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# Advances in Applied Nanobio-Technologies Based Materials as Emerging Trends for Dental Tissue Engineering: A mini-review

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## Abstract

Nanobio-technology is a term that refers to the junction of Nanotechnology and Biology. There has been considerable research interest in study of functionalized nanostructures in nanobio-medical applications in recent years. There are extensive applications of nanobio-technology in biomedical engineering such as implant and tissue engineering, diagnosis and therapy. The unique size-dependent properties of nanobio- materials make these materials superior and essential in many areas of tissue engineering. This brief mini-review tries to summarize the most recent advances in the field of applied nanobio-technology, in particular their application in dental tissue engineering.

**Keywords**: nanobio-technology, nanoparticles, dental tissue engineering, nanofabricates scaffolds, magnetic nanoparticles

## 1 Introduction:

Nanobio-technology has appeared as engaged field that contains great potential in oral medicine. The application of nanostructure particles for delivery of drugs, nucleic acids, antibacterial properties, ability to adhere to variety of molecules and cellular uptake and construction of scaffolds has caused a major change in methods of tissue engineering (1). Morphology of nanomaterials include nanoparticles, nanosheet, nanotubes, nanofibers, nanowires, etc. The application of nanobio-structures for tissue engineering has gained lots of attentions due to their small size that enables them to pass through tissues and cross the barriers. Additionally, nanoparticles play an important role in raising the cellular adherence of the scaffolds due to large surface area to volume ratio for providing support to the regeneration the tissues (1). Nanobio-materials play an important role in tissue engineering. They are used for fabricating scaffolds, which are porous structures that provide a cellular microenvironment required for excellent tissue regeneration (2). Tissue engineering methods have been recently introduced to prepare a reliable in vitro tissues microenvironment (3). Considering the nanostructured character of the tissues, recent advancements in nanobio-technology enable scientists to design and fabricate structures and drug delivery systems at the nano-sized to be more compatible with the tissue environment (3). The focus of this mini-review is to present the recent advances in applied nanobio-technologies based materials as emerging trends for dental tissue engineering.

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## 2. Application of Nanobio-Materials on Dental Tissues

Nanobio-materials have the potential to provide better control over manipulating of hard and soft dental tissue engineering due to their good bioavailability, efficacy and decrease of the required dose of medicine (4). The main types of nano-materials applied in dental tissue regeneration is demonstrated in Table 1. With development of new nanobio-techniques, (figure 1) application of nanobio-materials in dentistry has made a great impact and creates new methods for various applications. In dentistry, nanobio-technology has recently absorbed the attention of researchers and clinicians to significant advances in the detection, diagnosis, treatment and prevention of oral and maxillofacial diseases (5). Newly, nanoparticles have been used in tissue engineering in order to acquire advanced mechanical and biological properties (6). The surface adherence properties of metallic nanoparticles, the antimicrobial character of silver and other metallic nanoparticles and metal oxides, the fluorescence properties of quantum dots and the unique electromechanical properties of carbon nanotubes have made them very applicable in methods of tissue engineering (7). Therefore, physicochemical environment and elements of these nanomaterials can be helpful for advancement of biomedical applications (8).

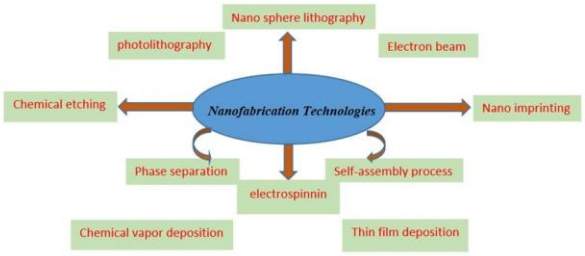


**Figure1**. methods of nanofabrication technologies

**Table 1.** The main types of nanomaterials applied in dental tissue regeneration

| Application | Morphology | Nanomaterials | References |
|---|---|---|---|
| ***Hard Tissue Regeneration*** | Nanoparticles | Nano HA[1]/ /Col; ColI/β-TCP[2] | Liu et al., 2011; Wang, Wang, Wan, Wang, & Wang, 2016 (9). Huang et al., 2010; Zhang et al., 2010 (10) |
| | Nanofiber | SF[3]/PCL[4] nanoscaffold ; COL ;CTS[5]/PEO[6] electrospun nanofibrous scaffold | Frohbergh et al., 2015(11); Kim et al. , 2015(12); Park et al., 2015(13); |
| | Nanosheet | Macroporous HA bioceramic | Xia et al., 2013(14) |
| | Nanotube | Graphene, CNT[7], Alginate gel including CNTs | Yan, Yang, Shao, Yang, & Liu 2016(15) ; Kajiya et al., 2015(16) |
| | Nanoplate | PLGA[8] films with graphene nanoplate | Wu et al., 2018(17) |
| ***SoftTissue Regeneration*** | **Vascular tissue engineering** | | |
| | PLLA/ PCL nanostructure<br><br>PLGA<br><br>3-D nanofiber scaffols | Titanium nanoparticle | Zhang et al., 2009(18) |
| | **Neural tissue engineering** | | |
| | PLLA/ PCL, carbon nanotubes, carbon nanofibers, peptide nanofiber scaffolds | CTS | Zhang et al., 2009(18) |

1. HA (hydroxy apatite) 2. β-TCP (Transgenic plants overexpressing) 3. SF (silk fibroin) 4. PCL (poly-ε-caprolactone) 5. CTS (Chitosan) 6. PEO (polyethylene oxide) 7. CNT (carbon nanotubes) 8. PLCG (poly lactic-co-glycolic acid)

## 3. Advances of Nanobio-Materials in Tissue Engineering

### 3.1 Nanofabricated Scaffolds

As 2D cell-nanotopography interactions was enabling us to manipulate cell behavior, great efforts have been done to fabricate 3D scaffolds at the nano-scale for tissue engineering applications. Nano-fibrous scaffolds exhibit similar physical composition to protein nanofibers in extra-cellular matrix (19). Across the 3D nanofabrication systems, electrospinning is a very simple and feasible method, which is suitable for fabrication of organized and complex 3D structures. Self-assembly technology imitates the process of extra-cellular matrix assembly and can generate very thin nanofibers. (20). Scaffolds based on nanocomposite are very popular in hard tissue engineering, especially for the reconstruction of bone tissue (21). Above nanofibers and nanocomposites, carbon nanotubes have also draw attention because of their multiple-layer assembly which could be incorporate with nano-topographic cues to make anatomically better scaffold design (22).

### 3.2 Surface Adhesion Advances

Dental tissue engineering has used some alternatives, mostly metal nanoparticles, to current conventional scaffold materials (23). The scaffold should not be toxic to cells and should be biocompatible and interact with the cells to increase cell adhesion positively. Creation of microenvironments similar to extra-

cellular matrix, can enable cells to enhance adhesion. Studies about cell attachment showed that cells are able to attach in the nanofibrous scaffolds. For instance, some in vitro studies showed that nano-phase Hydroxy Apatite (HA) significantly promote osteoblast adhesion compared to conventional grain size HA, after 4 h of culture (18). These results showed that the nanofibrous scaffold supports cell adhesion and proliferation and ergo, this scaffold can be applicable candidate for tissue engineering applications (24). Nanosurfaces have great influence on cell behavior. Cell–material adhesion are known to be better on nanophase ceramics compared to microphase ceramics (25). The research on chitin nanobioactive glass ceramic and chitosan nanobioactive glass ceramic composite scaffolds for tissue engineering provides an important reference to this fact (26, 27). Nanomaterial scaffolds provide cell adhesion, proliferation, and differentiation. Carbon nanomaterials have great properties as scaffolds for bone tissue engineering. Carbon nanomaterials includes graphene oxide (GO), carbon-nanotubes, fullerenes, carbon dots, and nano-diamond (28).carbon nanomaterials, such as (GO) based materials have a broad range of applications in tissue engineering. The high surface area, good wettability, high adhesion ability are effective advantages of GO nanomaterials (29).

### 3.3 Anti-Microbial and Toxicity Advances

Recently, studies have indicated that nanoparticles are promising alternatives to antibacterial agents because of their depict antibacterial activity in many biomedical applications, including tissue engineering. Additionally, nanobio-material studies report that there is a possible relationship between the morphological properties of a nano-material and the amount of its toxicity (30). The unique characteristics of metal nanoparticles, such as antibacterial effects and low cytotoxicity indicate that they can be used as newfound types of scaffolds for dental tissue engineering. Nano-metric dimensions of metal elements such as Ag, Au, Fe, Cu, Pt, Pd, Ni and Co are greatly used for antimicrobial purposes (31).According to the study of Ranjeet et al., gold nanoparticles have antifungal and antibacterial activity, therefore can be utilized in scaffolds (32). Marsich et al. demonstrated that silver nanoparticles exploit great bactericidal effect against both Gram+ and Gram− bacterial strains which indicates that these antimicrobial scaffolds possess ideal properties for tissue engineering applications (7). In the study conducted by Chang et al., the cytotoxicity of graphene-based nanomaterials is affected by their size and surface properties. Graphene oxide (GO) exerts size-dependent cytotoxicity; smaller GO causes more viability loss of lung epithelial cells through oxidative stress generation (33).

### 3.4 Drug Delivery Advances

Development of nanobio-technology systems for drug delivery systems is mandatory to lessen side effects of common treatment techniques and improve the therapeutic efficacy (34). Nano-structure based polymers have gained a lot of attention due to their chemical and physical properties to provide effective means of drug delivery (35). According to the study conducted by Mousavi et al., GO nano-carriers are suitable for delivering chemotherapeutic agents, genes, and short interfering RNAs (36). Graphene Nano ribbons (GNRs) has attracted lots of attention due to its imperative functions in drug delivery applications (37). Magnetic nano-particles such as α-$Fe_2O_3$ (hematite), γ-$Fe_2O_3$ (maghemite), $Fe_3O_4$ (magnetite), hexagonal ($MFe_{12}O_{19}$), garnet ($M_3Fe_5O_{12}$) and spinel ($MFe_2O_4$), aggregate easily in solution and are widely used in biology and medicine in many cases such as drug delivery systems (38).

## 4. Conclusion

Nanobio-technology has been used in the dental field with noticeable success. Nanobio-materials propose great promise in hard and soft tissue regeneration. Nanobio-technology plays an important role in dental tissue engineering. In this mini-review the use of nanobio-materials and some of their properties as emerging trends for dental tissue engineering was discussed. Details are provided on the dental nano-scaffolds, advances in surface adhesion, antimicrobial, toxicity and drug delivery properties of nanobio-materrials.

## Conflict of Interest

The authors have declared no conflicts of interest for this article.

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