ALTERNATIVE METHODS OF REMOVING CARIOUS TISSUE

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ABSTRACT

Aim of the study: This study aims to comparatively analyse two chemo-mechanical caries removers, Carisolv and BRIX3000. The study involves physico-chemical characterization of the substances followed by assessing their impact on carious lesions using extracted teeth. **Materials and Methods:** Carisolv, a caries removal gel, and BRIX3000, a gel from papaya protein, were used in this study. Extracted teeth with carious lesions were maintained in saline solution, treated individually with the respective substances, and examined using optical and spectroscopic techniques. **Results and Discussion:** FTIR spectroscopy demonstrated characteristic peaks confirming the specific compositions of BRIX3000 and Carisolv. Thermal analysis revealed the degradation behaviours of the compounds, indicating differences in thermal stability. VistaCam technology showed significant reductions in carious lesions post-treatment with both substances, with BRIX3000 exhibiting superior efficacy. **Conclusion:** The investigation confirmed the effectiveness of Carisolv and BRIX3000 in treating caries lesions, supporting their potential as viable treatment options. Further, BRIX3000 exhibited greater efficacy and distinct behaviour compared to Carisolv, offering insights into their impact on dental structures. However, cytotoxic effects were observed with BRIX3000, warranting further exploration into its safety profile.

Key words: Minimally Invasive Dentistry, caries treatment.

INTRODUCTION

The evolution of dental caries treatment has been a continual pursuit for researchers aiming to develop techniques that fulfill multiple criteria. These techniques must exhibit specificity, avoid damage to healthy dental tissue, minimize time consumption, utilize materials with minimal cytotoxicity and user-friendly properties, reduce aerosol production to protect medical staff from contamination, and ensure ease of comprehension for anxious paediatric patients, especially children.

In recent years, there has been a growing interest in chemo-mechanical methods for treating dental caries, particularly aligned with the rising demand for minimally invasive approaches like the Restorative Atraumatic Method (ART), predominantly applied in younger demographics. This interest is notably prominent in paediatric dentistry, reflected in numerous publications in specialized journals.

Chemo-mechanical methods of caries removal (CMCR) have gained traction and preference among children due to their simplified and easily comprehensible procedures. These methods offer a painless alternative, eliminating several drawbacks associated with conventional excavation techniques that involve rotating instruments, such as pressure, heat, noise, vibration, pain, and the necessity for local anaesthesia. CMCR, being minimally invasive,

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substantially reduces aerosol production by utilizing solely hand tools during cavity excavation, thereby minimizing aerosol generation [1-3].

The quest for aerosol-free dental caries removal has been ongoing for several decades, primarily to address the anxiety experienced by paediatric patients during dental visits. The heightened awareness of aerosol-related concerns was further highlighted during the COVID-19 pandemic, necessitating alternative methods with reduced aerosol generation [4-6].

Considering the documented advantages and the extensive scientific literature on mechano-chemical removal methods using Carisolv and BRIX3000, there arises a need for research into the mode of action of these substances, employing tools like the VistaCam Durr Dental system. This investigation could shed light on their efficacy and mechanism, contributing to the advancement of these promising treatment modalities.

Aim of this study

This study aims to perform a comparative analysis between two chemo-mechanical caries removers, Carisolv and BRIX3000. In a first stage, a physico-chemical characterization of the two substances was carried out, and in the next stage, the effect they have on carious lesions was monitored. For this purpose, extracted teeth with carious lesions were used.

MATERIAL AND METHODS

The substances used in this study are Carisolv, a caries removal gel, purchased as a 2.5 mL static mixer syringe, distributed by RLS Global AB Neongatan 5, Sweden, and BRIX3000, a 3 mL gel, distributed by BRIX SRL, Argentina.

The extracted teeth were washed with 9% saline solution, to remove the remnants of blood and soft tissue adhering to the tooth, later they were kept in physiological serum, NaCl 9%, each tooth being placed separately in plastic containers with a lid until they were treated with the two substances that are the subject of the study. The purpose of keeping the teeth in a moist environment was to avoid their dehydration, a fact that would have determined the modification of the characteristics of the areas of interest for the research, namely the carious lesion, the enamel, the dentine. Before applying the substances, they were removed from the liquid, dried with the air jet from the dental unit, then the substance was applied to remove the carious lesion on the affected tissue, untouched by the dental burr beforehand. It was left to act for 30 seconds for Carisolv and 120 seconds for BRIX3000, time chosen according to the manufacturer's recommendations. Next, using a dental excavator, the affected tissue was mechanically removed, starting with the lateral walls, and then on the pulp wall, it was subsequently rinsed with plenty of water and dried. The teeth were removed from the containers individually, treated and examined in turn, to eliminate the risk of dehydration and contamination. For BRIX3000 the color change from light gray to dark green (dirty) was observed. In the case of Carisolv, no color shift was noticeable, but the corresponding effect. Also, in the case of teeth treated with Carisolv, it was necessary to rinse with water and dry before starting the process of removing the affected tissue. The work protocol can be repeated until the expected result is reached, i.e. until the absence of the change in color to dark gray in the case of the Carisolv product, but it was applied only once on each dental unit, in order to be able to compare the effectiveness of the substances without differences in terms of time and working methods.

For the photographic recording of both the

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"bubbling" effect that Carisolv has, as well as the color change that BRIX3000 undergoes at the time of application, recordings were made with a digital microscope. The operating characteristics of the digital microscope used are: CMOS image sensor (color), Resolution: 640x480, maximum frame rate: 30fps, magnification: 50X-500X, illumination: 8 white LEDs with brightness control.

FTIR-UATR spectroscopy data was collected using a Shimadzu AIM-9000 Spectophotometer. 20 readings were performed with a resolution of 4 cm-1 over the spectral range 4000-250 cm-1.

The thermogravimetric analyzes carried out in this study aimed to investigate the thermal behavior of the chemo-mechanical removal agents BRIX3000 or Carisolv. Samples were analyzed in aluminum crucibles on a TG thermal analyzer from MettlerTOLEDO. All data was collected in an air atmosphere (synthetic air 5.0 Linde with a flow rate of 100 mL/min), a heating rate of β= 10°C/min, and a temperature range of 20° to 500°C.

To assess the efficacy of substances in removing caries, various optical methods were employed to derive qualitative insights. Specifically, the VistaCAM technology was utilized to gather both qualitative and quantitative data pertaining to the evaluation of treatment effectiveness. The carious lesions present in extracted teeth were examined using the VistaCam Durr Dental technology before and after the application of chemo-mechanical treatment. This involved utilizing two interchangeable heads provided by the device: the Proof end, which generates colorimetric and numerical maps of affected dental tissues, and the Cam end, enabling high-quality photography for macroscopic surface analysis. To conduct a comprehensive comparative analysis, the teeth were precisely sectioned at the carious lesion level, and each half was treated separately with either BRIX3000 or Carisolv.

Before and after treatment, the teeth were scrutinized, and the captured images were subsequently interpreted to derive conclusive findings regarding the efficacy of the treatments applied. This process aimed to provide valuable insights into the comparative effectiveness of the substances in addressing carious lesions.

RESULTS AND DISCUSSIONS

FTIR spectroscopy (Fourier transform infrared spectroscopy) was used for the compositional analysis of two chemo-mechanical caries removers: BRIX3000 and Carisolv. In the IR spectrum for BRIX3000 (Figure 1), characteristic peaks are observed at 3320 cm-1, 1615 cm-1, 980 cm-1 and 620 cm-1, confirming its specific composition.

The IR spectrum of Carisolv (Figure 2) highlights bands characteristic of functional groups at wavelengths 1628 cm-1 (C=O), 1456 cm-1, and 1395 cm-1. The broad band at 3255 cm-1 corresponds to the OH group and the N-H bond vibration in the Carisolv molecule.

Superimposing the two spectra (Figure 3), similarities between the substances are observed, suggesting similar actions on carious lesions. This similarity in composition and structure explains, at least in part, the similar results observed in their efficacy in treating caries.

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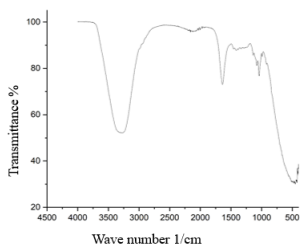

Fig.1. BRIX3000 IR spectrum.

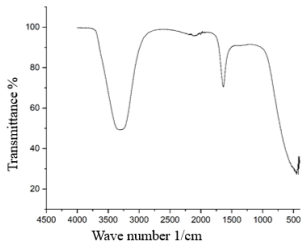

Fig.2. Carisolv IR spectrum.

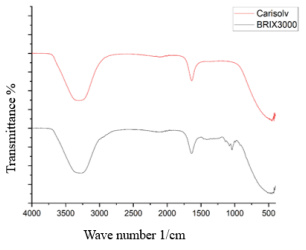

Fig.3. Superimposed IR spectrum of BRIX3000 and Carisolv.

Thermogravimetric analysis (TG/DTG) was used to investigate the thermal behavior of the therapeutic agent BRIX3000 and Carisolv. Thermoanalytical curves (TG and DTG) for BRIX3000 indicate complex thermal decomposition processes, with stages characterized by endothermic thermal effects. On the other hand, the thermal decomposition of Carisolv showed two stages, each with an endothermic thermal effect, and the total mass loss was lower compared to BRIX3000. Comparing the thermal stability of the two agents, it was observed that BRIX3000 suffers a greater mass loss in the same temperature range (20-500°C), but begins to decompose at lower temperatures than Carisolv. Thus, it can be concluded that BRIX3000 is more thermally stable than Carisolv (Fig.4).

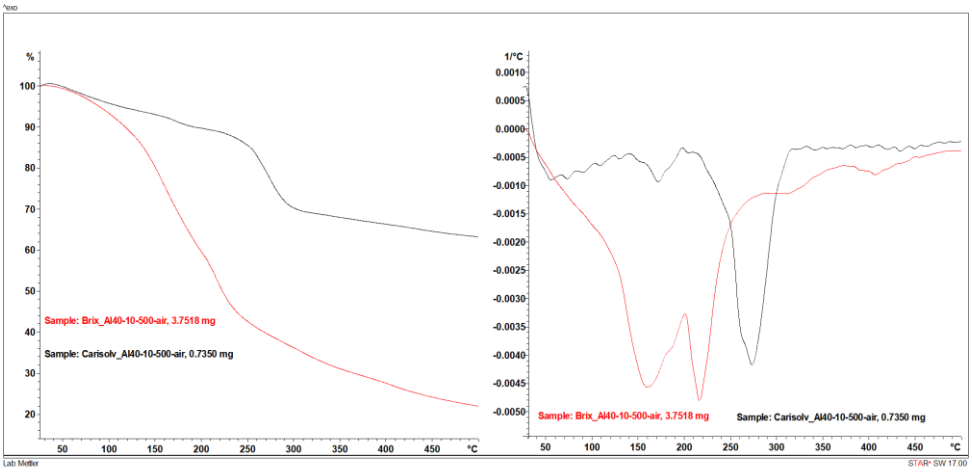

Fig.4. Thermoanalytical TG and DTG curves for BRIX3000 and Carisolv obtained with a heating rate of 10°C·min^{-1}.

By using the VistaCam device, tests were performed on extracted teeth to evaluate pre- and post-treatment effects. The values indicated in the pre-treatment analysis were considered to be the highest, representing the areas most affected by caries. After treatment, significant decreases in index values were observed, with an average reduction of approximately 0.85 for Carisolv and 1.37 for BRIX3000. It is important to emphasize that these reductions are influenced by the surface and depth of the carious lesion (Fig. 5,6).

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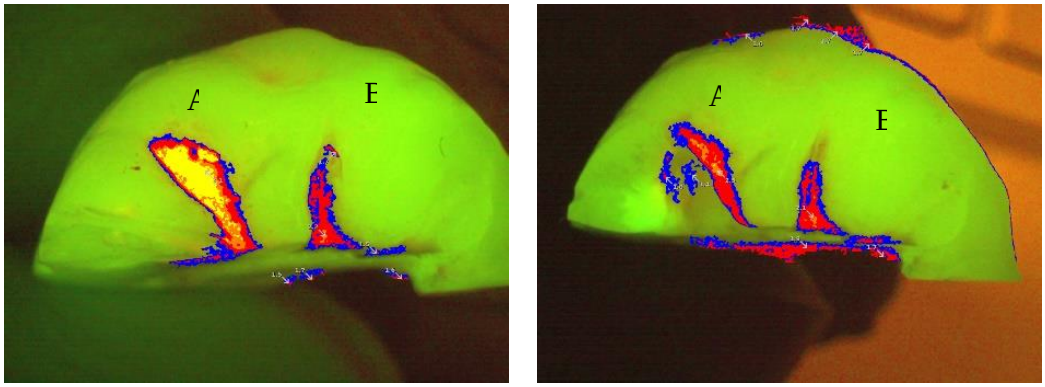
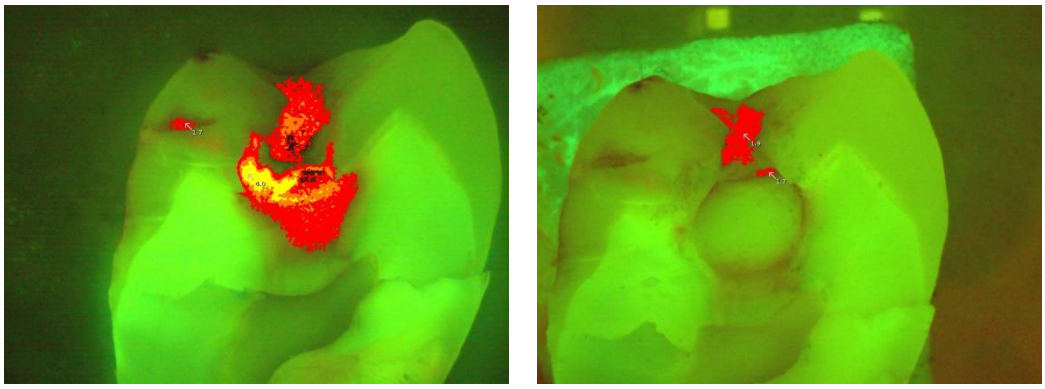


a. **b.**

Fig. 5. Images obtained using the VistaCam software for teeth treated with Carisolv before and after its application: a.Tooth 1 Lesion A and B -initial; b. Tooth 1 Lesion A and B-after treatment



a. **b.**

Fig. 6. Images obtained using the VistaCam software of teeth treated with BRIX3000 before and after its application: a. Tooth 1 -initial; b. Tooth 1 -after treatment.

The images obtained with VistaCam confirmed the reduction of the lesions, and the color code of the device reflected the changes at the level of the affected surface. Also, optical analysis using Optika SZM-2 and Scan 300 Interscience revealed the disappearance of carious tissue after application of treatment agents.

BRIX3000 showed a color change, going from light gray to dark green, while Carisolv showed a "bubbling" effect. This effect was also observed using the digital microscope and VistaCam recordings, highlighting the specific reactions of the agents on the carious surface.

This study demonstrated the effectiveness and different behavior of therapeutic agents in treating carious lesions, highlighting their impact on the affected tooth structure.

CONCLUSIONS

1. In this investigation, two compounds serving as alternatives to traditional caries treatment were scrutinized. Chemo-mechanical caries removal involves chemically altering damaged substrates before gently excavating them. The compounds studied are Carisolv—a blend of amino acids and sodium hypochlorite—and BRIX3000—a gel derived from papaya protein resembling human pepsin. While this method doesn't entirely replace rotary instruments, it's applicable in numerous cases, particularly

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with children (including very young children and those with challenging behaviour) and anxious patients.

2. Initially, we characterized these compounds using FTIR spectroscopy and thermogravimetric analysis (TG). The IR spectrum exhibited distinct peaks for both compounds. Thermal analysis revealed BRIX3000 starts degrading at 130°C, resulting in a 65% mass loss, while Carisolv starts at lower temperatures with a total mass loss of 35%.
3. The impact of both agents on carious lesions using VistaCam technology was evaluated. Visual and numerical data from VistaCam confirmed the efficacy of both substances in caries removal. BRIX3000 exhibited an average reduction of 1.37, while Carisolv showed 0.85. This difference underscores BRIX3000's superior efficacy in eliminating the carious process compared to Carisolv.
4. Our findings were reinforced by optical techniques using Optika SZM-2 and SCAN 300 Interscience, further supporting VistaCam's insights. Specialized studies corroborate the effectiveness of these agents, particularly for straightforward carious lesions. Moreover, Carisolv showed no adverse effects, except a potential hemostatic impact on exposed pulp tissue. Conversely, studies demonstrated that direct contact between BRIX3000 and dental pulp cells exhibited cytotoxic effects.

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