MTA BIOSEAL

WHITE PAPER

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CLINICAL PRODUCTS

1- Product description

The commercially available root canal sealers are categorized according to their chemical composition:

Main ingredients	Function
Mineral Trioxide Aggregate	**Bioactive component**
Silica nanoparticles	Filler
Salicylate resin	Complex formation
Silica nanoparticles	Filler
Calcium Tungstate	Radiopacifier

- Radiopaque
- No discolouration
- Not irritant
- Easy to remove if necessary

According to Grossman (1974) [1], root canal filling material must possess the following properties:

- Easiness of placement into the canal
- Ability to seal all canal including accessory ones
- No shrinkage
- Completely waterproof
- Unsuitable for bacterial proliferation

In this context, the root canal sealer allows tissue repair, because the periapical tissues are able to rest from the previous irritation, leading to the reorganization of the periodontal ligament. [2]

MTA BIOSEAL is an endodontic root canal sealer based on Mineral Trioxide Aggregate. It is a double paste component that allows complete filling of all root canals including accessory and lateral ones.

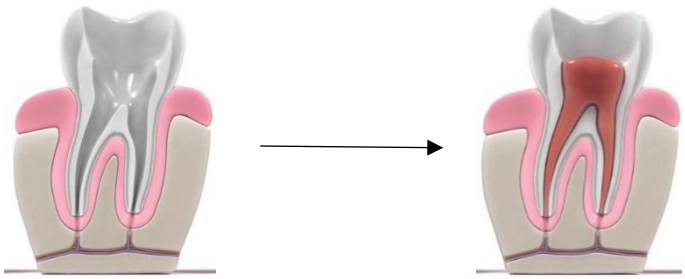
Mineral Trioxide Aggregate is a worldwide known endodontic reparative material that is more stable than calcium hydroxide.

Sealers based on MTA have been reported to be biocompatible, stimulate mineralization [3] and encourage apatite like crystalline deposits along the apical and middle thirds of canal walls [4]

Plus, Parirokh and Torabinejad (2010) [5] have shown that a chemical bond is generated between MTA and the dentinal walls and tubules when MTA cements are used as root canal filling materials in association with gutta-percha.

2- Indications

MTA BIOSEAL is indicated for root canal filling of definitive teeth with gutta percha points.



It is compatible with both cold and thermal condensation techniques, as MTA BIOSEAL's boiling point is over 140°C. [6] The presence of salicylate resin makes it easy to retreat if needed.

3- Product composition

MTA BIOSEAL is a double paste system composed of biocompatible resins mixed with Mineral Trioxide Aggregate.

MTA cements commonly come in powders and thus are difficult to use for the root canal filling application because of its sandy consistency, poor handling properties and impossibility of retreatment.

The adjunction of a biocompatible resin in MTA BIOSEAL allows the product to conserve the paste-paste cements physical advantages combined with the extraordinary bioactivity of the MTA. [6]

Mineral Trioxide Aggregate is a bioactive material that induces the healing of periapical lesions. It stimulates the formation of cementum, bone and indirectly, periodontal ligament. It is the first material known in Endodontics that allows the growth of cementum layer directly on its surface [7].

Mineral trioxide aggregate	
Silicate tricalcium (C3S)	Initial set & early strength
Silicate dicalcium (C2S)	Long term strength
Aluminate tricalcium (CA3)	Initial set
Calcium oxide (CaO)	Calcium ions release

4- MTA BIOSEAL

A- Properties, action and benefits

Property	Advantages
MTA Presence	Remineralization of hard tissues / Biological action
Biocompatibility	Total integration / Rapid recovery of the inflamed tissues No inflammatory reactions beyond the apex
Radiopacity	Easily visualised on x-rays
Flow	Able to penetrate all canals including lateral and accessory ones
Expansion	Provides a perfect biological sealing
Calcium release	Induce physiological wound repair processes
High pH	Prevents bacterial proliferation and induces remineralization
Pastes system	Easy to manipulate and insert inside the canals

A- Key chemical reactions: Hydration & Calcium complexation

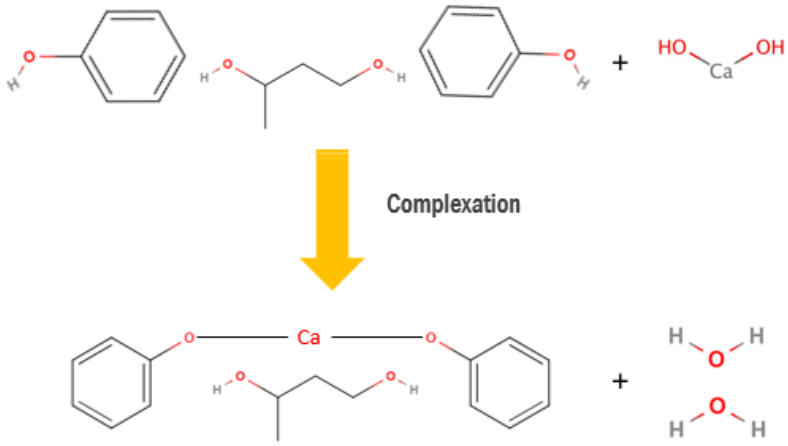
A complexation reaction can be described as a reaction that forms coordination complexes involving more than one species. A coordination complex consists of a central atom or ion, which is usually metallic, and a surrounding array of bound molecules or ions, that are in turn known as ligands or complexing agents.

The chemical reaction of the MTA BIOSEAL is an autocatalytic process based on this chemistry.

The MTA BIOSEAL reaction is initiated by the interaction of the product with water molecules from the dentinal tubules and surrounding tissues.

Free Calcium Oxides (CaO), present in high concentration inside the formula hydrate when in contact with water molecules to form Calcium Hydroxide (CaOH).

Then, a chelation reaction, which is a bonding between a metal ion and other ions or molecules, happens between the newly formed Calcium Hydroxide and the salicylate resin present in the formula of MTA BIOSEAL, forming a complex in which the calcium ions are trapped.



This reaction will release a new molecule of water, engaging a chain reaction and automatically accelerating the whole process.
Thus, the reaction is initiated thanks to the water molecules present inside the dentin tubules that will hydrate free Calcium Oxide, forming Calcium Hydroxide, which will in turn react with the resin. [6]

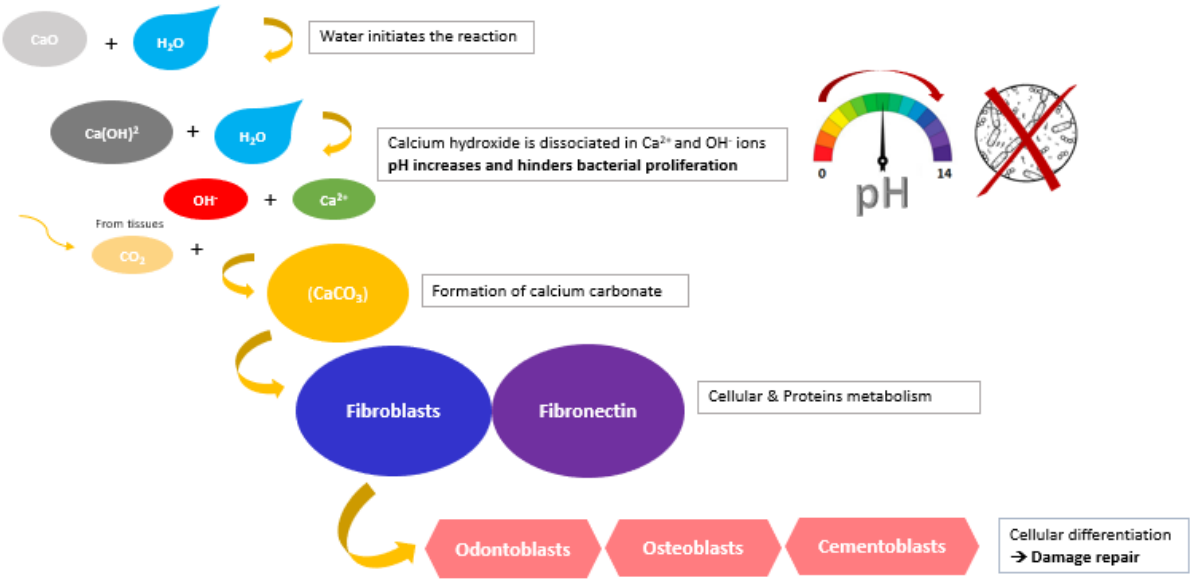
In the end, the presence of water is key to start the first hydration process of MTA BIOSEAL.
This chemistry is different of that of most of the resin based dental materials available on the market as the MTA BIOSEAL chemical reaction is not based on polymerization of its components.

Polymerization processes of dental material are known to release potentially toxic compounds during polymerization. Those reaction are also most of the time exothermic and thus increase the local temperature inside the mouth which can be harmful for the surrounding tissues. [8]

B- MTA mechanism of action

MTA BIOSEAL contains 13% of Mineral Trioxide Aggregate.

This concentration inside the formula is calculated to conserve the biological action of the Mineral Trioxide Aggregate and the ease of manipulation of resinous dental material.



Through dissociation, Hydroxide and Calcium ions are released from the material, leading to a highly alkaline local pH.

This environment is known to be inhospitable to bacterial proliferation.

Plus, Gandolfi et al. (2014) have shown that hydroxide ions stimulate the expression of Alkaline Phosphatase and Bone Morphogenetic Protein 2, indicators of mineralization processes. [9]

When in contact with fluids from the surrounding tissues, mineral precipitates are formed, leading to the formation of a hydroxyapatite-like layer.

This will lead to the formation of a Mineral Trioxide Aggregate and dentin interface, enhancing the sealing ability of the material. [10]

This aggregation will also trigger cellular differentiation and proliferation processes, leading to cementum and bone formation.

C- Controlled dimensional change

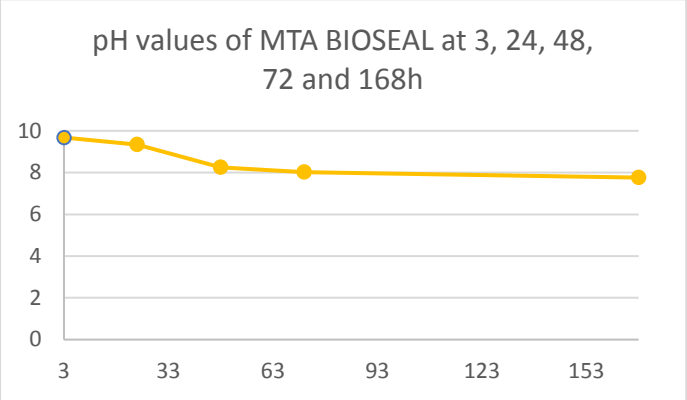
Contrary to common epoxy-resin cements, that undergo shrinkage during polymerization, MTA BIOSEAL expands due to the different chemical reaction.

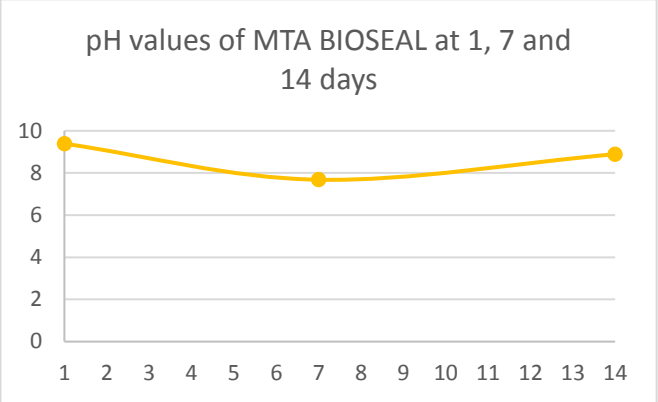
MTA BIOSEAL expands of 0,088%.

This controlled expansion is due to the hydration reaction occurring within the material. It is optimized for a better marginal sealing in order to prevent bacterial leakage. [6]

D- Bacteriostatic properties

MTA BIOSEAL allows a steady hydroxide ion release throughout the material, resulting in high pH values from 3 hours up to 2 weeks after setting of the sealer. [6] [11]



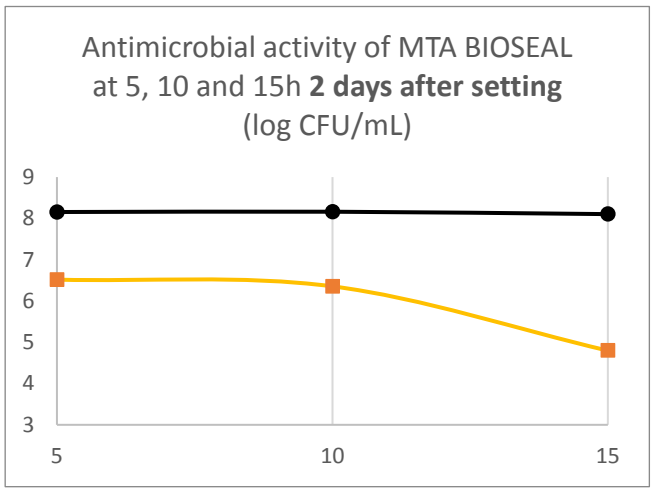


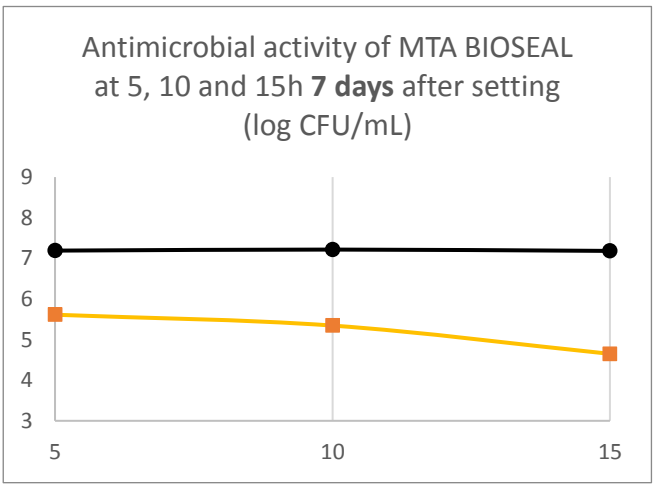
This accumulation of hydroxide ions creates a very alkaline medium, unsuitable for bacterial proliferation. This characteristic gives MTA BIOSEAL its bacteriostatic properties.

Plus, the high pH of the sealer may also neutralize the acids secreted by osteoclasts, preventing even further the destruction of the mineralized tissue. [12]

In teeth with periapical infection, bacteria may be present in the dentin walls and on the external apical root surface, making their elimination extremely difficult during root canal treatments. [13] [14]

Plus, when organized into biofilms, microorganisms have greater resistance against antiseptics and antibiotics. [15]



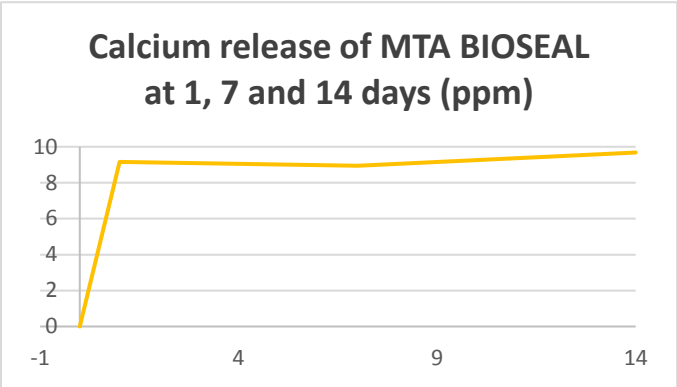


The figures show the quantity of bacteria allowed to form a biofilm at 5, 10 and 15 hours of contact with MTA BIOSEAL set for 2 and 7 days, compared to a biofilm alone. [16]

The quantity of bacteria is lower in the MTA BIOSEAL group, and tends to decrease steadily as the time of contact increases.

This means that MTA BIOSEAL shows a good bacteriostatic action against biofilm compared to the control, even 7 days after setting.

E- Calcium ions release

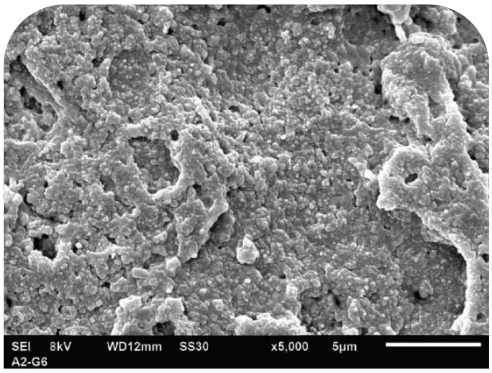


Adjacent to the hydroxide ions, MTA BIOSEAL also releases calcium ions over time. [6]

Holland et al (1999) have shown that calcium ions react with the carbon dioxide from the surrounding tissues and form calcium carbonate crystal-like granulations. [17]

Those nucleations will lead to the formation of a sticky calcium silicate hydrate gel that improves the sealing ability of MTA over time. [18]

This phenomenon is also said to reduce marginal gaps and porosities and to increase the retention of the cement [19]

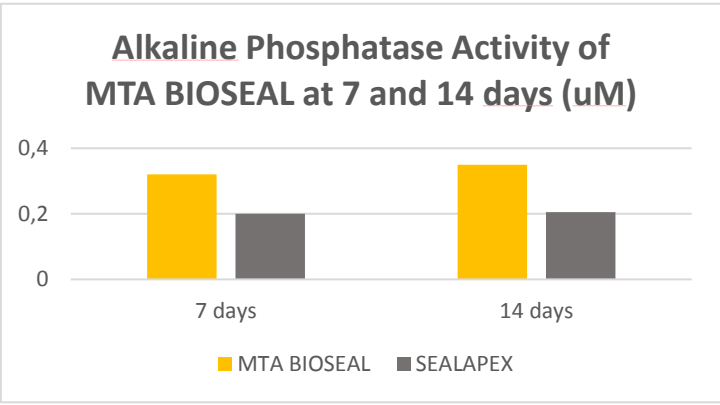


Scanning electron microscopy of MTA BIOSEAL (x5000) [2]

F- Biological properties

When in contact with water, the CaO present inside MTA BIOSEAL formula is converted into calcium hydroxide and dissociated into calcium and hydroxide ions.

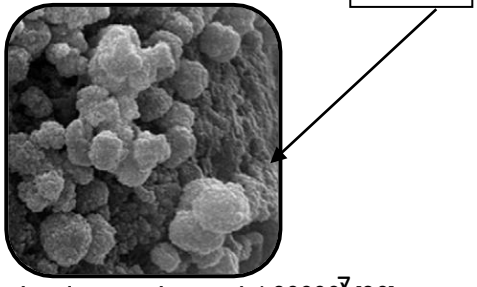
The diffusion of hydroxide ions from the root canal increases the pH at the surface of the root adjacent to the periodontal tissues, possibly interfering with osteoclastic activity and promoting alkalinisation in the adjacent tissues, which favours healing. [20] [21].



A high pH also activates alkaline phosphatase, enzyme strictly involved in the mineralization and hydroxyapatite nucleation processes. [12][22][23]

MTA BIOSEAL shows an enhanced Phosphatase Alkaline activity compared to another Calcium Hydroxide sealer, up to two weeks after the sealer setting [24].

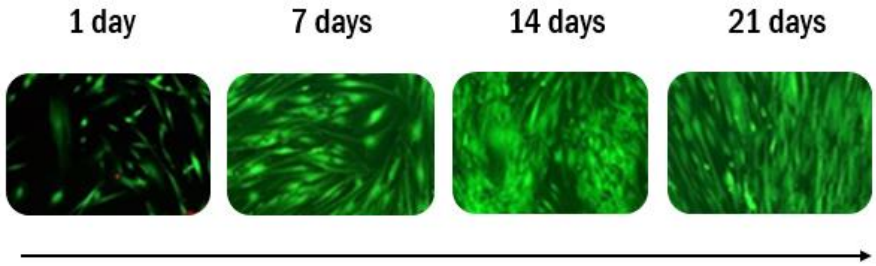
The diffusion of Calcium ions participates in the activation of the calcium dependant ATP and react with CO2 to form calcium carbonate crystals that serve as a nucleation site for calcification. [325]



Scanning electron micrograph (x20000) [26]

Plus, Salles et al. (2012) [26] have shown that MTA BIOSEAL have a significant stimulatory effect on the formation of a large number of mineralized hydroxyapatite-like crystals from 0,2µm to 0,8µm.

Calcium ions is also needed for cell migration and differentiation, as a rich extracellular network of fibronectin comes in close contact with the newly formed crystal and initiates the step in the formation of a hard tissue [27] [28].



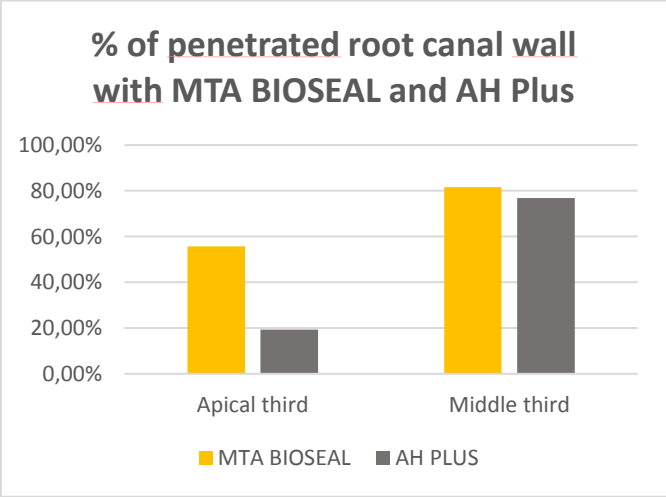
Cellular proliferation of osteoblasts in contact with MTA BIOSEAL up to 21 days

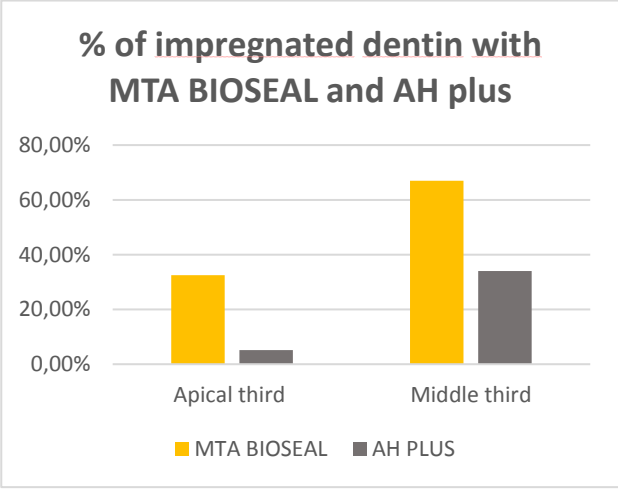
G- Dentin tubules penetration

Common failure of the root canal obturation processes are due to the presence of gaps and porosities at the sealer / dentin interface. [30]

Additionally, sealer penetration into the dentinal tubules is required in order to have a tight barrier with the residual bacteria and inhibit their growth to prevent reinfection after treatment. [31]

Sealer penetration inside the tubules also improves the adaptation and retention of the material and provide a mechanical interlocking between the sealer and root dentin. Silva RV et al 2015 – [32] [33]

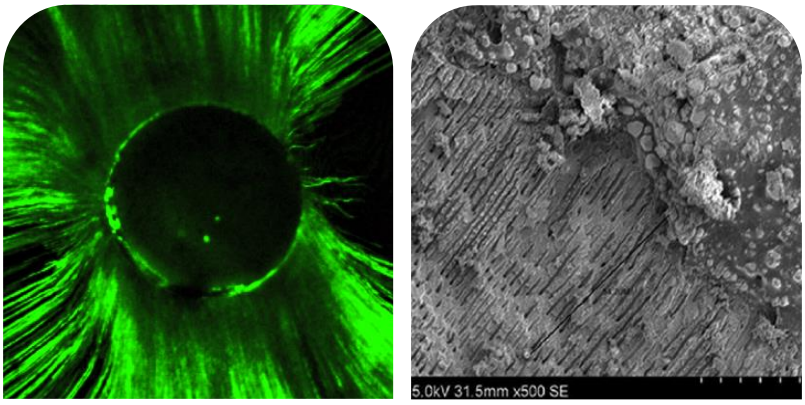




Mamootil *et al.* [34] have shown that the depth of penetration is influenced by the chemical and physical characteristics of the sealer's components.

Plus, due to the anatomical differences, sealers penetration varies between the apical third, that has tubules with a smaller diameter and the cervical third.

Thanks to its flowability properties, MTA BIOSEAL exhibits a great and homogenous tubules penetration at the apical and at the cervical third of the canal, compared to a classic epoxy-resin sealer. [35]



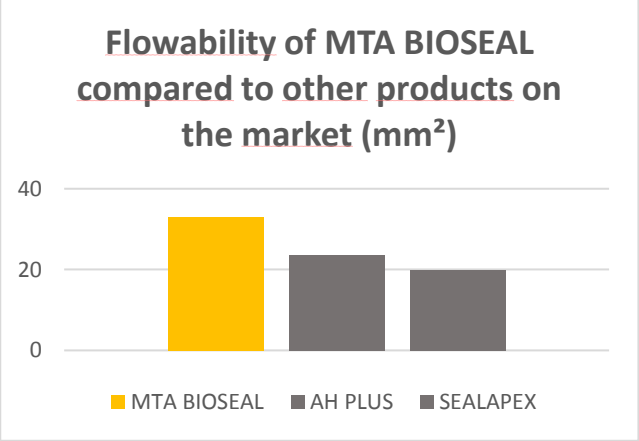
MTA BIOSEAL dentinal tubules penetration
Confocal laser scanning microscope (x10) [35] Scanning electron microscope (x500) [36]

2- Technical properties / Market

A- Flowability

Root canal sealers should have suitable flow value in order for them to be able to penetrate accessory canals and irregularities of root anatomies.

MTA BIOSEAL possesses the highest flow values compared to the other products above. [37]



Zhou et al. (2013) [38] have shown that flow of endodontic sealers has an effect on the obturation of accessory canals and micro-spaces. With its high flow values, MTA BIOSEAL is able to fill all canals even accessory and lateral ones.

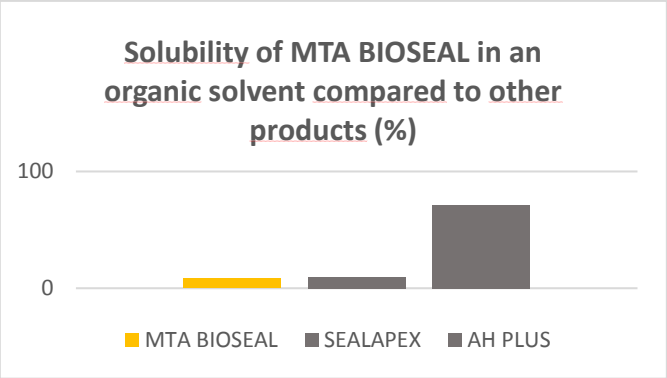
It is a common phenomenon that due to their fluidity, root canal sealers leak beyond the apex of the tooth during treatment and cause damage to the periodontal tissues.

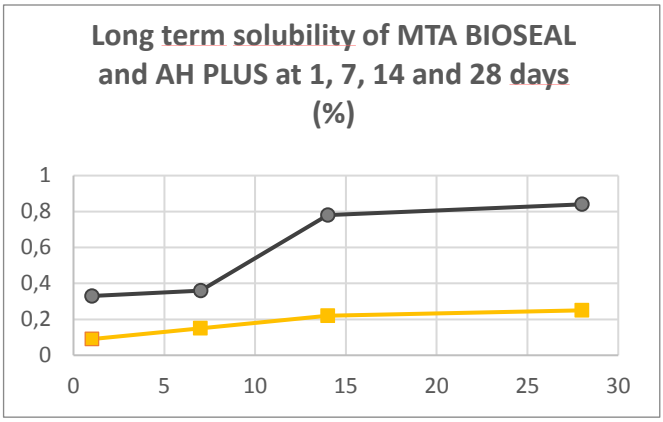
As MTA BIOSEAL is charged in bioceramic components, it does not induce inflammatory reactions if the sealer happens to leak at the apical foramen of the tooth.

B- Solubility

In general, endodontic sealers should have low solubility when in contact with tissue fluids to prevent the release of chemical compounds into the periapical region which can trigger an inflammatory reaction. [39]

Compared to other products, MTA BIOSEAL has a lower solubility inside organic solvents. [40]



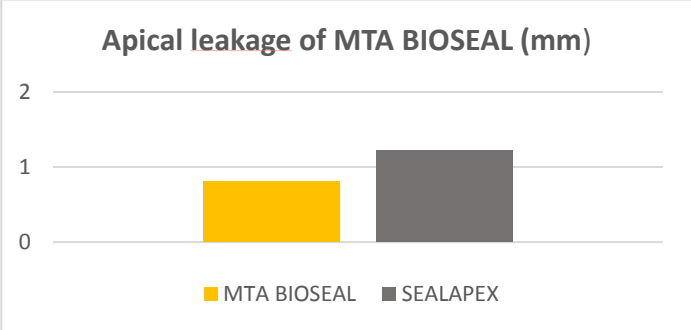


Moreover, long term solubility increases the possibility of gap formation between root canal dentin and the filling material, increasing the risk of bacterial leakage and fracture at the interface.

MTA BIOSEAL is not soluble over time compared to an epoxy-resin sealer, which guarantees its stability over time. [39]

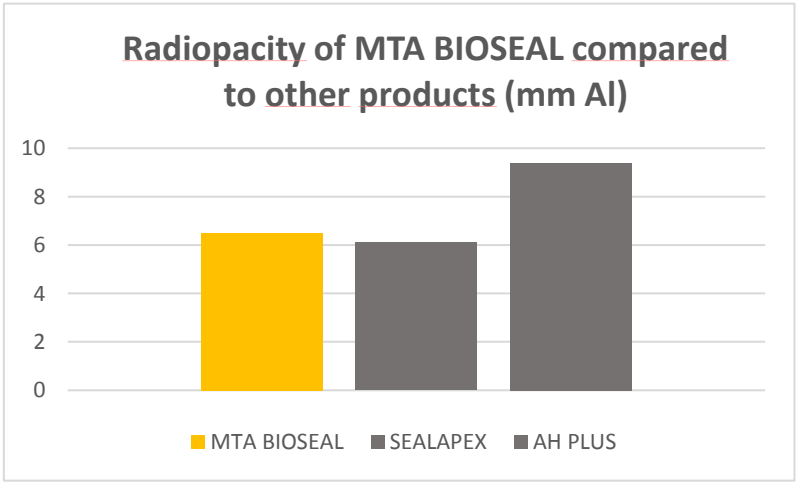
C- Apical leakage

Along with the solubility properties, the controlled expansion of MTA BIOSEAL allows the material to decrease the risk of apical leakage compared to another Calcium Hydroxide product. [6]



D- Radiopacity

According to the ISO 6876, endodontic root canal sealers should be radiopaque enough in order to allow their visualization next to adjacent anatomical tissues such as teeth and bone, and other restoration elements.



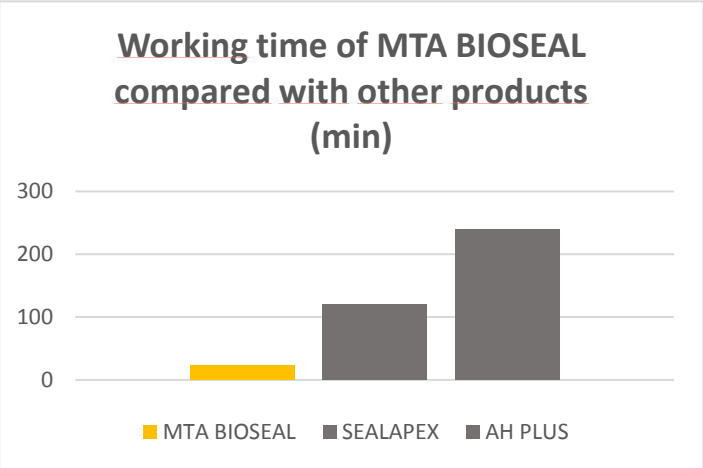
MTA BIOSEAL possesses high values of radiopacity for an easy visualization.

Its formula is based on Calcium Tungstate, a high quality radiopacifier that is not linked to discoloration of teeth. [6]

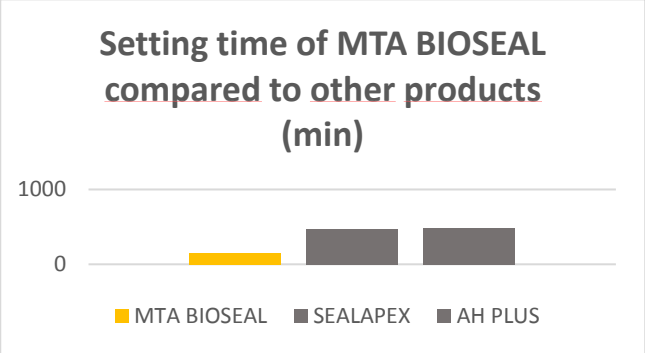
E- Working time

The working time is the period of time measured between the start of mixing until it is no longer possible to handle the sealer without promoting adverse effects on its properties.

MTA BIOSEAL possesses a working time of 23 minutes, suitable for the endodontic session while being shorter than other products on the market. [6].



F- Setting time



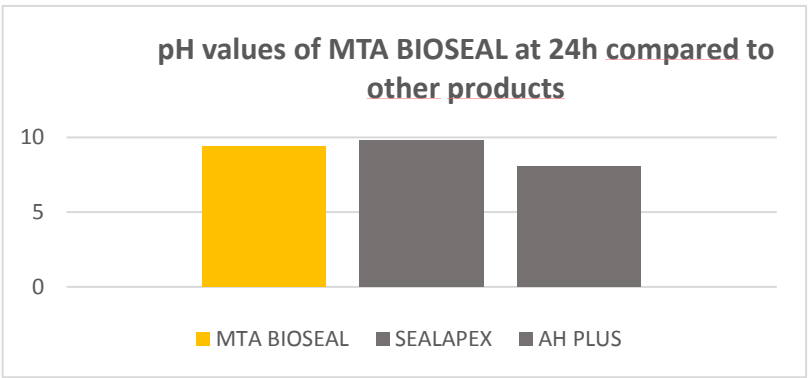
Root canal sealer are known to possess high values of setting time.

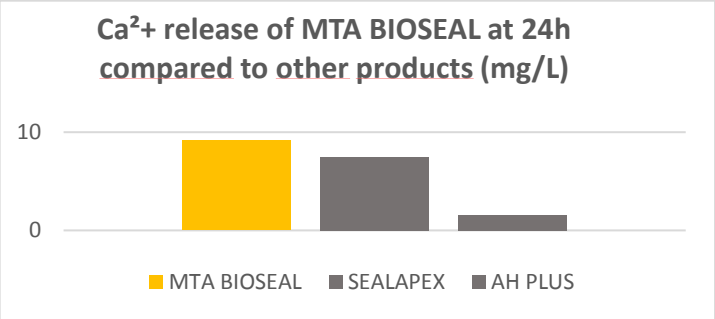
MTA BIOSEAL has a setting time of 2 hours, lower than the setting time of other products on the market. [6].

G- Ions release

MTA BIOSEAL possesses high values of pH, due to the release of hydroxide ions throughout the material.

Those values are stable in time (fig pH) and one of the highest on the market. [41].

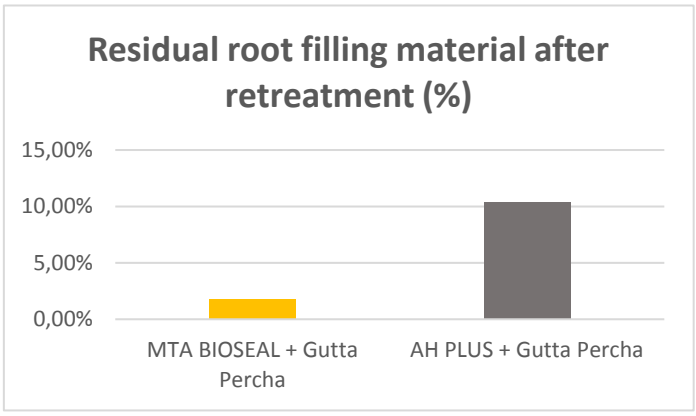




MTA BIOSEAL releases more calcium ions than other products on the market, awarding the product its excellent remineralization and tissue reparation properties. [41].

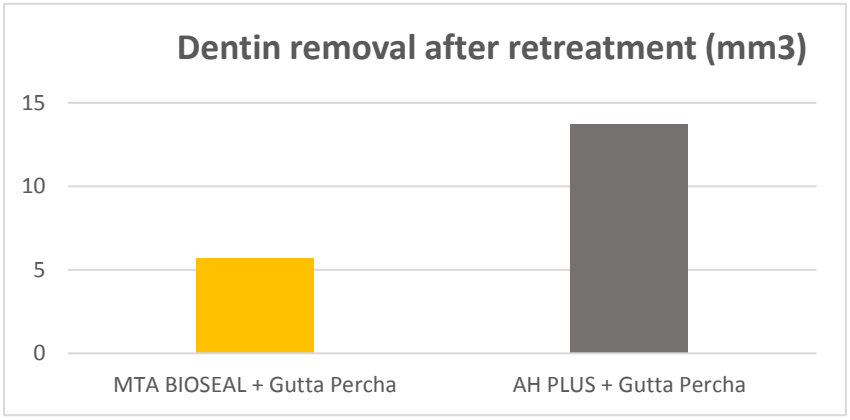
H- Retreatment

Retreatment of endodontically filled teeth aims at complete removal of the root canal filling material to regain access to the apical foramen in order to facilitate cleaning and shaping of the root canal system. [42].



Compared to a standard epoxy-resin sealer, MTA BIOSEAL show less residual material after retreatment, which highlights the product's ease of removal. [43].

Plus, MTA BIOSEAL shows less dentin loss after retreatment than the epoxy-resin sealer, indicating that its removal is less traumatic for the residual tissues. [43].



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