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Bioceramic –Based Nanocomposite Root Canal Sealers Reinforced with Different Nanomaterials

*Inaam Baghdadi**

Department of Endodontics, Beirut Arab University, Lebanon

Mini Review

Researchers worldwide concede that improvement in dental materials' properties is one of the prominent unrelenting problems challenging technological evolution. Clinicians and scientists at various dental fields are longing for new materials with enhanced properties and uncomplicated procedures to apply in this manner enduring competitive advantage. Physiochemical, mechanical and structural properties' execution of materials are critical in the progress of applied science. Due to some physiochemical and mechanical behaviors of ceramics in addition to nonmaterial's such as titanium carbide, carbon nanotubes, and boron nitrides, they have a wide-range of implementation in many fields.

The field of dentistry concerned with root canal treatment, named "Endodontics", is continually altering due to the launching of new techniques and technological progress. Development in endodontic material science, like the recently introduced bioceramic root canal sealers, significantly broadened this field and made a shift in endodontics.

The expression 'bioceramics' refers to biocompatible ceramic materials that are particularly studied for the application in medical and dental fields. In the endodontic field, active and re-absorbable bioceramics are applied [1]. They are comprised of alumina, zirconia, bioactive glass, glass ceramics, composites, hydroxyapatite, restorable calcium phosphates and radiotherapy glasses [2,3]. One kind of material amongst them is calcium phosphate–based used for filling bone defects. Other material like mineral trioxide aggregate (calcium silicate-based) was introduced for closure of open apices of root canals and repair of perforations [4,5].

Many endodontic sealers that are based on calcium silicate have been introduced. The first sealer was iRoot SP that exhibited biocompatibility and hydrophilicity [6]. EndoSequence BC, MTA Fillapex, Bioroot RCS and Endorsees MTA followed and were investigated in several studies that showed that BioRoot RCS was more biocompatible than iRoot SP, MTA Fillapex, and Endoseal MTA [7-10], and showed better antibacterial effects [8,11,12]. It proved prolonged ability to release calcium ions and alkalization [13]. Yet, it exhibited higher solubility and water sorption [14]. BioRoot RCS is one of the latest root canal sealers based on tricalcium silicate material that gain from both active bio-silicate technology and biodentin [15,16]. One of its main paramount properties is its adhesion to the root canal walls and its bioactivity that may initiate hard tissue deposition [17,18].

The privilege of bioceramic sealers made them an integral component of the endodontic obturation system, and has advanced into the field of surgical endodontics. This is due to their dimensional stability because they do not shrink upon setting and thus, remain non-restorable inside the root canal [19]. In addition to that, the formation of calcium hydroxide as a by-product of the setting reaction produces a high pH that initiates an anti-bacterial action during its setting time. This is an important physical property for an endodontic sealer [20] with excellent antimicrobial bioactivity, capable to induce mineralization of periapical tissues [21]. Another property is their ability to set in a humid environment, such as dentin, which is made of nearly 20% of water [5]. The main bioceramic components of BioRoot RCS are tricalcium silicate and zirconium oxide [22]. Despite their purported advantages, bioceramic-containing root canal sealers have important drawbacks such as the difficulty of insertion into root canals because of their texture, extended setting time, and high solubility. Also, scarce information exists concerning the efficiency of their mechanical properties especially fracture resistance of endodontically treated teeth [23].

Root canal walls may lose strength due to root canal cleaning and shaping, over-instrumentation, retreatment, root resorption or dehydration. As a consequence, the resistance of root canals to functional loads may decrease and the roots become more vulnerable to vertical root fracture which

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Correspondence:
Inaam Baghdadi, Department of Endodontics, Beirut Arab University, Lebanon, Tel: +961 3 727793; E-mail: innb2000@gmail.com

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may mostly lead to tooth extraction. Thus, root canal filling materials that have the ability to reinforce the tooth would be a great advantage to protect them against vertical fracture.

In any case there have been minor investigations on the properties of bioceramic root canal sealers reinforced with multi-walled carbon nanotubes, or titanium carbide or boron nitride composites. Furthermore, improvement in the development of bioceramic composites with the aid of sintering techniques might contribute to the properties of the developed composites to be applied in special conditions. Investigating the likelihood of strengthening a bioceramic root canal sealer reinforced by multi-walled carbon nanotubes, titanium carbides, and boron nitrides can considerably upgrade its properties. These nonmaterial's have mechanical properties that would assist in forming a dense microstructure and solid adhesion with the bioceramic matrix. Recent investigations focused at understanding the influence of adding these different nonmaterial's on the physiochemical properties, microstructure, and compressive strength of bioceramic root canal sealer.

Few of the materials that have been attempted for calcium silicate-based bioceramics have sufficient mechanical properties and favorable biocompatibility. Nanomaterials could be used as reinforcement nonmaterial's for enhancing the physiochemical and mechanical properties of bioceramic based root canal sealers.

The recent development of nanotechnology has opened up novel fundamentals and applied frontiers in material science [24,25]. The emergence of this technology may improve the properties of existing materials. Some nonmaterials have been used to improve the mechanical properties of bioceramics. Carbon nanotubes, titanium carbides, and boron nitrides nanoparticles are excellent reinforcement nonmaterial's for enhancing mechanical, electrical, and thermal properties of bioceramics.

The properties of ceramic materials and their structural strength may be improved by carbon nanotubes reinforcement [26,27]. The unique mechanical properties and bioactivity of Multi-Walled Carbon Nanotubes (MWCNTs) renders them as favorable reinforcement nonmaterial's used in manufacturing bioceramic nano-composite [28-32]. Similarly, Titanium Carbide (TC) is hard refractory ceramic material that has many appealing properties such as low density, relatively high thermal and electrical conductivity, and compressive strength [33,34]. Studies have shown that the cement paste mixtures with TC nanoparticles were characterized with high strength due to their ability to fill the pores in cement pastes [35-37]. Likewise, Boron Nitride Nanotubes (BN) are gaining more attentiveness as novel nonmaterial's due to their high oxidative properties, mechanical and chemical resistance [38]. All of the above may have the potential as reinforcement nonmaterial's in an attempt to improve the properties of bioceramics.

Rafiee et al. [39], and Walker et al. [40], showed that reinforcing a ceramic-matrix with graphene, can permit excellent toughness and can hinder crack propagation [39,40]. In addition to that, and due to the brittleness of bioceramics, new evolutions in the field of nano-composites has led to the use of nanoparticles as reinforcements to refine the mechanical features of ceramics [41]. Presently, the actual usages of nonmaterials for a variety of dental applications have advanced [24]. The superb properties of multi-walled carbon nanotubes, titanium carbide, and boron nitride have encouraged the synthesis of new composites with favorable versatile properties [42,43].

Furthermore, the brittle nature of bioceramic materials, the long setting time and high solubility of bioceramic root canal sealers, the determination of the optimal sintering temperature and stability in nitrogen atmosphere for root canal sealers reinforced with nonmaterials, present a technical problem from proceeding on these identified technologies. The process of fabrication of composite ceramics must be done under high sintering temperature to enhance densification. There are scarce studies that explore the aid of pressure less sintering in nitrogen atmosphere on calcium silicate nanoparticle-incorporated sealers. The appropriate sintering atmosphere for these composites presents a dilemma as to avoid their oxidation at high temperatures and enable the composite to retain the nonmaterials.

It will be very interesting to conduct future *in-vitro* studies in endodontically treated teeth to explore the different properties of bioceramic - based nano-composite root canal sealers reinforced with different nonmaterial's.

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