The use of bioceramic root canal sealers for obturation of the root canal system: A review

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Abstract

The use of bioceramic root canal sealers in endodontics is a promising approach because of the advantages such as improved flow properties, biocompatible and could promote the formation of hard tissue. Due to the recent technology and limited scientific evidence, the effectiveness of bioceramic root canal sealers remains unclear. This article focuses on the physicochemical properties, biocompatibility, biomineralisation, retreatability, 3D obturation and current practice of using bioceramic root canal sealers. The relevant articles for this review were searched manually from Google Scholar and PubMed using keywords ‘bioceramic root filling material AND endodontics’, ‘bioceramic root canal sealers AND endodontics’, ‘cytotoxicity AND bioceramic root canal sealers’, ‘bioceramic root canal sealers AND physicochemical properties’, ‘biomineralisation AND bioceramic root canal sealers’ and ‘retreatment efficacy AND bioceramic root filling materials’. Since the clinical data concerning the obturation with bioceramic root canal sealers is lacking, the selection of materials should be made based on the available scientific evidence, individual cases, material availability and operator’s preference.

Keywords: bioceramic root canal sealers, cytotoxicity, biomineralisation, physicochemical properties

Introduction

The use of bioceramic root canal sealers for obturation of the root canal system has been a subject of interest in the recent years. However, whether this material can provide an effective sealing of the complex root canal anatomy remains unclear due to the limited scientific evidence. The obturation of root canal system can be performed using a conventional technique with a combination of gutta-percha and root canal sealer, or thermoplastic technique. The goal standard of root canal sealers for obturating of the root canal system should have low porosity and solubility, adequate setting time and ability to promote hard tissue formation (Gandolfi and Prati, 2010).

Currently, there is a move towards using bioceramic root canal sealers such as MTA Fillapex, GuttaFlow Bioseal, iRoot SP root canal sealer, CeraSeal Bioceramic root canal sealer and others. Generally, the properties...
of root canal sealers are determined by the type and ratio of the main components, thus enabling them to function effectively under clinical situations (Zhou et al., 2013). For instance, bioceramic root canal sealers usually contain calcium silicate and/or calcium phosphate, have a higher pH value, chemically stable, lack of shrinkage and biocompatible, making them favourable root canal sealers (Zhou et al., 2013).

In general, bioceramics can be categorised into bioinert, bioactive and bioreabsorbable based on their interactivity with the surrounding tissues (Best et al., 2008; Wang et al., 2019). Bioinert ceramics such as alumina and zirconia are well-tolerated by the tissue, triggering no toxic response, whereas bioactive ceramics such as ceramics, glasses, glass-ceramics can interact and form a direct bond with the tissue (Best et al., 2008) through the formation of hydroxyapatite layer as the interfacial bonding (De Aza et al., 2007; Vollenweider et al., 2007). This layer has a similar chemical constituent and structure to the inorganic component of bone (De Aza et al., 2007; Best et al., 2008). The bioreabsorbable ceramics such as tricalcium phosphate and calcium sulphate will be replaced or incorporated into the hard tissue to become part of the structure (Raghavendra et al., 2017).

Mineral trioxide aggregate (MTA) is the first generation of bioceramic (Haapasalo et al., 2015; Assadian et al., 2016; Raghavendra et al., 2017; Song et al., 2020), introduced by Dr. Mahmoud Torabinejad and is composed of tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silicate oxide with the addition of bismuth oxide to make the material radiopaque (Torabinejad et al., 1995). This material is usually used in surgical endodontics, apexification, perforation repairs and pulpotomies (Torabinejad and Chivian, 1999). MTA is known to have excellent properties such as biocompatible, osteoconductive and osteoinductive (Raghavendra et al., 2017), hence making it suitable for various endodontic procedures. The limitations of MTA are its handling characteristics, discoloration due to the iron compounds and require longer setting time.

Bioceramic root canal sealers are the new generation with the advantages of being well-tolerated by the host tissue, able to promote hard tissue formation and has antimicrobial properties (Raghavendra et al., 2017) but at this stage, robust scientific evidence on this material is limited. The example of bioceramic root canal sealers that have been introduced into the market include EndoSequence BC Sealer (Brasseler, Savannah, GA, USA) or iRoot SP root canal sealer (Innovative BioCreamix Inc, Vancouver, Canada), MTA Fillapex (Angelus, Londrina, Brazil), Endoseal MTA (Maruchi, Wonju, Korea), Tech Biosealer Endo (Isasan, Como, Italy), CeraSeal Bioceramic root canal sealer (Meta Biomed CO. LTD, Korea), Sankin Apatite root canal sealer (Sankin-kogyo, Tokyo, Japan), GuttaFlow Bioseal (Coltène/Whaledent AG, Altstatten, Switzerland), BioRoot™ RCS (Septodont, Saint Maur Des Fosses, France), TotalFill BC sealer (FKG Dentaire, La Chaux-de-Fonds, Switzerland), Sealer Plus BC (MK Life Produtos Medical e Dental, Porto Alegre, Brazil), Smartpaste Bio® (CRD Ltd, Stamford, UK) and others.

**Physicochemical properties**

The American National Standards Institute/American Dental Association (ANSI/ADA) Specifications number 57 set the standards and tests for the physicochemical properties of root canal sealer. This includes setting time, flowability, solubility, radiopacity, film thickness, and dimensional stability. Some studies on the physicochemical properties of bioceramic root canal sealers have been conducted according to these specifications (Vidotto et al., 2011; Borges et al., 2014; Camargo et al., 2017; Lee et al., 2017; Poggio et al., 2017; Colombo et al., 2018; Khalil et al., 2019), although other researchers have used the International Organisation for Standardisation (ISO) 6876 specifications (Gandolfi and Prati, 2010; de Miranda Candeiro et al., 2012; Vitti et al., 2013; Zhou et al., 2013; Lim et al., 2015; Agarwal and
Nikhil, 2016; Lee et al., 2017; Poggio et al., 2017; Tanomaru-Filho et al., 2017; Colombo et al., 2018; Mendes et al., 2018; Zordan-Bronzel et al., 2019; Kharouf et al., 2020). The ASTM standards C266-07 and C373-88 have also been used to evaluate the setting time and solubility respectively (Gandolfi and Prati, 2010). The summary of physicochemical properties of some bioceramic root canal sealers are shown in Table 1.

**Setting time**

ANSI/ADA Specifications 57 recommends that all root canal sealers should have a setting time of no greater than 10% of the time determined by the manufacturer. In the studies by (Zhou et al., 2013; Camargo et al., 2017; Lee et al., 2017; Tanomaru-Filho et al., 2017; Zordan-Bronzel et al., 2019), a Gilmore needle was probed onto the surface of root canal sealers and the setting time was recorded when the indenter needle failed to create the indentation. The results revealed that GuttaFlow Bioseal met these specifications (Camargo et al., 2017; Tanomaru-Filho et al., 2017) but in other studies, the TotalFill BC sealer (Zordan-Bronzel et al., 2019) did not fulfil the ISO specifications.

**Dimensional stability**

ANSI/ADA Specifications 57 recommends that root canal sealers should not exceed 1% contraction or 0.1% expansion. In the studies by (Camargo et al., 2017; Zhou et al., 2013), the percentage of the dimensional alterations was calculated after 30 days following the complete setting of the materials and the results showed that GuttaFlow Bioseal (Camargo et al., 2017) did not meet these specifications. However, the MTA Fillapex and EndoSequence BC Sealer fulfilled the ISO specifications (Zhou et al., 2013).

**Solubility**

The solubility of material is the percentage of mass loss compared to the initial mass (Borges et al., 2014). ANSI/ADA Specifications 57 and ISO specifications recommend that an ideal root canal sealer should lose not more than 3% of its mass after immersion in water for 24 hours. MTA Fillapex (Vitti et al., 2013; Zhou et al., 2013; Borges et al., 2014; Poggio et al., 2017; Colombo et al., 2018) and GuttaFlow Bioseal (Khalil et al., 2019) fulfilled these specifications. However, BioRoot™ RCS and TotalFill BC sealer did not comply with the ANSI/ADA Specifications 57 and ISO specifications (Poggio et al., 2017; Colombo et al., 2018). Sealer Plus BC (Mendes et al., 2018) and CeraSeal Bioceramic root canal sealer (Kharouf et al., 2020) also did not fulfil the ISO specifications, whereby the solubility of these materials were higher than the recommended values. Although the solubility of the EndoSequence BC Sealer fulfilled the ISO 6876 specifications, it approached close to the maximum value for solubility (Zhou et al., 2013).

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Flowability

ANSI/ADA Specifications 57 recommends that root canal sealers diameter should be greater than 20 mm. GuttaFlow Bioseal (Camargo et al., 2017) did not meet these specifications. MTA Fillapex (Vitti et al., 2013; Zhou et al., 2013; Lee et al., 2017) and EndoSeal MTA (Lee et al., 2017) both met the ISO specifications. However, EndoSequence BC Sealer showed conflicting results where some studies indicate its diameter to be in accordance with the ISO specifications (de Miranda Candeiro et al., 2012; Zhou et al., 2013; Agarwal and Nikhil, 2016), while a study by (Lee et al., 2017) indicated otherwise.

pH values

High pH values is important for root canal sealers because the release of calcium ions not only stimulates hard tissue formation but also triggers antibacterial activity (Al-Haddad and Che Ab Aziz, 2016) as reported in the studies by (Colombo et al., 2018; Kharouf et al., 2020). BioRoot™ RCS (Colombo et al., 2018; Kharouf et al., 2020) and TotalFill BC sealer (Colombo et al., 2018) exhibited high alkaline pH (up to 11) at 24 hours, similar to the previous studies on EndoSequence BC Sealer, EndoSeal MTA and MTA Fillapex (Lee et al., 2017). High alkalinity of EndoSeal MTA (Lim et al., 2015) and CeraSeal Bioceramic root canal sealer (Kharouf et al., 2020) have also been reported.

Radiopacity

ANSI/ADA Specifications 57 and ISO 6876 specifications recommend that all root canal sealers must have radiopacity greater than or equal to 3 mm Al. GuttaFlow Bioseal (Camargo et al., 2017) complied with the ANSI/ADA Specification 57, as well as the ISO 6876 specifications (Tanomaru-Filho et al., 2017), similar with MTA Fillapex that fulfilled the ANSI/ADA Specifications 57 (Vidotto et al., 2011), (Borges et al., 2014) and ISO 6876 specifications (Lee et al., 2017). TotalFill BC sealer (Tanomaru-Filho et al., 2017), EndoSequence BC Sealer (de Miranda Candeiro et al., 2012; Agarwal and Nikhil, 2016; Lee et al., 2017) and EndoSeal MTA (Lim et al., 2015; Lee et al., 2017) were also in accordance with the ISO 6876 specifications.

Cytotoxicity

Cytotoxic analysis of bioceramic root canal sealers have been reported by many researchers (Loushine et al., 2011; Mukhtar-Fayyad, 2011; Silva et al., 2013; Yoshino et al., 2013; Chang et al., 2014; Baraba et al., 2016; Candeiro et al., 2016; Silva et al., 2016; Collado-González et al., 2017; Saygili et al., 2017; Victoria-Escandell et al., 2017; Benetti et al., 2019; Rodríguez-Lozano et al., 2019).

The findings on viability of cells observed in their studies was complex, could be associated with multiple factors such as the types of root canal sealers (Loushine et al., 2011; Silva et al., 2013; Candeiro et al., 2016; Baraba et al., 2016; Collado-González et al., 2017; Saygili et al., 2017; Rodríguez-Lozano et al., 2019), incubation periods (Bryan et al., 2010; Loushine et al., 2011; Silva et al., 2013) and concentration of the root canal in the extract solution (Bryan et al., 2010; Mukhtar-Fayyad, 2011; Yoshino et al., 2013; Benetti et al., 2019).

For example, the cytotoxic effects of Endosequence BC Sealer (Baraba et al., 2016; Giacomino et al., 2019) or iRoot SP root canal sealer (Mukhtar-Fayyad, 2011) have been reported but the findings were inconsistent in other study where the iRoot SP root canal sealer and MTA Fillapex showed no cytotoxic effects (Chang et al., 2014). The discrepancy between these findings could be attributed to the different types of cell cultures and methods used for evaluating the viability of cells. Despite this, it is suggested by many researchers that the chemical composition of MTA Fillapex which includes salicylate resin, diluting resin and silica (Silva et al., 2013; Baraba et al., 2016; Silva et al., 2016; Victoria-Escandell et al., 2017; Colombo et al., 2018) that could contribute to the cytotoxic effects.

Another aspect was the high pH value of MTA Fillapex and Endosequence BC Sealer
(Baraba et al., 2016) that was postulated to cause loss of cell viability and membrane integrity (Lee et al., 2017). Bioceramic root canal sealers that exhibit prolonged high pH value (up to 12) before its setting may also cause damage to the periapical tissue. This needs to be carefully considered when choosing bioceramic root canal sealers for obturating the root canal, despite the materials’ osteogenic and antimicrobial properties (Lee et al., 2017).

In addition to that, the high solubility of MTA Fillapex that leads to a higher release of the toxic components (Silva et al., 2016) and long setting time of Endosequence BC Sealer (Baraba et al., 2016) can be the contributing factors determining the viability of cells.

Regarding the influence of concentration of the root canal sealers in the extract solution, most concentrated extract leads to more cell damage compared to a more diluted concentration (Mukhtar-Fayyad, 2011; Yoshino et al., 2013; Benetti et al., 2019) and this might occur because of the high pH of the materials that causes damage to the adjacent cells and denatures proteins (Siqueira Jr and Lopes, 1999). For instance, pure extract of MTA Fillapex showed high toxicity levels throughout the incubation periods from 24 to 72 hours as measured by occurrence of cell death and alteration of cell growth rates (Yoshino et al., 2013). However, a decreased cytotoxic levels were observed in diluted MTA Fillapex (Yoshino et al., 2013) and Sealer Plus BC (Benetti et al, 2019). These findings showed that eluents from the root canal sealers were cytotoxic to the cell culture and dependent on its concentration (Bryan et al., 2010).

The incubation period could also be involved in determining the viability of cells. Perhaps, this might explain why the severe cytotoxicity could be observed at 24 hours regardless of any root canal sealers (Bryan et al., 2010; Loushine et al., 2011) but the findings were contradictory to the other study where no cytotoxicity was observed in BioRoot™ RCS and TotalFill BC sealer observed at 24 hours (Colombo et al., 2018). This could be due to the different types of cell cultures that might not response similarly despite similar incubation periods. Freshly mixed AH Plus root canal sealer was cytotoxic, but the cytotoxicity gradually decreased over time (Bryan et al., 2010 Loushine et al., 2011; Silva et al., 2013). However, the MTA Fillapex exhibited cytotoxicity throughout the incubation periods (Silva et al., 2013; Baraba et al., 2016). Despite no cytotoxic effect in BioRoot™ RCS and TotalFill BC sealer during the early incubation period, mild cytotoxicity was exhibited at later incubation periods (48 hours and 72 hours) (Colombo et al., 2018).

Previous studies on the material cytotoxicity were carried out using in vitro cell cultures under specific protocols. However, results from this approach were limited because the cell cultures were monoclonal in origin, not dynamic in nature, had no cell-cell interactions and did not accurately represent the real clinical situation (Loushine et al., 2011). Additionally, the cell culture does not contain mechanisms for removal of the irritants (Bryan et al., 2010). Root canal sealers showed high cytotoxicity in a 2 dimensional (D) cell culture compared to the 3D cell culture due to the absence of cell-cell interactions in the 2D cell culture and a reduced capability of the extracts of root canal sealers to penetrate the 3D cell culture (Silva et al., 2016). Therefore, the findings of in vitro studies must be carefully interpreted and the extrapolation to the clinical practice must be made with great caution.

In order to confirm the safety and effectiveness of bioceramic root canal sealers, an alternative approach through an in vivo technique using Wistar rats was introduced to assess the histological characteristics of subcutaneous tissues after implantation with the materials (Bueno et al., 2016; Santos et al., 2019). It was found that the GuttaFlow BioSeal triggered low inflammatory reactions during the early and late stages of observation and improved vascular changes during late assessment (Santos et al., 2019). However, mild-to-moderate inflammatory reactions were observed during the initial observation period when using Smartpaste Bio®, but this
subsequently decreased over time (Bueno et al., 2016).

It has been demonstrated that the cytotoxicity of a root canal sealers may decrease with time (Loushine et al., 2011; Silva et al., 2013; Bueno et al., 2016) and later become noncytotoxic, achieved by desorption of the toxic components into the surrounding tissue (Bryan et al., 2010). Although the toxic components may take time to diffuse away from the periapical tissue, their presence may delay the healing process of periapical inflammation (Bryan et al., 2010), therefore, it is essential to understand that this desorption is immune response and can cause ongoing inflammatory process (Giacomino et al., 2019).

Biomineralisation

The osteogenic potential of bioceramic root canal sealers, also known as the biomineralisation have been reported in the previous studies (Gandolfi et al., 2008; Bryan et al., 2010; Han and Okiji, 2013; Chang et al., 2014; Hoikkala et al., 2018; Giacomino et al., 2019). This process begins with the release of calcium ions from the materials followed by the formation of silicate hydroxyl (Si-OH) groups at the material's surface, this will act as an ideal site for nucleation of hydroxyapatite crystal which later precipitates the formation of amorphous layer and becomes crystallised into carbonated hydroxyapatite (Hoikkala et al., 2018). It has been demonstrated that the MTA Fillapex (Chang et al., 2014) Smartpaste Bio® (Bueno et al., 2016), GuttaFlow Bioseal (Hoikkala et al., 2018), iRoot SP (Chang et al., 2014) or EndoSequence BC Sealer (Giacomino et al., 2019; Seo et al., 2019), BioRoot™ RCS (Seo et al., 2019), EndoSeal MTA (Seo et al., 2019) and ProRoot® ES endodontic root canal sealer (Giacomino et al., 2019) showed mineralisation activity in the cultured cell models.
shorter retreatment times compared to AH Plus root canal sealer (Donnermeyer et al., 2018).

To date, research on the retreatability of bioceramic root canal sealers is increasing but there is still insufficient evidence to draw robust conclusion pertaining to the most effective material that can facilitate retreatment procedure.

3D obturation

The goal of obturation is to create a 3D seal of the root canal system to prevent the recurrence of bacterial infection (Schilder, 1967). 3D obturation seals not only the main canal but also the eccentricities in the root canal system (Schilder, 1967). The use of heat softens the gutta-percha and allows it to be adapted to the root canal wall with the intention to seal the exits to periodontal tissues. This technique requires careful handling of the heat source, clinical skills and more time consuming to achieve effective sealing. A modified version of this technique has been introduced such as continuous and interrupted waves of vertical compaction to achieve similar 3D obturation (Tomson et al., 2014) which is also technique-sensitive procedure. Without proper handling and skill, 3D obturation would not be possible.

Studies have shown that thermoplastic gutta-percha provides good adaptation to the root canal wall (Gencoğlu et al., 1993; Gulabivala et al., 1998; Venturi and Breschi, 2004; Withworth, 2005), but leakage in thermoplastic and cold lateral compaction obturation techniques have also been highlighted (Vizgirda et al., 2004). Despite contradicting findings, thermoplastic gutta-percha has been shown to adapt uniformly to the root canal wall with only minor voids (Torabinejad et al., 1978).

Comparative studies on the ability to provide 3D obturation between bioceramic root canal sealers and other obturation techniques have not been reported because of the recent technology in endodontics. Future research works comparing various obturation techniques with bioceramic root canal sealers should be done to provide an insight into this aspect, thus can help the profession in the decision-making process with respect to the most effective materials for obturation of the root canal system.

Current practice

The obturation techniques have improved since the introduction of bioceramic root canal sealers. These developments facilitate easier methods of obturation and provide alternative to conventional obturation techniques (Topçuöğlu et al., 2013).

When obturating the root canal system, the root canal sealer is used to seal the gap that is present within the root filling materials and root canal wall. To date, the monocone obturation technique is the commonly practiced because of its ease of delivery and less time-consuming, however, the quality of obturation, apical seal and bacterial penetration when using this technique are questionable (Pereira et al., 2012). Due to the greater volume of sealer that can be present in the complex root canal system, this technique has been considered less effective (Pereira et al., 2012; Robberecht et al., 2012). Contradictory to this, some studies have reported similar performance of this technique (Inan et al., 2009; Koçak and Darendeliler-Yaman, 2012; Robberecht et al., 2012; Obeidat and Abdallah, 2014). To overcome the limitations associated with the monocone obturation technique, the role of conventional root canal sealers have gradually been replaced by the bioceramic root canal sealers.

Studies on fracture resistance of teeth obturated with combination of gutta-percha cones and bioceramic root canal sealers have been conducted in the recent years. An increased fracture resistance was seen when using iRoot SP root canal sealer if compared to the conventional root canal sealers (Ghoneim et al., 2011). However, when comparing the fracture resistance of iRoot SP root canal sealer and EndoSequence BC Sealer, it was equivalent (Celikten et al., 2015). The increased fracture resistance in EndoSequence BC Sealer (Topçuöğlu et al., 2013; Hegde and Arora, 2015) or iRoot SP root canal sealer (Ghoneim et al., 2011)
could be due to its chemical bonding through the formation of hydroxyapatite crystals during setting when the material is in contact with moisture (Ghoneim et al., 2011). Obturation of the root canal system using iRoot SP root canal sealer (Wang et al., 2018) or EndoSequence BC Sealer (Celikten et al., 2016), MTA Fillapex (Al-Haddad et al., 2015) and Smartpaste Bio® (Celikten et al., 2016) provided equivalent obturation quality as of AH Plus root canal sealer, as determined by the microscopic evaluation of the presence of voids and marginal gaps. Conversely, the EndoSequence BC Sealer (Al-Haddad et al., 2015) and MTA Fillapex (Polineni et al., 2016) exhibited more marginal gaps when compared to resin-based root canal sealers. These opposite findings could be associated with the different obturation techniques used in their studies. On the other hand, iRoot SP root canal sealer (Zhang et al., 2009; Ersahan and Aydin, 2013) and TotalFill BC sealer (Hasnain et al., 2017) were equivalent to AH Plus root canal sealer in apical sealing ability, as determined by dye penetration method (Hasnain et al., 2017) and fluid filtration analysis (Zhang et al., 2009; Ersahan and Aydin, 2013).

In general, regardless of any obturation techniques and root canal sealers, the presence of voids and marginal gaps is inevitable (Nabavizadeh et al., 2013; Samadi et al., 2014; Adhikari and Jain, 2018; Jain and Adhikari, 2018; Wang et al., 2018).

Conclusion

To date, robust scientific evidence on the obturation of the root canal system with bioceramic root canal sealers is limited, therefore, its use in clinical practice must be considered with great caution, taking into consideration the physicochemical properties, biocompatibility, biomineralisation as well as retreatability of each material. Since the clinical data concerning obturation with bioceramic root canal sealers is lacking, the selection of materials should be made based on the available scientific evidence, individual cases, material availability and operator’s preference.

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Conflict of interest

None

References


Physiochemical and antibacterial properties of novel, premixed calcium silicate-based sealer compared to powder-liquid bioceramic sealer. *Journal of Clinical Medicine*, 9(10), 3096.


human dental pulp stem cells. Materials, 12(15), 2482.


