TOPOGRAPHIC AND CHEMICAL ANALYSES OF FIBER POSTS AFTER SURFACE DISINFECTION WITH DIFFERENT METHODS

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ABSTRACT

Aims: This study aims to comprehensively examine the surface morphology and chemical composition of fiber posts after undergoing various disinfection methods, utilizing scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).
Materials and Methods: Twenty-one fiber posts were randomly allocated into seven experimental groups, each consisting of three samples. The disinfection methods employed were as follows: GC - no disinfection treatment; GAL - immersion in 70% alcohol, following the manufacturer's recommended protocol; GHP - soaking in 2.5% sodium hypochlorite for a duration of 10 minutes; GCL - soaking in 2% chlorhexidine gluconate for a period of five minutes; GAC - 30-second etching with 35% phosphoric acid; GPH - soaking in 10% hydrogen peroxide for a duration of 20 minutes; and GSL - auto-clave sterilization. Following the disinfection procedures, SEM was employed to scrutinize the surface topography of the posts, while EDX was utilized to identify the chemical elements present on the sample surfaces. Subsequently, a descriptive analysis was conducted on the SEM images and EDX data.
Results: SEM analysis revealed that all groups exhibited regions with epoxy resin-coated fibers alongside sections with exposed glass fibers. Analysis of the EDX data indicated that there were no significant differences in the predominant chemical elements across the groups. Carbon (C) and oxygen (O) registered the highest peaks, followed by silicon (Si), zirconium (Zr), sodium (Na), aluminum (Al), and calcium (Ca).
Conclusions: The disinfection methods under investigation did not induce substantial morphological or chemical alterations in the surface of the fiber posts.

KEYWORDS: Restorative dentistry. Disinfection. Scanning electron microscopy. Energy dispersive x-rays.
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INTRODUCTION

The success of both endodontic and restorative treatments hinges on several critical factors. Apart from selecting the most suitable material for replacing any lost structural components, it is equally important to carefully choose the decontamination material used before insertion into the root canal.

The utilization of intraradicular posts necessitates the implementation of a biosafety protocol to ensure their effective function and prevent recontamination of the root canal, thereby discouraging bacterial growth[1].

Table 1. Table of experimental groups.

Groups	n	Disinfection Methods
GC	3	no disinfection
GAL	3	70% alcohol
GHP	3	2.5% sodium hypochlorite
GCL	3	2% chlorhexidine gluconate
GAC	3	35% phosphoric acid
GPH	3	10% hydrogen peroxide
GST	3	autoclave sterilization

Various substances can be employed for the decontamination of intraradicular posts. Hydrogen peroxide, known for its disinfectant properties, induces protein denaturation and disrupts bacterial membranes[2]. Sodium hypochlorite[3] and chlorhexidine[4] are renowned antimicrobial agents commonly employed in endodontic treatments. Alcohol, which is already used in the protocol for cleaning pins before cementation, also acts as a bactericidal and virucidal agent against specific strains[5]. In contrast, phosphoric acid reduces the microbial load on surfaces but may not completely eliminate it[6].

Fiber posts have gained widespread acceptance in the restoration of endodontically treated teeth[7] due to their ability to yield favorable esthetic outcomes, distribute stress effectively, and adhere well to tooth structures[8-9]. These posts are primarily composed of a high volume of continuous reinforcement fibers embedded in a polymer matrix, typically an epoxy resin matrix[10]. This organic component exhibits a high degree of conversion and possesses a densely crosslinked structure, which does not interact with resinous monomers[10]. However, it remains uncertain whether contemporary disinfectants can be safely used on these posts without compromising the integrity of the glass fibers and organic constituents.

This study sought to assess the surface characteristics of these posts after undergoing disinfection using various methods, employing scanning electron microscopy (SEM) for morphology examination and energy-dispersive X-ray spectroscopy (EDX) for chemical analysis.

MATERIALS AND METHODS

Sample selection

The sample comprised twenty-one #1 prefabricated conical fiber posts (Exacto, Angelus Indústria de Produtos Odontológico S/A, Londrina, Paraná, Brazil), each having an apical diameter of 1.1 mm and a length of 16 mm.

To allocate the samples into seven experimental groups (as outlined in **Table 1**), a simple random sampling method was employed, facilitated by a Microsoft Excel spreadsheet (Microsoft, Redmond, WA), based on the chosen surface disinfection method. The sample size for each group was determined following the methodology used by Naves et al.[11] (2011), who conducted a similar descriptive topographic analysis of fiber posts. In this study, glass fiber post (15) and carbon fiber post (15) were used, which were divided into five groups with three samples per group. However, it's important to note that their study focused on different surface treatments, not disinfection.

Surface disinfection methods

In the control group (GC), no disinfection was applied to the posts.

For the alcohol group (GAL), the posts were initially cleaned with a microbrush (FGM, Joinville, Brazil) and then immersed in 70% alcohol (LBS Laborasa Indústria Farmacêutica Ltda., São Paulo, Brazil) for a duration of 20 seconds, adhering to the manufacturer's guidelines.

In the sterilization group (GST), the samples were placed in sterilization envelopes (Medsteril, São Paulo, Brazil) and sealed using a sealer (RSR 2000, Ron, Micromecânica Ltda., São Paulo, Brazil). Subsequently, they were sterilized within a Vitale 12 autoclave (Cristofoli, Curitiba, Brazil) using a 40-minute cycle at 240°F (126°C) and 20 psi pressure.

As for the GHP, GCL, GAC, and GPH groups, the disinfection procedures were conducted in accordance with the protocols outlined in **Table 2**. The solution-soaked posts were dried at room temperature.

It is noteworthy that all post-disinfection protocols were carried out at room temperature (25 ± 1°C). Following disinfection, all posts underwent a thorough rinse with saline solution for a duration of 30 seconds and were subsequently dried using an air jet.

Scanning Electron Microscopy

Following the surface disinfection process, the posts were carefully dried and subsequently assembled and prepared for metal sputtering with gold in accordance

Table 2. Methods and protocols used to disinfect the surface of fiber posts.

Group	Disinfection Methods	Protocol
GHP	2.5% sodium hypochlorite (Iodontosul, Industrial Odontológica do Sul LTDA, Porto Alegre, Brazil)	Posts were soaked in 10 mL of solution for 10 minutes[12].
GCL	2% chlorhexidine gluconate (Maquira Indústria de Produtos Odontológicos S.A., Maringá, Brazil)	Posts were soaked in 10 mL of solution for 5 minutes[13].
GAC	35% phosphoric acid (FGM, Joinville, Brazil)	Gel was applied to the surface of posts placed in a Petri dish for 30 seconds[11].
GPH	10% hydrogen peroxide (Quimesp Química, São Paulo, Brazil)	Posts were soaked in 10 mL of solution for 20 minutes[14-15].

with the established protocol recommended by the Microscopy and Microanalysis Center.

The scanning electron microscope (Cam Scan MV2300, Electron Optic Services Inc., Ottawa, Canada) was operated at a magnification of 500 times[16]. This operation was conducted by the responsible technician and was carried out in the presence of one of the authors.

For electron micrograph acquisition, three specific areas were chosen on each post, following a standardized approach pre-established at 2 mm from each end of the post and in its central region.

All electron micrographs were compiled into a digital file using a CD-R Maxell® type CD-ROM, and they were maintained at the same resolution (600 dpi). Notably, the experimental group to which each image belonged was omitted to ensure that the observer was blinded to group allocation.

The topographic parameters of the post surfaces, analyzed through SEM, were consistent with those employed in the study conducted by Silva et al.[17] (2019). Morphological changes were evaluated in the fiber areas covered by epoxy resin and in the exposed areas of glass fibers, which were solely supported by the post's resin.

X-ray energy dispersive spectroscopy

EDX analysis was employed to identify the chemical elements present on the surface of the samples. Utilizing the same microscope, equipped with a model X-ACT secondary electron detector (EDX, Oxford INCA 350 EDS, Oxford Diffraction, Abingdon, UK), the analysis was conducted at an accelerating voltage of 15 kV, and the specimens were exposed to a high vacuum environment (10-5 mbar). This allowed for the determination of both the type and quantity of each chemical element within the sample[18].

Data analysis

SEM images and EDX data were subject to descriptive analysis conducted by a proficient and qualified professional who was kept unaware of the specific disinfection method employed for each sample. This blinding approach ensured the objectivity and impartiality of the analysis.

RESULTS

The qualitative examination of post surfaces using SEM (**Figure 1**) disclosed that the pins in all experimental groups exhibited regions where fibers were coated with epoxy resin and areas where glass fibers were exposed. Notably, no areas devoid of fibers were observed.

In the qualitative analysis of EDS data (**Figure 2**), no substantial differences were identified in the prevalence of chemical elements across the various groups. The most prominent peaks were consistently attributed to carbon (C) and oxygen (O), followed by silicon (Si), zirconium (Zr), sodium (Na), aluminum (Al), and calcium (Ca).

DISCUSSION

The success of both endodontic and restorative treatments hinges on the paramount importance of maintaining biosafety during surgical procedures to prevent any form of contamination or compromise of the root canal. Simultaneously, it is crucial that disinfection protocols applied to the surface of intraradicular posts do not negatively impact the essential properties and components of these retainers.

SEM and EDX analyzes were carried out descriptively, as was done in studies with other methodologies[19-20]. According to the microscopy center, due to the analysis of only one area of the post and in accordance with the objectives proposed in the study, a quantitative analysis could not be carried out.

The SEM images obtained in this study consistently revealed that

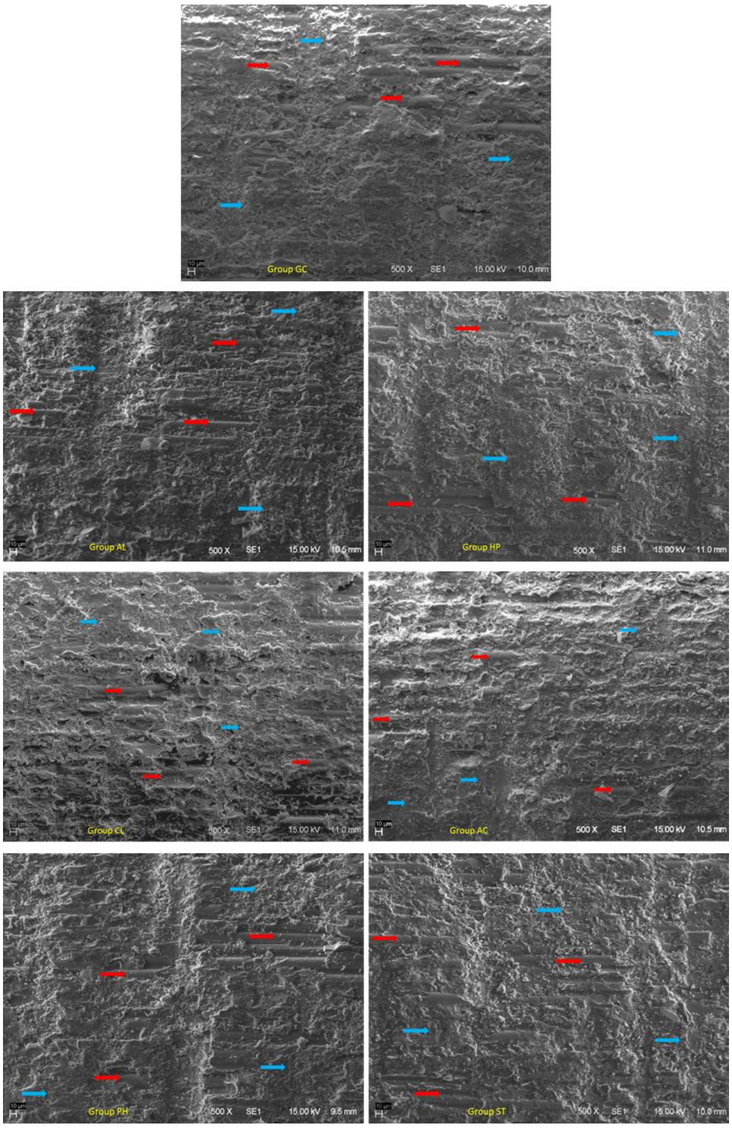

Figure 1. SEM photographs of post surfaces in different experimental groups at 500X magnification show areas of epoxy resin (→) and some areas of exposed fibers (→).

the posts in all experimental groups exhibited areas where fibers were coated with epoxy resin alongside regions where glass fibers were exposed. It is noteworthy that, in the literature, this aspect has been recognized as a potential factor that could affect the utility of such posts. A majority of fiber posts are coated with epoxy resin, which possesses a high degree of conversion and limited reactive sites for interaction with the functional monomers found in resin cements[10]. Therefore, prior to cementation, posts typically undergo surface treatments to enhance micromechanical interactions, such as blasting with abrasive particles and silane application.

According to the findings of Yenisey and Kulunk[21] (2008), these surface treatments serve to expose fiber areas, creating chemically reactive sites that facilitate the bonding of resin compounds. Such results are congruent with the observations made in samples that underwent disinfection. Additionally, Monticelli et al.[14] (2006) explored the effects of various substances on the morphological appearance of fiber post surfaces. Their research demonstrated that different composites, hydrochloric acid, hydrogen peroxide, and sodium ethoxide promoted surface degradation of the epoxy matrix, thereby exposing some of the underlying fibers. In the case of hydrogen peroxide applied to glass fiber posts, it was found to dissolve the epoxy resin matrix and reveal the fiber surface[15], while still preserving the integrity of the posts themselves[22].

All disinfection methods involve certain clinical steps, which can increase the complexity of the operative technique and the duration of the procedure. When comparing the tested protocols in this study, it was observed that autoclave sterilization was the least practical method for the clinical cementation of an intraradicular post within a single session. The time interferes the practice if you let the sterilization for the moment of the consultation, but the dentist/clinic could let this fiber glass posts already sterilized for a necessary moment. In contrast, the other methods required shorter durations, typically up to 20 minutes, which are not expected to significantly impact the overall appointment time.

Furthermore, it's crucial to assess the potential impact of disinfection treatments on the integrity of the posts, particularly with regards to any alterations in the glass fibers. The longevity and biomechanical behavior of restorations employing intraradicular retainers depend on factors beyond just mechanical properties, such as the hardness and flexural strength of the posts[23]. Effective bonding between the post, resin, and tooth structure also plays a pivotal role[24]. The bond strength of fiber posts within the root canal can be assessed through various mechanical tests, including the pull-out test[25] and push-out test[26]. Notably, Weschenfelder et al.[27] (2021)

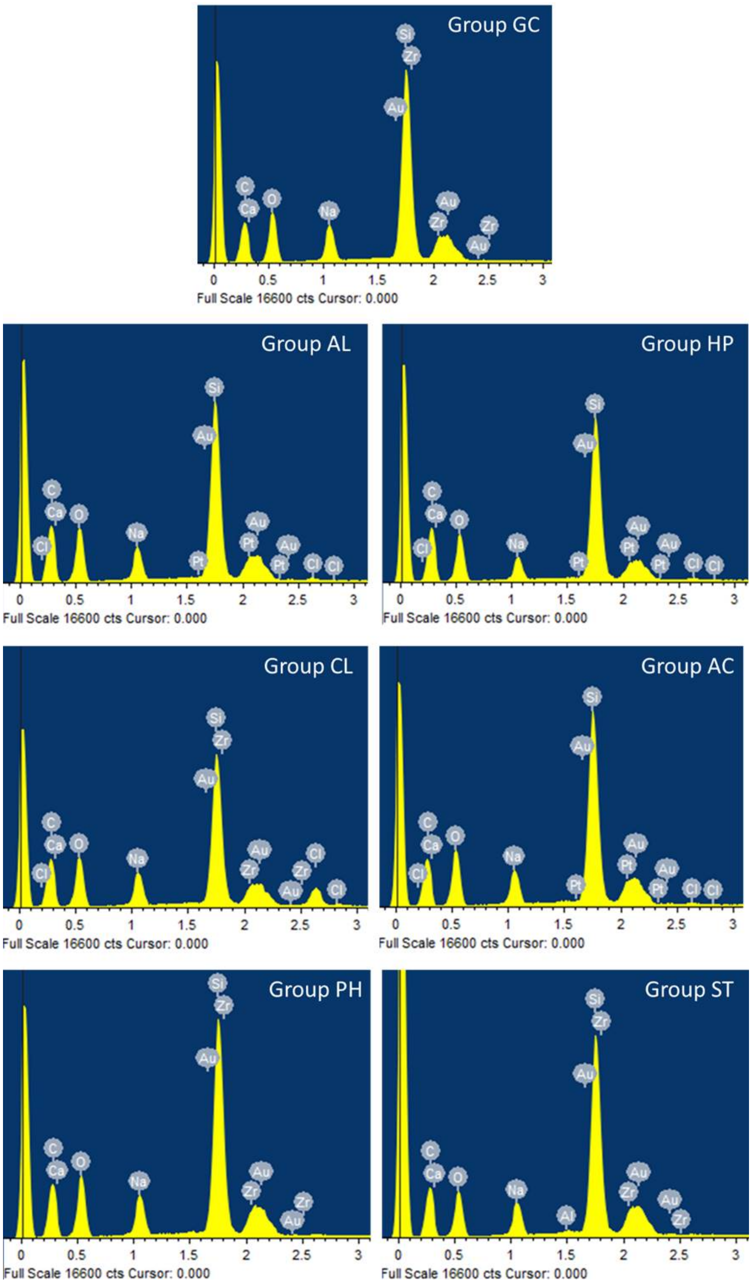

Figure 2. EDS graph for surface of fiber posts in different experimental groups.

conducted an analysis of different post disinfection methods and found that autoclave sterilization, as well as the use of 2.5% sodium hypochlorite, 2% chlorhexidine digluconate, 70% alcohol, or 35% phosphoric acid, did not compromise the resistance to displacement of cemented intraradicular fiber posts.

In terms of chemical composition, EDS analysis detected the presence of carbon, oxygen, silicon, zirconium, sodium, aluminum, and calcium in the posts across all groups, which aligns with the expected composition based on the original structure of the posts. Importantly, after disinfection, there was no deposition or presence of any chemical element that was not already present on the post's surface, regardless of the disinfection substance used. Carbon and oxygen are integral components of the cyclic portion of the epoxy resin layer's molecular structure[28-29]. Silicon and aluminum are chemical elements that constitute the glass fiber composition[29]. The high silicon percentage observed in the results arises from the exposure of areas containing glass fibers, and zirconium is also associated with fiber exposure[30].

CONCLUSION

Based on the methodology adopted and results obtained, it can be concluded that none of the disinfection methods under examination seemed to induce morphologic or chemical alterations to the fiber post's surface.

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