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In Vitro Study Of The Physicochemical Properties Of Association Between MTA Cement And Sealapex For Applications In Endodontic Treatments

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Abstract

This study investigated the physical and chemical properties of the association between mineral trioxide aggregate (MTA) cement and Sealapex cement, with the aim of evaluating its potential as a retrofilling material in endodontic procedures. MTA is widely used in endodontics due to its developed properties, such as biocompatibility and tissue-promoting capacity.However, difficulties in its clinical consequences led to the proposal of combining it with Sealapex cement. The research focused on analyzing five main aspects: solubility, surface morphology, calcium ion release, pH variation and electrical conductivity. The methodology complements the procedures proposed by previous studies, using polyethylene rings to measure solubility, scanning electron microscopy (SEM) to observe surface morphology, and atomic absorption spectrometry to quantify calcium ion release. In addition, the pH and conductivity of the samples were measured for verification. The results indicated that the MTA + Sealapex combination presented an average solubility of 5.29%, a value higher than that recommended by the American Dental Association (ADA), which establishes a limit of 3% for endodontic cements. Pure MTA, by comparison, has a significantly lower solubility of 0.67%, according to the literature. The high solubility of the combination may compromise apical adaptation and promote the liberative release of toxic products. However, this same solubility may favor the controlled release of ions. The release of calcium ions was 15.6 ppm for the MTA + Sealapex combination, lower than the value of 20.7 ppm provided for pure MTA. This release

is essential for increasing the pH, which reached an average of 10.3 in the combination, promoting antimicrobial action and favoring the formation of calcite, essential for tissue supplements. It is concluded that, although the MTA + Sealapex combination presents promising results, especially in terms of biocompatibility and reparative potential, further studies are necessary to determine its clinical efficacy. Solubility control is crucial to balance the seal.

Keywords: *MTA, Seal, Solubili, Biocompat, pH, Conduction, Repair, Scanning electron microscopy.*

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I. Introduction

Since the creation of the Endodontic Association in 1943, endodontics has undergone constant evolution, especially in recent decades. This progress is largely due to the development of new technologies and materials that allow significant improvements in endodontic treatments. The history of endodontics reveals a constant search for effective solutions to dental problems, and the materials used play a crucial role in this evolution. The ideal endodontic materials must present a series of physical, chemical and biological properties that guarantee clinical results.

Among the main properties that these materials must have, biocompatibility stands out, which is essential to ensure that the material does not cause adverse reactions in the surrounding tissues, and low solubility, which is essential to maintain the tooth seal and prevent bacterial infiltration. In addition, it is interesting that the materials are bactericidal or bacteriostatic, helping to eliminate or control the presence of microorganisms, which are one of the main causes of failures in endodontic treatments. Another relevant aspect is the ability to assist in the process of tissue parts, promoting the healing of injured tissues around the tooth root. To this end, the material needs to have adequate setting and working times, allowing.

Despite the specialized qualities of MTA, one of the challenges reported in several studies is the difficulty of clinical operations. The consistency of MTA and its prolonged setting time may make its application difficult in some clinical situations, especially in areas of difficult access or in cases where rapid manipulation is essential (VIVAN, 2009). To overcome this limitation, Gomes Filho et al. (2011) suggested combining MTA with Sealapex-Kerr endodontic cement, a calcium hydroxide-based cement used in fillings. This combination showed promising results in terms of biological properties, but further studies are still needed to evaluate other important characteristics, such as solubility, release of calcium ions, pH variation, electrical conductivity and the presence of pores, which are essential for the ideal clinical application of MTA.

The release of calcium ions is directly related to the process of tissue repair. The presence of hydroxyl ions in tissue fluid creates an antimicrobial environment, while calcium ions help form mineralized tissue barriers, promoting healing. MTA, being based on calcium silicate, has the ability to release calcium ions when it comes into contact with fluids, which raises the local pH and favors the formation of calcite, an essential mineral for tissue regeneration (FRIDLAND et al., 2003; SEUX et al., 1991). The combination of MTA with Sealapex, a material that also releases calcium ions, has the potential to amplify this effect, contributing to more efficient healing.

Another important aspect to be evaluated when combining endodontic sealers is the pH variation. Increasing the pH at the lesion site is beneficial for two main reasons: first, a high pH creates a hostile environment for the growth of pathogenic microorganisms, helping to prevent recurrent infections; second, it favors the tendencies of compounds such as calcite, which are essential for the formation of mineralized tissue barriers. The ability of a material to increase local pH is directly related to its chemical composition and its ability to release ions.

Furthermore, electrical conductivity is an important property for evaluating the release of calcium ions in an aquatic environment. Conductivity indicates the presence of free ions in the solution, which, in the case of endodontic sealers, is related to the release of calcium in its ionic form. An analysis of electrical conductivity can provide useful information about the solubility and availability of calcium ions, factors that directly influence the process of tissue repair and the effectiveness of the implant.

The surface morphology of the sealer also plays a crucial role in its sealing ability and long-term clinical success. The formation of pores during the solubilization process can compromise apical placement and allow infiltration of fluids and microorganisms, which can result in failure of endodontic treatment. Scanning electron microscopy (SEM) is an essential tool for detailed analysis of the sealer surface after solubilization. It allows observation of pore formation and other morphological changes that may occur during the curing process of the sealer, providing deeper insight into the suitability of the material for clinical use (DEDAVID et al., 2007).

Given this context, the present study aims to evaluate the solubility of the combination of MTA and Sealapex cements, in addition to performing a morphological analysis of their surface during the solubilization process using scanning electron microscopy (SEM). The levels of calcium ion release will also be quantified using an atomic absorption spectrometer, and the pH and electrical conductivity values of the mixture will be evaluated over time. The current literature on the MTA-Angelus restorative cement will be used as a basis for comparison for the results.

This study will contribute to the understanding of the physicochemical properties of the combination of MTA and Sealapex, helping to determine its clinical applicability. Although the biocompatibility of this combination has already been demonstrated in previous studies, other factors, such as solubility, calcium ion release and surface morphological characteristics, need to be investigated further to ensure that this combination presents real benefits for endodontic procedures.

II.Methodology

The methodology employed for this study strictly followed the procedures established in previous studies, ensuring that the tests performed were comparable with reference research. For all tests, the mixing ratio between the cements was the same as that suggested by Gomes Filho et al. (2011), who explored the combination of MTA and Sealapex to improve the clinical handling of the material and its biological results.

Solubility Test

To evaluate the solubility of cements, the methodology described by Carvalho-Junior et al. was used.

(2007). This procedure is widely accepted in studies on endodontic materials, due to its decisiveness in determining the mass loss, which indicates the level of solubility of the material. A set of polyethylene rings, with a width of 1.5 mm and an internal diameter of 4.47 mm, was used to contain the sealers during the test.

The rings were placed on a glass plate covered with cellophane paper, ensuring that the interaction between the cement and the environment was isolated. The cements were then inserted into the rings according to the specifications indicated by the manufacturers, ensuring that the standardized requirements were in accordance with the manufacturing instructions for each material. Subsequently, a second glass plate, also covered with cellophane paper, was pressed onto the rings to ensure a flat surface on the samples. This step is essential to ensure that the contact of the cement surface with the test medium is uniform, minimizing variations in specifications (CARVALHO-JUNIOR et al., 2007).

The samples were prepared at room temperature, approximately 25ºC, and then the assemblies were placed in a cabin with a controlled temperature of 37ºC and relative humidity between 90% and 100%. The exposure time in the cabin was 50% longer than the setting time reported by the manufacturers of the tested cements. This additional time was necessary to ensure that the cements had enough time to complete the setting process, an important factor to specifically evaluate solubility (GOMES-FILHO et al., 2011).

After the exposure time, each sample was removed from the rings and weighed three times on an analytical balance, with an accuracy of 0.0001 g. This solution is essential to ensure the accuracy of the results, since the loss of mass is a crucial measure to determine the solubility of the cement. The average of the three readings was recorded as the initial weight of the samples (CARVALHO-JUNIOR et al., 2007).

The samples were then placed in vials containing 2.5 ml of deionized distilled water, sealed and stored in the cabin for 24 hours. After this period, the samples were removed, washed with deionized water, dried with absorbent paper and placed in a desiccator for 24 hours. After drying, the samples were weighed again three times, following the same procedure described previously, and the average readings were recorded. This cycle was repeated three times for each sample in order to ensure the reproducibility of the results (CARVALHO-JUNIOR et al., 2007).

Solubility was calculated as the percentage of mass loss of the samples, using solution 1, which expresses the difference in weight of the samples before and after the experimentation process in distilled water (CARVALHO-JUNIOR et al., 2007). This value is important to determine whether the material maintains its mechanical and chemical properties after interaction with the aqueous medium, which is essential for success in clinical procedures, such as apical sealing and perforation repair (VIVAN, 2009).

Surface Morphology Analysis

The same samples used in the solubility test were used for the surface morphology analysis. After the solubility test, the samples were dried in a desiccator for 24 hours to remove any traces of moisture that could interfere with the morphological analysis. To be observed under a scanning electron microscope (SEM), the samples were first metallized with gold. This process was performed with the aid of a sample metallizer, where each sample was carefully coated with a thin layer of gold to improve conductivity and allow a more detailed visualization of the surface characteristics (DEDAVID et al., 2007).

$$S = \frac{M_f - M_i}{M_i} \times$$

S=Solubility; Mf=Final Mass and Mi=Initial

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The metallized samples were then discovered with a scanning electron microscope (SEM), model EVS ZEISS LS15. SEM allows the observation of details of the surface of the samples in high resolution, providing valuable information about the presence of pores, cracks and other irregularities that may arise during the solubilization process. Surface morphology is a critical factor in evaluating the effectiveness of endodontic materials, since the presence of pores can compromise the sealing and allow the infiltration of bacteria, resulting in treatment failures (DEDAVID et al., 2007).

The images found were compared with reference samples, which did not undergo the inspection process, to identify any morphological changes associated with the solubility test. These analyses provided crucial information on the structural stability of the cements, a determining factor for their long-term clinical applicability (GOMES-FILHO et al., 2011).

Ion Release Test

The release of calcium ions was evaluated using a method that employed five polyethylene tubes, with an internal diameter of 1 mm and a length of 10 mm, filled with the cements under test. The tubes were filled with the help of a Macspaddem compactor, adapted to a low-speed motor, ensuring that the amount of material inside the tubes was standardized. Any excess material was removed with the help of a sterile eye, ensuring that the samples were collected uniform and comparable to each other (GOMES-FILHO et al., 2011).

To ensure the accuracy of the results, the tubes were weighed on an analytical balance before and after the response, and any samples with values very different from the others were discarded and removed. This strict control was essential to standardize the mass of the material tested, preventing weight variations from interfering with the ion release results (CARVALHO-JUNIOR et al., 2007).

The samples were individually immersed in screw-capped test tubes containing 10 ml of deionized water. Before analyzing the samples, the pH, conductivity and calcium ion concentration values of the deionized water were measured to confirm its neutrality and ensure that the changes observed after the test were attributed exclusively to the cements (GOMES-FILHO et al., 2011).

The tubes were stored in a cabin with a temperature of 37 ± 1ºC and relative humidity between 95% and 100%, for a period of 21 days. This environment simulates real clinical conditions, such as body temperature and the presence of humidity, which are critical factors for the release of calcium ions and the interaction of the material with the surrounding tissues (VIVAN, 2009).

After the run-in period, each sample was removed from the vial, and the remaining aqueous solutions were distributed into a 5 mL beaker. The pH of the solutions was measured using a pH meter QUIMIS, model Q-400, calibrated with standard solutions of pH 4.0 and 7.0. Conductivity measurement was performed with a DIGIMED conductivity meter, model CD20, calibrated with a calcium standard of 1,412 µS/cm at 25ºC. These questions provided valuable data on the release of ions and the interaction of cements with the aqueous medium (GOMES-FILHO et al., 2011).

The release of calcium ions was quantified in a VARIAN SPECTRAA 55 B atomic absorption spectrometer, using the most intense calcium emission line, at 422.7 nm. To eliminate interferences that could mask the amount of Ca^{2}ÿ in the tested solution, 19 mL of lanthanum oxide in 1 mL of solution were used. The fuel used for the flame was air-acetylene, ensuring a clean and consistent burn for the analysis (CARVALHO-JUNIOR et al., 2007).

In order for the spectrometer to provide accurate values of calcium ion concentration in the solution, a deficiency curve was created using calcium standards with concentrations of 0, 1, 2, 3, 4.

III.Results And Discussion

In this study, the solubility parameters, pH variation, electrical conductivity and calcium ion release of MTA and Sealapex cement samples, both isolated and combined, were evaluated.

The results obtained are presented in Table 1, and the scanning electron microscope (SEM) images show the morphological changes of the sample surfaces before and after immersion in distilled water.

Table 1: Results of tests performed

Samples	Solubility (%)	pH	Conductivity (µs/cm)	Calcium Ion Release (ppm)
1	5,63%	9.4	282	18,7
2	5,79%	10.5	172	15,4
3	5,50%	10.4	149	14
4	4,07%	10.8	290	17,2
5	5,50%	10.8	250	12,7
Average	**5,29%**	**10.3**	**228**	**15,6**

The solubility of an endodontic sealer is a critical characteristic for its clinical success, since it directly influences the sealing capacity and durability of the material in the moist environment of the human body. As observed in Table 1, the combination of MTA and Sealapex presented an average solubility of 5.29%. According to the American Dental Association (ADA) standard 57, endodontic sealers intended for clinical purposes must present a solubility of less than 3%, which indicates that the solubility of the tested samples is above that recommended for an ideal material (COSTA et al., 2014).

High solubility may compromise apical placement and allow infiltration of fluids and microorganisms, which may result in clinical failures. The solubilization process may also cause the formation of pores in the material, which affects its sealing capacity. However, the presence of calcium hydroxide in both MTA and Sealapex may lead to the release of calcium ions during solubilization, which aids in the formation of a mineralized tissue barrier, favoring the process of tissue attachment (FRIDLAND et al., 2003).

Samples with solubility greater than 5% indicate that the material, although biocompatible, may not be the most suitable for long-term sealing in situations requiring high resistance to infiltration.

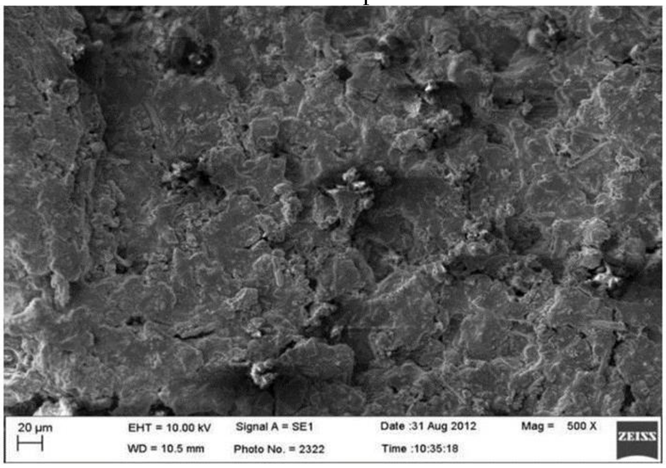
Comparatively, pure MTA cement presents a much lower solubility, around 0.67%, according to the literature by Costa et al. (2014). This suggests that, despite the benefits of combining MTA with Sealapex, the solubility of the material should be better controlled in future developments in order to improve its clinical performance.

Surface Morphology

The images obtained through scanning electron microscopy (SEM) clearly demonstrate the changes in the surface morphology of the samples after the analysis process. Photos 10 A, B, C and D show the cement surface before and after immersion in distilled water.

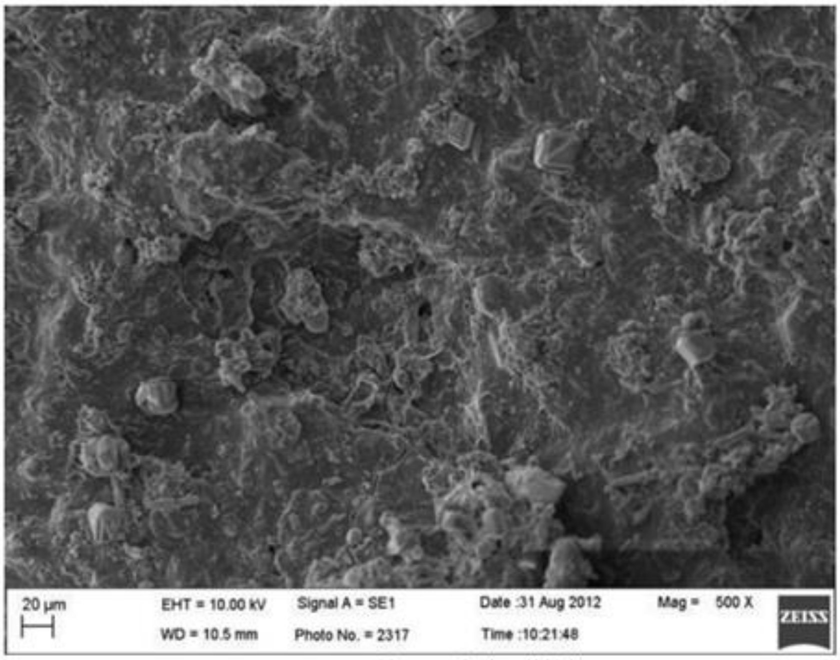
Photo 10: SEM images of the samples before and after water immersion

Photo 10 : MTA + Sealapex before tradition



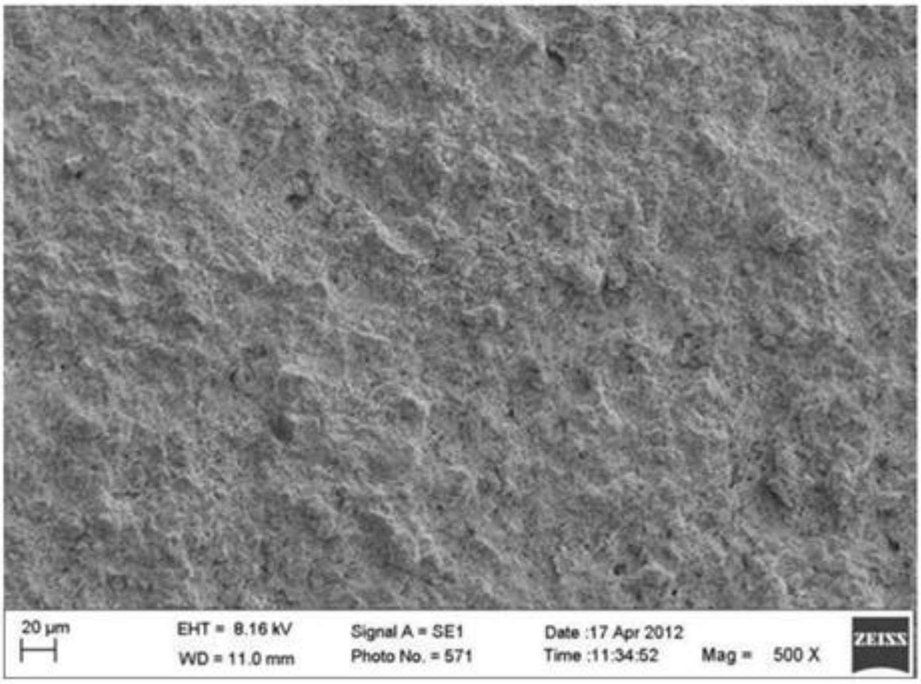
Source: Author (2024)

Photo 10B : MTA + Sealapex after tradition



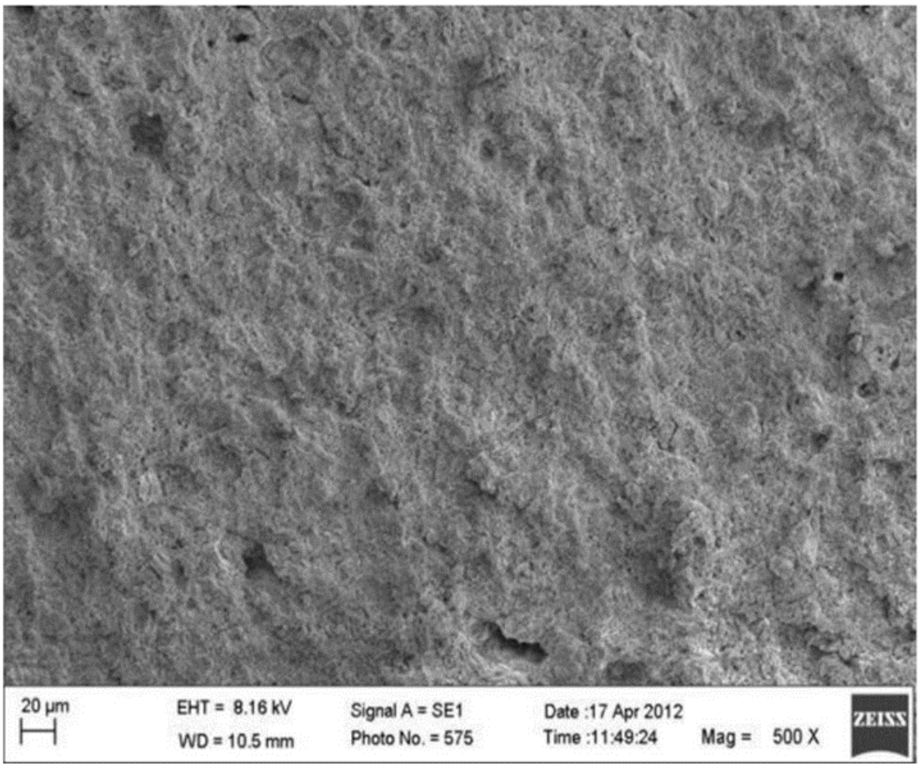
Source: Author (2024)

• **Photo 10C :** MTA before tradition



Source: Author (2024)

Photo 10D : MTA after inheritance



Source: Author (2024)

The images show that the MTA + Sealapex combination has a rougher surface compared to MTA alone. After immersion, the transition surface undergoes more pronounced wear, forming a more porous and irregular structure, while pure MTA demonstrates little variation in its surface morphology before and after immersion. These results indicate that the addition of Sealapex to MTA may compromise its structural integrity, creating a surface more susceptible to manipulation and pore formation (DEDAVID et al., 2007).

Pore formation during solubilization can vary in terms of material performance, since pores can allow infiltration of fluids and microorganisms, compromising apical sealing.

Therefore, although the combination of MTA and Sealapex offers some advantages, such as the release of calcium ions, structural integrity should be an important consideration in the future development of this formulation (GOMES- FILHO et al., 2011).

pH variation

The pH variation of the tested samples is a critical factor for their effectiveness, since a high pH can create a hostile environment for the growth of bacteria and promote chemical reactions that favor tissue replacement. As shown in Table 1, the average pH of the MTA + Sealapex samples was 10.3, with variations between 9.4 and 10.8. These values are close to the pH of pure MTA cement, which has an average of 10.5, according to Costa et al. (2014).

The alkaline environment created by calcium hydroxide-based cements, such as MTA and Sealapex, is beneficial for the elimination of microorganisms, making the material bactericidal (FRIDLAND et al., 2003).

Furthermore, the high pH facilitates the introduction of compounds, such as calcite, which are essential for the formation of a mineralized tissue barrier. The presence of hydroxyl and calcium ions in the medium promotes the formation of calcite, which, in turn, aids in tissue healing (SEUX et al., 1991).

These results suggest that the combination of MTA and Sealapex maintains the ability to create an alkaline environment conducive to healing and infection prevention. However, high solubility should still be a concern, since, despite the appropriate pH, handling the material may compromise the durability of the treatment.

Release of Calcium Ions

The release of calcium ions is one of the most important properties of endodontic sealers, since these ions are crucial for the formation of mineralized tissue barriers and for the promotion of tissue healing. Table 1 shows that the combination of MTA and Sealapex presented an average release of 15.6 ppm of calcium ions, which is lower than the average release of pure MTA, which is 20.7 ppm, as reported by Costa et al. (2014).

Although calcium release is essential for the process of parts, it must occur in a controlled manner. If solubility is excessive, the material may lose its integrity before completing the healing process, compromising the apical seal. The lower release of calcium ions by the combination of MTA and Sealapex compared to pure MTA may be an indication that Sealapex, despite increasing solubility, does not proportionally increase the release of ions significantly (GOMES-FILHO et al., 2011).

This observation suggests that the addition of Sealapex to MTA may not be as effective in terms of promoting tissue parts as pure MTA, especially if the solubility of the material is a critical factor.

Thus, future investigations can focus on optimizing this combination to achieve more efficient calcium ion release without compromising the structural integrity of the material.

Electrical Conductivity

Electrical conductivity is a parameter that reflects the presence of free ions in the solution and is therefore an indirect measure of the release of calcium ions. As shown in Table 1, the tested samples presented an average conductivity of 228 µS/cm. Higher conductivity values indicate a greater release of ions into the solution, which is related to the material's ability to promote tissue healing (COSTA et al., 2014).

The conductivity observed in the MTA + Sealapex samples is consistent with the levels expected for calcium hydroxide-based materials, which are known for their ability to release ions in aqueous media. However, conductivity alone is not sufficient to determine the clinical efficacy of the material, and should be proven in conjunction with other parameters, such as solubility and surface morphology.

The results obtained in this study show that the combination of MTA and Sealapex presents some promising characteristics, such as the ability to create an alkaline environment and the controlled release of calcium ions. However, the high solubility and changes in surface morphology suggest that this material may not be ideal for all endodontic applications. The comparison with pure MTA highlights the need for improvements in the formulation to ensure that the material presents both biocompatibility and long-term mechanical resistance. Future studies should focus on optimizing this combination to achieve a balance between solubility, ion release and structural stability, ensuring that the material can be successfully used in long-term clinical procedures.

Furthermore, it is crucial to evaluate the performance of this material under different clinical conditions, such as variations in humidity and temperature, which can influence its physical-chemical properties. Additional studies should investigate the impact of solubility on apical placement capacity and prevention of bacterial infiltration, since these characteristics are determinants for endodontic success.

Another important aspect to be considered in future research is the interaction of MTA + Sealapex with biological tissues in real clinical scenarios. While in vitro properties provide a solid basis for analysis, in vivo studies have provided a better understanding of how the material behaves in prolonged contact with periapical tissue and other dental structures. Long-term evaluations of the material's efficacy in promoting tissue regeneration and preventing new infections are also warranted to confirm its suitability.

Therefore, optimizations in the composition, as well as rigorous testing in different conditions and with different clinical approaches, are recommended so that the combination of MTA and Sealapex can become a more viable and effective alternative for professionals.

IV.Conclusion

The results of this study demonstrated that the combination of MTA and Sealapex cements has potential in terms of biocompatibility and release of calcium ions, which are important factors for success in endodontic procedures. However, the results also highlight some challenges, such as high solubility and changes in surface morphology, which may compromise the efficacy of this combination in certain clinical applications. In order for the combination of MTA and Sealapex to be widely recommended and used in endodontic treatments, it is essential that additional studies be carried out with the aim of evaluating in more detail the clinical behavior of this material, especially under adverse conditions and in the long term.

Relevance of Biocompatibility

The biocompatibility of a material is one of the main factors that determine its clinical applicability.

The combination of MTA and Sealapex, as shown in this study, showed promising results regarding this characteristic. Biocompatible materials are essential in endodontics, since they are used in direct contact with living tissues and should promote healing without causing adverse reactions, such as chronic inflammation or tissue infection (VIVAN, 2009). MTA, in particular, is already widely recognized for its ability to promote tissue regeneration and minimize the inflammatory response, while Sealapex, based on calcium hydroxide, contributes to the release of calcium ions, which play a crucial role in the formation of calcium-mineralized tissue barriers (FRIDLAND et al., 2003).

However, despite proven biocompatibility, other factors such as solubility and surface morphology must be taken into consideration, since they can directly impact the clinical efficacy of the material. The combination of MTA and Sealapex, although promising in this regard, still has limitations that need to be addressed in future studies. It is necessary to determine how this combination behaves in different clinical scenarios, including perforation treatments, apical sealings and periapical tissue regeneration.

Solubility: A Challenge to Be Overcome

The high solubility observed in the MTA and Sealapex samples was one of the main points of concern in this study. The solubility of an endodontic material directly influences its adaptability, resistance to humid environments, and durability over time. According to the standards established by the American Dental Association (ADA), endodontic sealers must have a solubility of less than 3% to ensure that they are capable of maintaining apical sealing and preventing bacterial infiltration (COSTA et al., 2014). However, the samples tested in this study presented an average solubility of 5.29%, which is above the recommended limit.

Excessive solubility may compromise apical placement and allow the entry of fluids and microorganisms, increasing the risk of treatment failure. This condition is particularly critical in endodontic treatment and root perforation cases, where the material needs to remain stable and functional for a prolonged period. In addition, the formation of pores during the solubilization process may impact the material's ability to effectively seal the periapical space, compromising the longevity of the treatment (GOMES-FILHO et al., 2011).

In this sense, the high solubility of the MTA + Sealapex combination highlights the need for reformulation of the material or adjustments in its composition to reduce this characteristic without compromising the release of calcium ions. The addition of other components or changing the proportion between MTA and Sealapex may be a viable strategy to improve the material's resistance to solubilization.

Importance of Calcium Ion Release

The release of calcium ions is a desired property in endodontic materials, especially in cements that aim to promote healing and tissue regeneration. Calcium ions are essential in the formation of mineralized tissue barriers and in the induction of biological responses that accelerate the tissue repair process. In this study, the combination of MTA and Sealapex presented an average release of 15.6 ppm of calcium ions, which, although lower than pure MTA (20.7 ppm), is still sufficient to promote adequate healing in many clinical cases (COSTA et al., 2014).

It is important to note that the controlled release of calcium ions must be balanced with the solubility of the material. If the solubility is too high, the material may degrade before the release of calcium ions has a long-term beneficial effect. In this context, the release of calcium ions by MTA + Sealapex needs to be optimized to ensure that the material maintains its integrity while releasing sufficient ions to promote healing.

Furthermore, future studies should investigate whether the release of calcium ions by the MTA + Sealapex combination is sufficient for more complex clinical cases, such as root resorption treatments or severe perforations. These cases disable a robust biological response, and it is essential that the material is capable of releasing an adequate amount of calcium ions to ensure treatment success.

pH Variation and Bactericidal Effect

pH variation is another important factor that affects the effectiveness of endodontic materials. A high pH creates a hostile environment for the growth of microorganisms, making the material bactericidal. In the present study, the combination of MTA and Sealapex presented an average pH of 10.3, which is consistent with the pH of other calcium hydroxide-based materials (FRIDLAND et al., 2003). The alkaline environment results not only in the elimination of bacteria, but also favors the formation of calcite, a mineral compound essential for tissue healing.

The bactericidal effect of the material is particularly important in endodontic treatments, where the presence of microorganisms is one of the main causes of failure. The ability of MTA + Sealapex to maintain a high pH for a prolonged period of time can help prevent secondary infections, especially in cases of endodontic treatment or extensive periapical lesions.

However, the long-term impact of this pH variation needs to be further studied. Although a high pH is beneficial in terms of bacterial elimination, it is important to ensure that the material maintains this property over time, even after continued exposure to body fluids. pH stability over prolonged periods of time is crucial to ensure that the bactericidal effect is suspended until the healing process is complete.

Surface Morphology and Structural Stability

Images obtained through scanning electron microscopy (SEM) revealed significant changes in the surface morphology of the MTA + Sealapex combination after immersion in distilled water.

The wear observed in the samples and the formation of a more porous surface indicate that the structural stability of the material may be compromised when exposed to fluids, which is an important concern for clinical use in endodontic treatments (DEDAVID et al., 2007).

The structural stability of an endodontic sealer is crucial to ensure that it can improve the periapical space and prevent the infiltration of microorganisms. The formation of pores on the surface can compromise this condition and allow the entry of bacteria, increasing the risk of treatment failure. Although the combination of MTA + Sealapex has been shown to be effective in terms of biocompatibility and release of calcium ions, changes in surface morphology highlight the need to improve the structural stability of the material to avoid long-term clinical problems.

Pore formation during the solubilization process can also affect the mechanical strength of the material, making it more susceptible to fracture or failure when subjected to mastication or other mechanical forces. Further studies should focus on evaluating the mechanical strength of the material after its immersion in fluids, as well as investigating methods to reduce pore formation and improve surface durability.

Final Considerations and Future Perspectives

Although this study has provided valuable insights into the properties of the MTA and Sealapex combination, it is clear that further testing is needed to assess its clinical predictability. Biocompatibility and calcium ion release are promising features, but the high solubility and changes in surface morphology suggest that the material needs optimization to be used effectively in a wide range of endodontic treatments.

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