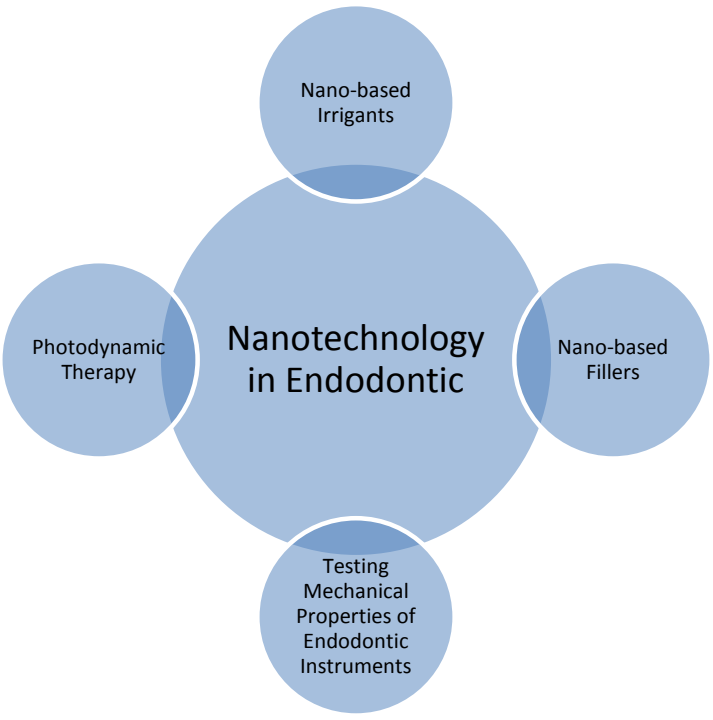

Fig 1. Applications of nanotechnology in endodontics

It was concluded that silver nano particles had favorable ability in elimination of smear layer; moreover, these nano particles were appropriate choice for removal of *E. faecalis* in root canal. In another study, the cytotoxic impact of silver nano particles as an irrigant was investigated and it was observed that nano-silver particle endodontic irrigant was not cytotoxic to both human periodontal ligament stem cell and another cell type called mouse fibroblast National Institutes of Health 3T3 [33]. In another study, the efficacy of nanosilver-particle-based irrigant was compared with NaOCl 5.25%. Based on the obtained results, it was concluded that the novel irrigant, which was based on silver nano particles, was as effective as NaOCl 5.25% in elimination of both *E.faecalis* and *S.aureus* [34]. Other types of nano particles can also be used against endodontics pathogens. Monzavi et al. [35] utilized nano MgO aqueous solution in order to evaluate its performance in eliminating endodontics pathogens. The antimicrobial efficiency of the mentioned solution was compared with that of sodium hypochlorite and chlorhexidine gluconate. Results indicated that nano MgO with 5 mg/lit concentration showed notably long-term efficiency with regard to removal of E. *faecalis* in comparison with NaOCl 5.25% [35].

There are various cements used for filling the root canals [36, 37]. Several studies have been carried out to modify the properties of cements by adding some materials or decreasing the size of cement particles [38]. Nanotechnology can be used to enhance the quality of the cement utilized as filler in endodontics. Hosseinzade et al. [39] Conducted a study on the physiochemical properties of various dental cements. The cements investigated in the study were Calcium Enriched Mixture (CEM), Mineral Trioxide Aggregate (MTA), calcium phosphate hydroxyapatite and nano hydroxyapatite-chitosan. Attained results demonstrated that CEM and nano hydroxyapatite-chitosan had more appropriate bioactive features based on PH values. The ranges of pH values for HA, nano-HA-ch, CEM and MTA were 7.92 7.04, 10.28, and 12.05, respectively.

Other types of nano particles have been used as sealer to prevent leakage in the procedure of root canal therapy. In a well-conducted study [40], the effects of bismuth oxide particle size on the physical properties and tricalcium silicate–based cements radiopacity were investigated. It was concluded that adding bismuth oxides affected their physical properties (push-out and compressive strength). Adding regular-size particles reduced the physical properties while nano-sized particles enhanced the mentioned properties. In addition, it was observed that adding 20% bismuth oxide nano particles improved the physical properties, such as push-out and compressive strength, without any significant impact on radiopacity [40].

In another study, Javidi et al. [41] utilized nano zinc oxide nano-powder and compared its leakage with AH26 and microsized zinc oxide eugenol sealer. Their results indicated that zinc oxide nano-powders had the lowest micro-leakage among the investigated sealers; as a consequence, these types of sealer were appropriate for root canal therapy. The lower leakage of the sealer with smaller particle size was attributed to the effective surface. Since increase in particle size results in reduction of effective surface, smaller size of nano particles is more favorable to prevent leakage [41].

Another type of nano-based sealer was investigated by Masudi et al. [42] They assessed the sealing performance of nano hydroxyapatite filled epoxy resin which was used as sealer and compared it with AH26. They concluded that the nano-based epoxy resin made appropriate apical seal against dye penetration which was similar to AH26 silver free; therefore, it could be used as an alternative for the existing conventional sealer.

As it was mentioned earlier, nanotechnology is able to enhance the mechanical strength of various materials. This ability can be applied in order to enhance mechanical properties of the materials utilized in root canal therapy. Lee et al. [43] utilized nano diamond to modify Gutta Percha (GP) which is widely used as fillers in endodontics. In the study, GP was embedded with nano diamonds (GPND). The characterization of materials showed that using nano diamonds enhanced the mechanical properties of GP. Results from the highest stress point showed that the tensile strengths for GP, NDGP with 5% wt nano diamond, and NDGP with 10% wt nano diamond were (70.3) MPa, (121.2) MPa and (190.3) MPa, respectively [43]. In addition to enhancement in mechanical properties of materials used in endodontics, nanotechnology has been employed in order to decrease setting time of endodontics materials. Based on a study carried out by Akbari et al. [44] adding silica nano particles to the mineral trioxide aggregate (MTA) resulted in faster hydration and

decrease in setting time without any unfavorable influence on the flexural and compressive strength of MTA. Results demonstrated that adding 10% silica nano particles decreased setting time from 229.66 minutes to 199.33 minutes.

Nanotechnology is applicable to novel endodontics treatment method such as photodynamic therapy [45]. Photosensitizer based on nano particles can augment antimicrobial ability of photodynamic therapy [46]. In a study [47], a type of nano particle (poly lacticco-glycolic acid) was loaded on a photosensitizer (methylene blue) and was exposed to the light in order to investigate its efficacy in elimination of E. *faecalis.* Results indicated that using the nano particles which was encapsulated with photoactive drugs could be a favorable supplement in antimicrobial endodontic therapy [47]. Akbari et al. [48] investigated the efficacy of photodynamic therapy by using indocyanine green as photosensitizer. Moreover, another nano-based photosensitizer which was obtained by incorporating indocyanine green into nano graphene oxide, used as photosensitizer. Their Results demonstrated that using the nano-based photosensitizer led to higher antimicrobial and anti-biofilm formation compared with photodynamic therapy by utilizing indocyanine green as photosensitizer [48]. In addition to improvement in antimicrobial effectiveness of photodynamic therapy, some nano particles have been used in photosensitizers to enhance their stability and make them more appropriate for treatment process [49].

Various instruments are involved in the procedures of endodontic treatment [50, 51] and their mechanical properties are important [52-54]. Nanotechnology can be used to evaluate mechanical properties of instruments utilized in endodontics procedures. For instance, Jamleh et al. [55] applied nano-indentation test to investigate the impact of cyclic fatigue on the nickel-titanium (NiTi) tool which was used in endodontics. The study showed that the mentioned technique (nano-indentation test) was applicable to evaluate failure mechanism of the NiTi instruments. In another study, Zinelis et al. [56] applied nano-indentation technique to assess in-depth hardness of endodontic instrument.

CONCLUSION

In the present study, several scientific researches conducted on the applications of nanotechnology in endodontic are reviewed and their results are presented. Based on the obtained results from the reviewed studies, nanotechnology can be applied in various aspects of endodontics, including enhancement the properties of fillers, irrigants and photodynamic therapy. For instance, by using nano particles, it is possible to enhance disinfection ability of irrigants. In addition, sealers containing nano particles are able to prevent micro-leakage.

Since applying nanotechnology can result in enhancement in mechanical properties of materials, some studies have shown that, fillers with higher mechanical strength is achievable by using nanotechnology, which is favorable in endodontic treatment. Moreover, nanotechnology can be used to evaluate properties of instruments utilized in endodontics.

ACKNOWLEDGMENTS

The authors would like to thank reviewers and A. Babaei for their helpful comments.

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