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Research Article

Bioceramic Sealer a New Paradigm in 21st Century Endodntics Basic Guidelines for Selection

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Abstract

A thorough and critical analysis of bioceramic sealers was made. A classification of the different groups of bioceramic sealers with their main representatives has also been made.

Their important physical attributes such as: flow, water sorption and solubility dimensional stability and setting time. These physical characteristics of sealers can influence the quality of the root canal filling and the correct selection depends on the individual clinical case.

Keywords: Bioceramic sealer, Physical Properties, Classification

1. Introduction

Successful endodontic treatment consists of multiple stages and begins with an accurate diagnosis, subsequent treatment plan. The importance of correctly determining the working length should not ignored. Root canal treatment (RCT) is defined as a combination of proper mechanical instrumentation of root canal space, with the main goal of reducing the microbial count and removing any tissue debris by means of chemical desinfection. The most important aim of endodontic therapy is to eliminate microorganisms and prevent recontamination and reinfection. Root filling is therefore a critical last step of root canal treatment and sealing both the main root canal and its accessory ramifications achiving a three-dimensional filling to provide an arttight hermetic seal from the coronal orifice of the canal to the apical foramen thereby preventing the passage of microorganisms between the root canal and the periradicular tissues[1, 2] Due to of the complexity of root canal system , sealers must be used to occupy the irrequlrities and penetrate dentinal tubules to obtain a hermetic seal of the root canal.

The sealer characteristics play an essential role in the success of root canal obturation and should have display appropriate physicochemical and biological properties. According to Grossmann the requirements for the sealers are that they should dimensional stability with excellent sealing ability, insolubility, and biocompatibility [3].

Based on their chemical composition, sealers are divided into various groups: zinc-oxide eugenol-based (ZOE), calcium-hydroxide-based, resin-based, glass--ionomer-based, silicon-based [4]. The earliest, a ZOE-based root canal sealer, was introduced by Rickert in 1931. Calcium hydroxide was introduced to endodontics by Herman in 1920. In 1972, Davis et al. used injectable silicone impression material into the prepared root canals. Resin based sealers can be classified into: epoxy resin–based and methacrylate resin–based sealers [5]. Epoxy resin was invented in 1938 by P. Castan. The first generation of methacrylate resin-based sealers appeared on the market in the mid-1970. In 1976 Pitford recomended the glass ionomer ketac endo as a root canal sealer [6].

The evolution in the development of endodontics is expressed in the introduction of new techniques and materials. The first bioactive ceramic material developed by the Torrebinead and Dr. White teams and applied in endodontics are Original-ProRoot® MTA (Dentsply, Tulsa Dental, Johnson City, TN, USA). The era of bioactive calcium-silicate cements in dental practice started in 1990. [7] Bioceramics are ceramic materials that contain silica, alumina, zirconia, bioactive glasses, ceramic glasses, calcium silicates, hydroxyapatite, and calcium phosphate [8]. The introduction of MTA in clinical dental practice became the basis for the appearance of Bioceramic-based root canal sealers. Recently, bioceramic-based root canal sealers were introduced as a novel category of innovative root-end filling materials, based on the development of bioceramic technology in dentistry. In 2007, the first premixed and ready-to-use hydraulic calcium silicate–based material sealer, iRoot SP (Innovative Bioceramix, Vancouver, BC, Canada), was introduced [9]. Since then, various sealers have been commercially available

to the market. This sealer is also on the market under the names EndoSequence BC Sealer (Brasseler USA, Savannah, Georgia) and Totalfill BC Sealer (FKG Dentaire, Switzerland) The materials are packaged in pre-loaded syringes and are supplied with disposable tips . All three materials are the same in chemical composition[10].

The bioceramic sealers chemically bond to dentine by a process known as alkaline etching (caused by the alkalinity of the sealer), and a mineral infiltration zone develops at the interface of the dentine in contact with the material [11, 12].

Root canal sealers can penetrate into the dentinal tubules, forming a physical barrier, enhancing root filling retention, and encasing residual microorganisms. Nonetheless, the depth and consistency of the sealer penetration into root dentine tubules are influenced by physical and chemical parameters such as particle size, solubility, viscosity, and surface tension [13].

The penetration of root canal sealers depends on the diameter and density of the dentinal tubules. In addition, the surface activity of the sealers, the contact angle formed between the sealer and the dentin, the obturation technique employed for root filling, and the sectioning method involved in the sample preparation play a key role in the sealer penetration and the gap formation [14].

The diameter and density of the dentinal tubules are greater at the coronal and middle thirds of the root canal system whereas they are minimal at the apical third, factor plays a major role in sealer penetration [15].

The chemical nature of sealers plays a major role in their penetration; hydrophilic sealers penetrate deeper than hydrophobic sealers. [16].

Bioceramic-based endodontic sealers can be classified into calcium silicate-based (iRoot SP, EndoSequence BC Sealer), MTA-based (MTA Fillapex, Endo CPM Sealer, ProRoot Endo Sealer), and calcium phosphate-based (iRootSP and EndoSequence BC, Bio-C Sealer) [16]. The main advantages of these sealers are: excellent biocompatibility, intrinsic osteoinductive capacity, functions as a regenerative scaffold [17].

1.1. MTA Based Sealers

Several MTA-based sealers are made and utilized in endodontics: MTA-Fillapex (Angelus, Londrina, PR, Brazil), Endo CPM (Egeo, Buenos Aires, Argentina), MTA-Angelus (Angelus, Londrina, PR, Brazil), ProRoot Endo (DENTSPLY Tulsa Dental Specialties), and EndoSeal MTA (MARUCHI, Wonju, Korea).

This type of sealer creates hermetic seal, can also have antibacterial activity against M. luteus, S. aureus, E. coli, P. aeruginosa, C. albicans and E. faecalis by its alkaline pH, high mineralization potential through the formation of hydroxyapatite crystals, released calcium in solution and encouraged the deposition of calcium phosphate crystals [18]. Seriuos Disadvantages of this type sealers are: Long setting time about 2 hours 45 minutes. , Working time is less than 4 minutes. 4. Improper handling; may cause discoloration; difficult to remove from root canal [18].

1.2. Calcium Silicate-Based

They exhibit several interesting properties, especially biocompatibility, antimicrobial properties, and bioactivity. This type of sealer provides a high alkaline environment, due to its antimicrobial activity owing to their Ca+ releasing potential [19, 20]. There are two premixed calcium silicate-based sealers with similar chemical composition: iRoot SP and EndoSequence BC[21-23].

1.3. Calcium Phosphate-Based Sealers

Some of the new calcium phosphate-based sealers can elimineted Eradicating bacterial biofilm and strengthen of root structures. The basic new calcium phosphate-based sealers on the market are Sankin apatite root canal sealer (I, II and III) and Capsea (I and II) [24]. The sealers are based on calcium phosphate cement, whose it's composition almost resembles bone and tooth minerals.

The latest generation of calcium and phosphate silicate-based root canal sealers are the so-called premix bioceramic sealers, which do not require any manipulation These bioceramics sealers release more calcium hydroxide during setting [25].

Various and wide ranging branded bioceramic root canal sealers are available on the market. And this is the reason why it is difficult for the dentist to navigate and choose the most suitable one for different clinical cases.

Some physical characteristics of sealers can influence the quality of the root canal filling [26, 27]. The effectiveness of a sealer depends on its physical properties [28].

Root canal sealers should be low solubility, adequate flow, dimensional stability, sufficient radiopacity. Some important physical properties are:water sorption, rheological properties, suitable setting time , viscosity [29].

1.4. Flow

Flow is an essential property that allows the sealer to fill difficult-to-access areas, such as the, isthmus, accessory canals. According to ISO 6786/2001.a root canal sealer should have a flow rate of not less than 20 mm. BioRoot™ RCS was characterized by results slightly below the minimum standard (16 mm) Factors that influence the flow rate of the sealer include particle size, temperature, shear rate, and time from mixing. [30, 31]. Relatively high flow rates of bioceramic-based sealers could be related to nano-sized particles of calcium silicates and zirconium. However, as the flow rate increases, the risk of sealer extrusion beyond the apical foramen becomes more likely [32].

According to manifactories the bioceramic sealer exhibited high flowability which fulfills the requirements of ISO 6876:2012 [30]. The flow rate for MTA Fillapex and Ceraseal

recorded by Choudhary et al found to be 23-29mm. [33].

1.5. Water Sorption and Solubility

Water sorption and solubility are related to dimensional stability. The solubility standards of root canal sealers are well described in International Organization for Standardization (ISO) 6876: 2012, according to which sealers should exhibit a solubility of less than 3% weight loss after water immersion [31].

A highly soluble root canal sealer would invariably permit the formation of gaps within and between the materia and dentin root walls and may cause microleakage , sealer degradation and the dissolution of biologically incompatible components in the root canal . [34]. The sealer" s solubility seems to be influenced by multiple factors, including setting time and composition. The high solubility of bioceramic-based sealers may be due to the hydrophilic nature of these materials. There is conflicting information available in the dental literature regarding the solubility of some of the bioceramic selears. [35, 36].

The high solubility of bioceramic sealers occurs as a result of hydroxyapatite nanosized particles which increase their surface area and allows more liquid molecules to come in contact with the sealer. Moreover, release of calcium ions can be correlated with high initial solubility of Bioceramic sealers. It is found that EndoSequence BC has low solubility. The reasons is that this sealer has nanoparticle size which tend to produce more efficient hydration reaction and it has calcium phosphate in its composition which improves its setting time. The same authors were established that Bio C sealer has higher solubility than EndoSequence BC. The size of particles of Bio C sealer larger than those of EndoSequence BC [37].

The calcium silicate sealers are advantageous because of flowability and film thickness, but their property of high solubility remains an issue of concern [38].

1.6. Radiopacity

An ideal sealer must have sufficient radiopacity in order to be able to distinguish it from surrounding structures , the extention and the quality of the root canal filling. [39]. It is typically measured in millimeters of aluminum equivalent (mmAl), and higher values indicate greater radiopacity, which makes the material more visible on X-rays. The radiopacity of root canal sealers should be at least 3 mmAl for a 1 mm root canal sealer sample thickness [31]. The different radioopacifiers may result in different radioopacity values for sealers. [40].

Different formulations of bioceramic sealers such as BioRoot™ RCS, EndoSequence® BC Sealer™, EndosealMTA®, MTA Fillapex® ,. TotalFill® BC Sealer HiFlow demonstrated higher radiopacity compared to the ISO standards. [40, 41].

In literature the radioopacity value of MTA Fillapex was found to be in the range of 2.7 to 8.9 mmAl [42, 43]. According to Vidotto et al. [44] the radioopacity value of MTA Fillapex was 6.5 mm Al.

1.7. Dimensional stability

The dimensional stability of root canal sealers is another important factor in the success of endodontic treatment. Although minimal shrinkage is expected, excessive expansion may cause root fracturesMost root canal sealers shrink or expand as a result of setting. Dimensional change studies are important to show the potential of sealers to provide the desired hermetic seal and bond core materials to the dentinal walls. ISO standards recommend a maximum shrinkage of 1% or expansion of 0.1 % of the measured sample length for root canal sealers [31].

In a comparative study was found that MTA Fillapex presented higher solubility, dimensional and volumetric change than other sealers [45]. According to [45] the BioRoot exhibits a significant expansion of 0.20%.

1.8. Setting Time

The ideal root canal sealer setting time should permit adequate working time. The setting time has an impact on the working time and clinical performance of root canal sealers. The length the of setting time depends on the composition and quality of the hydration reaction. There is a scarcity of information regarding setting reaction and time of these type of sealers. Some bioceramic sealers such as EndoSequence BC Sealer or iRoot SP, the setting reaction is catalysed by the presence of moisture in the dentinal tubules [46].

According to Zhou et al [47]. (setting time of EndoSequence BC Sealer is 2.7 hours while Loushine et al. reported that EndoSequence BC Sealer requires at least 168 hours until it completely hardens[48]. The setting time of EndoSequence BC Sealer is 4 h and it may be extended in overly dry canals [49].

The average setting time of Bio C sealer is 120 min (maximum up to 240 min) after insertion into the root canal and it highly depends on the moisture inside the root canal [50]. Bioceramic sealers show high setting times [51].

2. Conclusion

The quality of the root canal filling and the success of endodontic treatment depend on the physical characteristics of the sealers used. The new group of innovative bioceramic sealers provides a chemical bond and they can penetrate into the dentinal tubules, forming a physical barrier, enhancing root filling retention. Various and wide ranging branded bioceramic root canal sealers are available on the market. And this is the reason why it is difficult for the dentist to navigate and choose the most suitable one for different clinical cases.

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