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Surface analysis and roughness of fiber-reinforced composite post after hydrogen peroxide treatment : an integrative review

Alexia Graziella De Azevedo

Dissertação conducente ao Grau de Mestre em Medicina Dentária (Ciclo Integrado)

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Trabalho realizado sob a Orientação de Dr. Valter Fernandes e Professor Doutor Júlio C.M. Souza

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RESUMO

Objectivo: Realizar uma revisão sistematica integrativa sobre a análise da superfície microscópica do espigão reforçado com fibras, particularmente no que diz respeito à sua rugosidade, após tratamento de superfície com H_2O_2. A hipótese nula é que o tratamento de superfície com H_2O_2 não afecta a superfície e a rugosidade do espigão reforçado com fibra após este tipo de condicionamento.

Método: Foi efectuada uma pesquisa de artigos na base de dados PubMed, utilizando uma combinação de palavras-chave. Foi aplicado um filtro temporal e linguístico, apenas foram pesquisados artigos escritos entre 2011 e 2022 em inglês.

Resultados: A pesquisa inicial obteve 187 resultados e 15 artigos foram considerados relevantes para o estudo. Todos os artigos utilizaram o MEV (Microscópio Eletrônico de Varredura), 3 deles analisaram a rugosidade da superfície. Dois artigos foram adicionados após uma pesquisa manual para desenvolver a discussão. O pré-tratamento com H_2O_2 altera a superfície do espigão, dissolve a sua matriz epóxi com exposição das fibras do espigão. Os estudos sobre a rugosidade da superfície após o tratamento observaram um aumento da ultima. Não foi observados efeitos negativos tais como fracturas ou danos no próprio espigão.

Conclusão: O tratamento de superfície com H_2O_2 afecta a superfície microscópica e aumenta a rugosidade do espigão sem efeito negativo na sua estrutura. Estes resultados são microscopicamente visíveis, dependem da concentração e do tempo de aplicação do produto. São necessários mais estudos, sobre a rugosidade, para confirmar os resultados.

Palavras-chave: espigão de fibra, tratamento com peróxido de hidrogénio, profilometria, rugosidade, microscopia.

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ABSTRACT

Purpose: Conduct an integrative review about the analyse of the microscopic surface of Fiber-Reinforced Composite Post (FRCP), particularly with regards to its roughness, after surface treatment with hydrogen peroxide. The null hypothesis is that surface treatment with H_2O_2 does not affect the surface and roughness of the FRCP after this type of conditioning.

Method: An article search on the PubMed database was carried out using a combination of keywords. A temporal and language filter was applied, only original articles written between 2011 and 2022 in English were searched.

Results: The initial search obtained 187 results and 15 articles were considered relevant to our study. All article used o SEM (Scanning Electron Microscope), 3 of them analysed surface roughness. Two articles were added after a manual search to develop the discussion. Surface treatment with H_2O_2 alters the surface of the fiber post, dissolves its epoxy matrix with the exposition of the fibers of post. The studies that analysed the surface roughness after the treatment observed an increase of this latest. No negative effects such as fractures or damages to the post itself are observed.

Conclusion: The surface treatment with H_2O_2 affects the microscopic surface and increase roughness of the post without negative effect on the structure of the post. These results are microscopically visible and depend on the concentration and application time of the product. But more studies particularly above the measure of roughness changes are required to confirm these results.

Keywords: fiber post, hydrogen peroxide treatment, profilometry, roughness, microscopy.

TABLE OF CONTENTS

INDEX OF FIGURES AND GRAPHS

INDEX TABLE

LIST OF ACRONYMS AND ABBREVIATIONS

H_2O_2 or HP : hydrogen peroxide

MEV: Microscópio Eletrônico de Varredura

SEM: Scanning Electron Microscope

FRCP : Fiber-Reinforced Composite Post

MP: Metal Post

PRISMA-Scr: Preferred Reporting Items for Systematic reviews and Meta-Analyses - Scoping reviews

µm : micrometre

PCC : Population, Concept, Context

mm – millimeter

SB – Sandblasting

HF - Hydrofluoric acid

H_3PO_4 - Phosphoric acid

CH_2Cl_2 – Dichloromethane

SiOx – Aluminum trioxide particles modified by silica

Al_2O_3 - Aluminum Oxide

Ra - Roughness Average

WP : Warmed Post

S : Silane

UDMA - Urethane Dimethacrylate

NH_3 – Ammonia

HMDSO – Hexamethyldisiloxane

FRP – Fiber-Reinforced Post

Er:YAG: Erbium-Yag laser

Er;Cr:YSGG: Erbium, chromium-doped yttrium, scandium, gallium and garnet laser

Si - Silicon

O – Oxygen

Si-O-Si: oxygen–silicon bond or siloxane

CH_3 - Methyl radical

1. INTRODUCTION

The inflammation or infection of a tooth occurs when root canal is contaminated by microorganisms and their products. The treatment of choice in this situation is the removal of the infected tissues, so called, a non-surgical endodontic treatment [(1)]. This procedure consists in an adequate cleaning and a shaping of the root canal, followed by a permanent three-dimensional sealing of it in order to eradicate peri radicular infection [(1,2)].

A high quality of coronal restoration is important because coronal sealing is as essential as the apical sealing to a successful outcome [(1-3)]. The ideal restoration depends on parameters like the amount and condition of residual tooth structure, position, function and aesthetic requirements [(3,4)]. In the case of endodontic treatment with large coronal destruction, the tooth function must be restored with the help of an intracanal dental post to offer stability and retention at the restoration [(2,5-7)]. There is a huge variety of materials and designs for dental posts [(6)]. An ideal post should present some characteristics like elastic modulus close to that of dentin, good retrievability, high retention, biocompatibility, aesthetics [(4)]. The prefabricated Metal Post (MP) has high resistance to fracture, low production costs and easy to use protocol. However, it also presents some disadvantages like waste of retention, an elastic modulus different to dentine, unfavourable colour and tendency to corrosion [(2,6,8)].

To overcome disadvantages, prefabricated quartz, glass or carbon Fiber-Reinforced Composite Post (FRCP) were developed [(4,6,8)]. They offer aesthetic advantages, an elastic modulus very close to dentine thus inflicting less stress to structure, allow more conservative preparation, easy to use, a good biocompatibility and require less chairside time [(2,6-9)]. One of most frequent cause of failure of FRCP is due to a debonding risk [(2,6,8)]. Indeed, the MP materials offer a lower retention and more resistance to post fracture but it is more traumatic for the tooth with the threat of vertical root fractures [(4)]. Regarding their components, most of intracanal FRCP are made of highly cross-linked polymer resin matrix that binds a high volume of reinforced quartz, carbon or glass fibers [(2,4-6)]. Their capacity to adhesive bonding and their configuration allows greater ease to create a consistent "monoblock" formed by bonds between materials and dental structures that help for the oclusal stress distribution uniformity [(2,10)].

It has been suggested that the configuration of matrix fiber posts are responsible for the poor bonding of dental post [4]. It was proposed to pre-treat the surface post to expose fibers and consequently create roughness in order to enhance bonding between interfaces [4,9,10].

There are mechanical surface treatments over FRCP like grit blasting or laser irradiation and chemical surfaces treatment like hydrogen peroxide, hydrofluoric acid or potassium permanganate [4,5]. With these methods, it is the topographical aspect and the chemical surface of the dental post that are modified [5].

Hydrogen peroxide (H_2O_2) is well known in dentistry because of its abilities: easy to use, safe, antiseptic and disinfectant power and it is widely used for teeth bleaching, as a toothpaste or a mouthwash component. Due to its composition, H_2O_2 is a very unstable oxidising agent that reacts with various materials [2,11]. Based on studies, post pre-treatment with H_2O_2 dissolve selectively the matrix and permit exposition of undamaged fibers [2,7,10]. As a result, post surface roughness creates a retention into root canal [5].

Treatment effects depend on factors like H_2O_2 concentration, time application and characteristic on the post [5,7]. Treatments surface are vital and play a key role in fiber post retentions [5].

2. OBJECTIVES AND HYPOTHESES

The aim of this study is to conduct an integrative review to evaluate and analyse the microscopic surface of fiber-reinforced composite post, particularly with regards to roughness, after surface treatment with hydrogen peroxide. The null hypothesis is that surface treatment with hydrogen peroxide does not affect the roughness surface of the fiber reinforced post and that its microscopic analysis is not altered after this type of conditioning.

3. MATERIALS AND METHODS

3.1. Sources of information and search method

A literature search was carried out on PubMed (via National Library of Medicine), stated that this database that it contains the most of the relevant articles on our research in the area of endodontic. The following combination of search terms were used in this study: "*fiber post" AND "hydrogen peroxide treatment" AND "roughness" OR "fiber post" AND "hydrogen peroxide treatment" AND "microscopic" OR "fiber post" AND "hydrogen peroxide treatment" OR "fiber post" AND "roughness" OR "fiber post" AND "roughness" AND "microscopic" OR "fiber post" AND "profilometry" OR "fiber post" AND "roughness" AND "profilometry" OR "fiber post" AND "profilometry" AND "microscopy" OR "fiber post" AND "hydrogen peroxide treatment" AND "profilometry".* The inclusion criteria used were articles published between 2011 and 2022 in the English language, based on fiber-reinforced endodontics posts, analysing and describing microscopically the surface modification and roughness after surface treatment with hydrogen peroxide. Only these following types of studies are included and can be used in the study: In vitro studies; meta-analyses; randomized controlled trials and prospective cohort studies. Papers were excluded with these following criteria: Studies in other languages except English language, papers testing other types of endodontic posts than fiber-reinforced posts like zirconia or metal post or papers used exclusively other type of surface treatment, articles where the full text is not available or without abstract, papers whose title and/or abstract do not reflect the subject. Types of articles included in the exclusion criteria were systematic review, bibliography review, theses and essays and finally studies without valid evidence.

In addition, a manual search was conducted in order to find other studies to complete and develop our discussion.

3.2. Method of search selection and data collection

Once the search process was completed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses - Scoping reviews (PRISMA-ScR) method, the articles selected were subjected to a 3-step evaluation. First, each article was checked by title and abstract. Two of the authors (VF, ADA) individually analysed the titles and abstracts of each potentially relevant article not yet excluded to determine their relevance and compliance with the study. Following this, a table was created to compile the articles for each keyword combination, and therefore the duplicates were removed using the Mendeley citation manager (Ed. Elsevier). The second step was the evaluation of the remaining articles by assessing the inclusion and exclusion criteria through the abstract, this consist in a preliminary assessment of the abstracts to see if the article met the objective of the study. Selected articles were totally read to check their eligibility. The last step was to identify and collect in a table the following variables of each paper: author with publication year, study type, purpose, Fiber-Reinforced Composite Post (FRCP) details, surface treatments, roughness (μm), surface microscopic analysis and main outcomes. The PCC (Population, Concept, Context) question developed for study was adjusted to the problem with "P" for fiber-reinforced composite post, "C" for microscopic analysis of the surface and roughness of the post and finally the other "C" for the surface pre-treatment with hydrogen peroxide.

4. RESULTS

Literary research conducted on PubMed resulted in a total of 187 articles, as show in figure 1. Among them, 65 duplicated articles were removed. Then the evaluation of the titles and abstracts of the remaining articles was carried out individually and 96 articles were excluded because they did not meet the inclusion criteria. The remaining 26 articles selected were reading in their entirety to select the most relevant. 11 papers did not match with the aim of the present study. In addition, a manual search was conducted in order to find other studies to complete and develop our discussion, thus 2 studies were added. Finally 17 studies were included in this integrative review, 15 selected for the development of the results and 2 to complete the discussion.

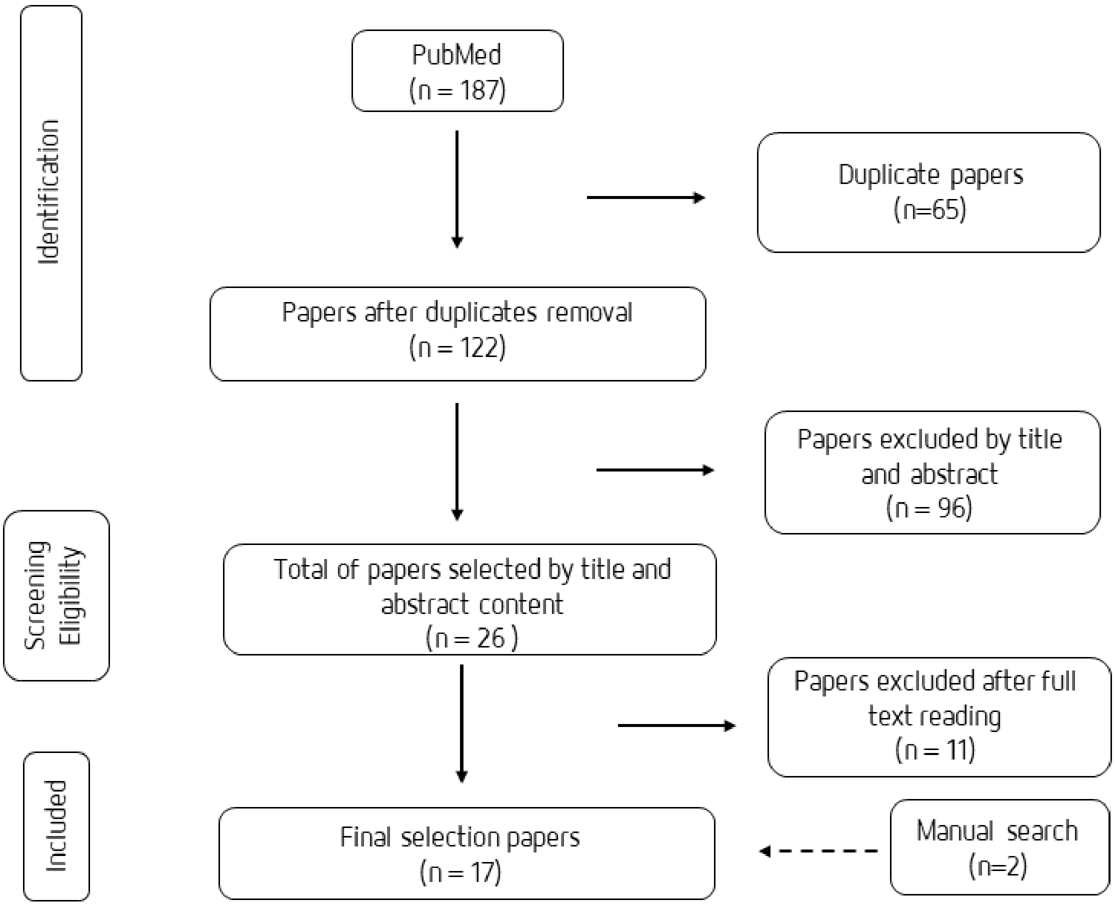


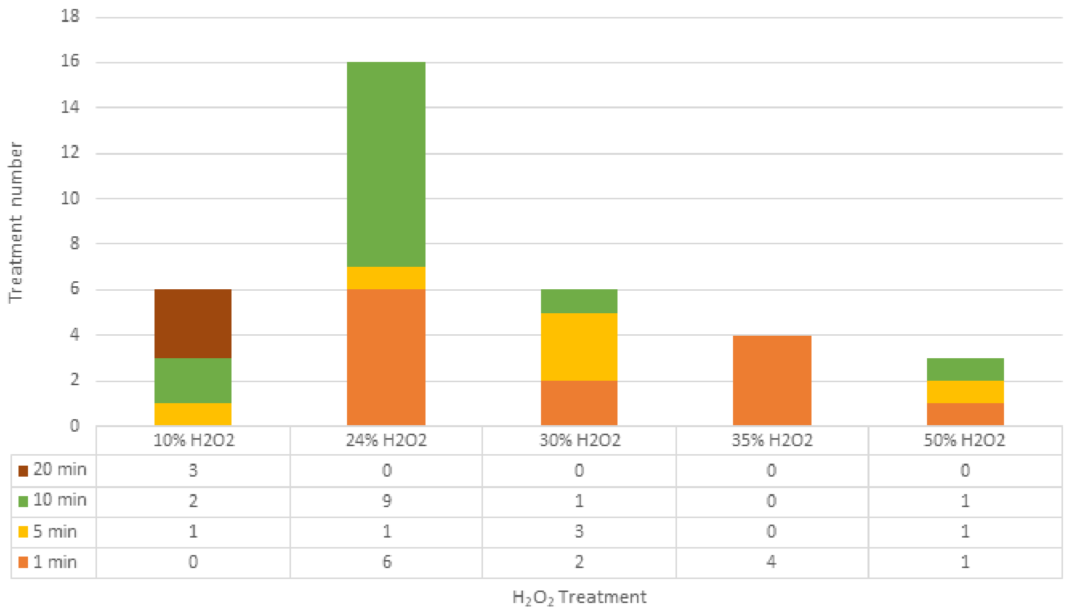
Figure 1 – Prisma flow diagram of the data search strategy

Among the 15 selected studies, the publication dates are distributed from 2011 to 2021. The years 2013, 2019 and 2021 have 1 article (7% each). There are 2 articles (13% each) for years 2012, 2014 and 2016. Finally, the most represented publication dates in our study are 2011 and 2017 with 3 articles (20% each).

Regarding the type of study, all of the 15 studies are in vitro studies (100%).

In the selected studies, the 3 types of posts used were glass, quartz or carbon fiber posts. There are 11 articles (73%) that use only 1 type of post in their studies, 3 studies (20%) that compare 2 different posts and only 1 study (7%) compares 3 different posts. Taking in consideration all the selected studies, the distribution of posts is as follows: 15 of the 20 posts used are glass fiber posts (73%). Of the remaining 5, 4 (20%) are quartz fiber posts and only one is made of carbon (7%).

With regard to surface treatments with hydrogen peroxide. The different studies used a hydrogen peroxide concentration between 10% and 50% with application times ranging from 1 min to 20 min. In some studies, the addition of a post-treatment silane agent or storage time is also observed. Figure 2 shows the different concentrations and their respective application times. H_2O_2 treatments combined with another treatment are not considered.



	10% H2O2	24% H2O2	30% H2O2	35% H2O2	50% H2O2
20 min	3	0	0	0	0
10 min	2	9	1	0	1
5 min	1	1	3	0	1
1 min	0	6	2	4	1

Figure 2 – Distribution of H_2O_2 treatments

Different types of analysis were conducted. The 15 articles (100%) conducted a Scanning Electron Microscopy (SEM) analysis from x35 to x4000 magnification. 3 of the 15 studies (20%) proposed a roughness analysis after treatment and a stereomicroscopy analysis was proposed by 9 articles (60%). Finally in some of the studies, the analysis of the surface was completed by spectroscopy for 2 studies (13%), optical microscopy and tensiometer for 1 study each (7% each).

The main data from the 15 selected articles have been listed in Table 1.

Table 1. Relevant data and variables retrieved from the selected studies

Author (year)	Study type	Purpose	FRCP details	Surface treatments	Roughness (µm)	Surface microscopic analysis	Main Outcomes
De Sousa Menezes M. et al. (2011) [10]	In vitro study	Evaluated the effect of concentration and application time of hydrogen peroxide on the surface topography and bond strength of glass fiber posts to resin cores.	Quartz fiber posts (Aestheti-Plus Fiber post) Embedded in an epoxy resin matrix with a maximum diameter of 2.1 mm. (Bisco Inc, Schaumburg, IL)	**G1**: control (no treatment) **G2**: 24% H_2O_2 for 1 min + silane coupling agent for 60s **G3**: 24% H_2O_2 for 5 min + silane coupling agent for 60 s **G4**: 24% H_2O_2 for 10 min + silane coupling agent for 60s **G5**: 50% H_2O_2 for 1 min + silane coupling agent for 60s **G6**: 50% H_2O_2 for 5 min+ silane coupling agent for 60s **G7**: 50% H_2O_2 for 10 min + silane coupling agent for 60s H_2O_2: immersion	-	SEM analysis (JSM-5600LV; JEOL, Tokyo, Japan), surface topography, x500, x1000 and x1500, Gold sputter-coated.	Etching with H_2O_2 increased the surface roughness and exposed the fibers for all concentrations and application times. ⇨ **G1** present a relatively smooth surface without fiber exposure and entirely covered by epoxy resin – Poor retention. ⇨ **G2** generated the lowest fiber exposure. ⇨ **G2** and **G5** were able to partially dissolve the epoxy resin and expose the glass fibers. It is important to note that all treatments with H_2O_2 exposed the fibers without damaging or fracturing them. ⇨ **G2** is a feasible clinical time technique and compared with other results it is preferable in clinical use. All failures were adhesive between the fiber post and resin core.
Khamverdi Z. et al. (2011) [12]	In vitro study	Evaluate the effect of two different surface treatments on the microtensile bond strength of quartz fiber posts to composite core in long-term	White quartz fiber posts (DT Light-Post radiopaque, RTD, Grenoble, France) Composition: - 60% quartz fibers embedding in the epoxy resin matrix.	**G1**: 24% H_2O_2 for 10 min without storage **G2**: 24% H_2O_2 for 10min + stored for 3 months **G3**: 24% H_2O_2 for 10 min + stored for 6 months **G4**: 24% H_2O_2 for 10 min + stored for 9 months **G5**: SB for 5s without storage **G6**: SB for 5s + stored for 3 months	-	SEM analyse: (JSM-5310, JEOL, Tokyo, Japan), morphology of interfaces, x500 e x1000, Gold palladium sputter-coated.	Voids and disintegrates were observed in stored groups. ⇨ **G1, G2, G3, G4**: fibrils were relatively intact and just the epoxy resin between fibrils was eliminated. ⇨ **G5, G6, G7, G8**: fibrils were destroyed and some of the fibrils were completely broken.

		water storage time.	Maximum 1.8 mm of diameter.	**G7**: SB for 5s + stored for 6 months **G8**: SB for 5s + stored for 9 months H_2O_2: immersion SB: sandblasting with 110 µm aluminum oxide particles. (Rocatector Delta, 3M, ESPE, Seefeld, germany)		Stereomicroscopy: (Nikon Eclips E600, Tokyo, Japan), failures surface modes, x20.	All failures occurred as adhesive failure.
Naves L. et al. (2011) [13]	In vitro study	Evaluate the effect of different chemical etching procedures on the surface characteristics of carbon and glass/epoxy fiber reinforced resin posts.	2 different fiber-reinforced post systems: 1.Gfp, Glass fiber post (Reforpost Glass, Angelus, Londrina, Parana, Brazil) Composition: 85% quartz fiber, 15% epoxy resin 2.Cfp, carbon fiber post (Reforpost Carbon; Angelus). Composition: 62% carbon fiber, 38% epoxy resin Both posts are serrated and 1.5 mm in diameter.	**C**: Control (no treatment) **G2**: 24% H_2O_2 for 10 min **G3**: 10% H_2O_2 for 20 min **G4**: 4% HF acid gel for 60s **G5**: 37% H_3PO_4 acid gel for 30s H_2O_2, HF, H_3PO_4: immersion	-	SEM analysis: (LEO 435 VP; LEO Electron Microscopy Ltd., Cambridge, UK), morphology, etching patterns, surface modification and surface characterization, x50 to x4000, gold sputtered.	Post microscopic surface morphology was modified with all treatment when compared with a **G1** for both type of posts. For Gfp ⇨ **G1**: rough surface with fibers covered by epoxy resin. ⇨ **G2, G3**: Dissolution of epoxy resin and exposure of the superficial fiber resulting in cleaner surface. ⇨ **G4**: HF seems to penetrate around the fibers and promote surface alteration with the presence of by-product precipitate along the resin matrix-glass fiber interface. ⇨ **G5**: relatively smooth surface area was produced, affecting only the superficial part of the post resin matrix but with similar features to **G1.** For Cfp: ⇨ **G1**: rough surface with fibers covered by epoxy resin. ⇨ **G2, G3**: dissolution of epoxy resin and exposure of the superficial fiber resulting in cleaner surface. ⇨ **G4**: seems to be inefficient for etching Cfp. The epoxy polymer matrix also seems unmodified after the treatment.

							⇨ **G5**: relatively smooth surface area was produced, affecting only the superficial part of the post resin matrix but with similar features to **G1.** Post treatment with H_2O_2 resulted strength of carbon and glass/epoxy resin fiber posts to resin composite core. A simple, fast and inexpensive protocol, using H_2O_2 and silane, may serve to increase bonding interaction facilitating the stress distribution and improving the post retention.
Kulunk S. et Al. (2012) [14]	In vitro study	Evaluate the effects of different mechanical and chemical surface pre-treatment methods on a quartz fiber post that could be used to obtain a reliable bond between the quartz fiber post and adhesive resin cement.	Quartz fiber posts (Light Post, Resin Bisco, Schaumburg, USA) Composition: 2-stage - Translucent fiber post 62% Quartz Fiber, - 38% Epoxy	**C**: Control, silanization for 60s **MC**: CH_2Cl_2 for 5s + silanization for 60s **HP**: 24% H_2O_2 for 10 min + silanization for 60s **Co**: Silica coating with 30 µm SiOx + silanization for 60s **K**: Air abrasion with 50 µm Al_2O_3 + silanization for 60s **D**: Air abrasion with 1–3 µm synthetic diamond particles + silanization for 60s Silanization: (Monobond-S) CH_2Cl_2: (LAB-SCAN Analytical Science, Ireland) H_2O_2: (Perhidrol, Sihhat Ltd, Turkey) Air abrasion **D**: (Micron + MDA)	Profilometer: (Mahr Pertran Perthometer S-P, Göttingen, Germany), average surface roughness (Ra) in µm. **C:** 1,28 **MC:** 1,39 **HP:** 1,44 (standard deviation: 0,07 µm) **Co:** 1,68 **K:** 2,32 **D:** 2,40 confidence interval of 95%.	SEM analysis: (JSM, 6335F; JEOL, Tokyo, Japan), surface morphology, x250, gold sputter-coated (S150B; Edwards, Crawley, UK)	Application of surface pre-treatment affected the surface morphology of post. ⇨ **MC, HP**: affected by dissolution of the superficial layer of epoxy resin matrix of quartz fiber post (arrow) and exposed quartz fibers, they did not produce any harmful effect on fibers. ⇨ **Co, K**: resulted in fractured or coated quartz fibers in some areas (arrow), removed and abraded the epoxy resin matrix. ⇨ **D**: rough and undamaged quartz fiber (arrow), abraded the epoxy resin matrix and exposed quartz fibers. Regarding roughness: significant differences were found between different surface pre-treatment methods. ⇨ **C**: lowest Ra values and no significant differences were found with **MC**. ⇨ **D**: highest surface roughness (Ra) values. No significant differences were found with **K.** ⇨ No significant differences were found between **HP** and **Co.**

						<u>Stereomicroscopy</u>: (Leica, MZ125, Milton Keynes, UK), failure mode, x40	⇨ **C and MC**: Completely adhesive failure between cement and post (100%). ⇨ **HP**: adhesive failure between dentin and cement (72%), cement and post (17%) and mixed failure (11%). ⇨ **Co**: adhesive failure between dentin and cement (78%) and mixed failure (22%). ⇨ **K and D:** completely adhesive failure between dentin and cement (100%).
Braga N. et al. (2012) [15]	In vitro study	Assess the influence of surface pre-treatments of fiber reinforced posts on flexural strength (FS), modulus of elasticity (ME) and morphology of these posts, as well as the bond strength (BS) between posts and core material.	2 types of glass fiber-reinforced posts: Post1: Reforpost #3 (Angelus, Londrina, PR, Brazil) Parallel, serrated and have a 1,5 mm diameter. Post2: White Post DC #1 (FGM, Joinville, SC, Brazil) Dual shape and diameter of 1.6 mm in the cylindrical part.	**A-ST**: Control (no treatment) **B-HP-10**: 10% HP for 10 min **C-HP-24**: 24% HP for 1 min **D-Al$_2$O$_3$**: 50 µm airborne aluminum oxide particles abrasion 10%HP: (Dynamics, São Paulo, SP, Brazil), immersion 24%HP: (Dynamics) immersion in 2 mL Al_2O_3: (Polidental LTDA, Cotia, SP, Brazil)	-	<u>SEM analysis</u>: (JSM-5410; JEOL Ltd., Tokyo, Japan), x500, gold-palladium sputter coated. (Denton Desk II; Dentonvacuum LLC, Moorestown, NJ, USA) <u>Stereomicroscopy</u>: (Leica microsytem LTD, Wetzlar, Germany) ×40, fracture modes.	Partial dissolution of the resin matrix in all treated groups. ⇨ On control group (**A-ST**), for both posts: the fibers were continuous and covered by epoxy resin matrix. ⇨ **B-HP-10**, C-**HP-24 or D-Al2O3** were different from the **A-ST** (control). ⇨ **B-HP-10:** a slight exposure of the post fibers (arrows), more evident for the post2. ⇨ **C-HP-24**: more areas with dissolution of resin matrix and exposure of the post fibers (arrows). Areas with discontinuity of the fibers (circles). ⇨ **D-Al2O3**: Exposed fiber areas (arrows) and discontinuity (circles) post fibers. Predominance of adhesive mode in **A-ST** and mixed in others groups of both posts.
Elsaka S. (2013) [16]	In vitro study	Evaluate the effect of fiber post surface treatment with CH_2Cl_2 and H_2O_2 on the morphological aspects of the	2 types of glass fiber posts: **RP**: Rebilda post, Size #Ø1.5 (VOCO, Cuxhaven, Germany) <u>Composition</u>: 70% glass fiber, 10%	**G1**: control (no treatment) **G2**: silanization for 60s **G3**: 10% H_2O_2 for 5 min **G4**: 10% H_2O_2 for 10 min **G5**: 30% H_2O_2 for 5 min **G6**: 30% H_2O_2 for 10 min **G7**: CH_2Cl_2 for 5 min **G8**: CH_2Cl_2 for 10 min	-	<u>SEM analysis</u>: (JEOL; JXA-840A, JEOL, Tokyo, Japan), morphological aspects, x200, gold-	The surface topography of posts was modified following treatment which dissolved the resin matrix of the posts and exposed the glass fibers of the posts. <u>RP post</u>: **G1:** rather rough surface with some glass fibers exposed. **G2**: no changes.

		post surface, and the influence of different surface treatments on the micro push-out bond strength of fiber posts to different composite resins for core-build up.	filler and 20% UDMA. **RX**: RelyX post, Size #2; (3M ESPE, St. Paul, MN, USA) Composition: Glass fiber reinforced composite, methacrylate resin.	Silane: (Ceramic Bond, 3-methacryloxypropyltrimethoxysilane in an ethanol/water solution, isopropanol, VOCO, Cuxhaven, Germany) H_2O_2: (Hydrogen Peroxide, Liza, Mash Co., Egypt), immersion. CH_2Cl_2: (Methylene chloride, formula weight: 84.13 g/mol, El Nasr Pharmaceutical Chemicals Co., Egypt), immersion.		sputter coated. (Sputter Coater S150A; Japan) Stereomicroscopy: (Olympus SZX ILLB100-Olympus Optical Co. Ltd., Tokyo, Japan), failure modes, x40.	Rx post: **Gr1**: smooth surface. **Gr2**: no changes. The surface topography of posts was modified following treatment with H_2O_2 and CH_2Cl_2. Efficacy of the CH_2Cl_2 and 30% H_2O_2 in modifying the fiber post surfaces. It appears to be simple, effective and inexpensive methods that might improve the clinical performance of glass fiber posts. In addition, the exposed glass fibers were not damaged or fractured by the surface treatments. Adhesive failure was the predominant failure (93.5%). In addition, mixed failures (5.1%), cohesive failures within the core material (1.1%), and cohesive failures within the post (0.3%).
Samimi P. et Al. (2014) [17]	In vitro study	Compare the effects of two kinds of chemical etching pre-treatments of the fiber-post surface on the pushout bond strength and to determine whether the Heat treatment of the applied silane solution with warm water could increase the bond strength to exceed that	Glass fiber posts #3 (FRC Postec Plus, Ivoclar Vivadent) Composition : polymer matrix was composed of: aromatic and aliphatic dimethacrylates and ytterbium trifluoride. Prefabricated conical shape post.	**C**: Control (no treatment) **HF+S** = 9,5% HF for 60s + silane layers for 60s **HF+S+WP** = 9,5% HF for 60s + heat-treated silane layers for 60s and warmed posts (WP) immersion at 45° for 10s **H_2O_2+S** = 10% H_2O_2 for 20 min and silane layers for 60s **H_2O_2+S+WP** = 10% H_2O_2 for 20min + heat treated-silane layers for 60s and warmed post (WP) immersion at 45° for 10s HF: (Porcelain Etchant, Bisco, Schaumburg, IL, USA) Silane: (Bis-silane, Bisco)	-	SEM analysis: (Philips XL30, Philips Eindhoven, Netherlands), surface characteristics of posts, x200 or x1000, gold alloy sputter-coated. (SCD 005 Sputter coater, Bal-Tec Co., Balzers, Vaduz, Liechtenstein, Germany) Stereomicroscopy: (Lomo SF-100, MBC-10, Moscow, Russia), failure mode.	Post surface morphology was altered after treatments 9.5% HF and 10% H_2O_2, dissolved the post resin matrix and created microspaces among the exposed fibers. Treatment with 9.5% HF had a greater impact on the post surface, dissolved the resin matrix more extensively than did treatment with 10% H_2O_2. In the cross-section view it was revealed that more superficial fibers were exposed with the HF pre-treatment because larger amounts of the resin matrix were removed to a greater depth. Evaluation of the failure mode revealed that the most frequent failure was mixed (77.5%), followed by adhesive failure (14%), and cohesive failure in the post (8.5%). There was no cohesive failure in dentin.

		resulting from a room-temperature airdrying procedure.		H_2O_2: immersion			
Menezes MS. et al. (2014) [18]	In vitro study	Evaluated the effect of the concentration and application mode of hydrogen peroxide on the surface topography and bond strength of resin composite to glass fiber posts. In addition, the surface of fiber posts was evaluated using scanning electronic microscopy (SEM).	Glass fiber-reinforced epoxy post system. (White Post DC3, FGM, Joinvile, SC, Brazil)	**G1:** control (no treatment) **G2**: 24 % H_2O_2 immersion for 1min + silane coupling agent for 60s **G3:** 24 % H_2O_2 application for 1min + silane coupling agent for 60s **G4**: 35 % H_2O_2 immersion for 1min + silane coupling agent for 60s **G5**: 35 % H_2O_2 application for 1min + silane coupling agent for 60 24% H_2O_2: (Dinâmica, São Paulo, SP, Brazil) 35% H_2O_2: (Whiteness HP Max, FGM)	-	<u>SEM analysis</u>: (LEO 435 VP, Nano Technology Systems Division of Carl Zeiss SMT, Cambridge, UK), surface topography, x80 to x4000, gold sputter-coated. (MED 010, Bal-Tec AG, Balzers, Liechtenstein)	All experimental conditions increased the exposure of glass fibers without damaging them. H_2O_2 solutions can partially dissolve epoxy resin, thus exposing the fibers. The ability of H_2O_2 to affect fiber post etching is related to the concentration and the application mode. ⇨ **G1**: relatively smooth surface without fiber exposure. Shows epoxy resin covering the glass fibers of the post and some areas with exposed fibers and flaws. ⇨ **G2, G4, G5:** more exposed fibers in relation to **G1** ⇨ **G3**: did not effectively increase the amount of exposed glass fibers. Based on the results of this study, the application of high-concentration H_2O_2 using a microbrush, is a feasible clinical procedure. Differences in the composition and viscosity of materials can alter the results.
Daneshka-zemi A. et al. (2016) [7]	In vitro study	Evaluate the effect of different surface treatments of epoxy resin based glass fiber posts on its microtensile bond strength to composite resin foundation material and on	Glass fiber posts (Whitepost DC #3; FGM) <u>Composition of the posts</u>: - 80.0% ± 5.0% glass fibers - 20.0% ±5.0% epoxy resin	**C**: control (no treatment) **S**: silanization for 1 min **H1**: 30% H_2O_2 for 1 min **H1S:** 30% H_2O_2 for 1 min + silanization for 1 min **H5**: 30% H_2O_2 for 5 min **H5S**: 30% H_2O_2 for 5 min + silanization for 1 min **P1**: 35% H_3PO_4 for 1 min **P1S**: 35% H_3PO_4 for 1 + silanization for 1 min **P5**: 35% H_3PO_4 for 5 min	-	<u>SEM analyse</u>: (ProX; Phenom), surface morphological characteristics, x255, Without gold sputter-coated.	The tested posts had a very rough surface showing cracked and dislodged fibers, which may have similarly acted as a H_2O_2 reservoir, thus producing lower results in hydrogen peroxide groups. SEM analysis revealed cracked and dislodged superficial fibers in all groups including group **C**. The frequency of exposed glass fibers was not obviously different among the groups. ⇨ **H5**: The cut end of the fiber posts, showed intact internal fibers.

		the morphological aspects of the fiber post surface using the scanning electron microscope (SEM).	Coronal end: cylindrical in shape and 2 mm in diameter. Remaining apical: conical in shape and 11 mm in diameter.	**P5S**: 35% H_3PO_4 for 5 min + silanization for 1 min Silane coupling agent: (Prosil; FGM) 30% H_2O_2: immersion 35% H_3PO_4: (Condac37; FGM)		Stereomicroscopy: (ZTX-20-W; Huaguang), failures modes, x40.	Treating the fiber post surface with either 30% H_2O_2 or 35% H_3PO_4 for 1 or 5 min is not recommended Most of the specimens showed adhesive failure and 2 specimens of **S** showed cohesive failure.
Roperto R. et al. (2016) [19]	In vitro study	Evaluated if different post surface treatment can affect the bond strength of urethane dimethacrylate (UDMA) fiber-posts with resin-cements.	UDMA fiber-posts (DT Logipost, Synca, Canada) Composition: longitudinally oriented fibers, coated with UDMA resin. More rigid and heavily cross-linked polymer matrix and more stiff molecular structure with hydroxyl groups aimed to provide good bonding adhesion and interaction with other resin based materials without any necessary pre-surface treatment. Maximum diameter of 1.5 and 20 mm long.	**G1**: No surface treatment + silane application for 60s **G2**: immersion in ethyl alcohol for 10 min + silane application for 60s **G3**: 24% H_2O_2 for 10 min + silane application for 60s Silane: (Silane Component, Bisco, Schaumburg, IL, USA) H_2O_2: immersion	-	SEM analysis: (Hitachi S2500, Tokyo, Japan), longitudinally superficial aspect, x35, x500, x1000 and x2000, platinum-sputtered. (Polaron SL 515 machine, Watford, Herts, UK) Stereomicroscopy: (Nikon SMZ445, Melville, NY, USA) Failure analysis, x35.	All groups showed only a small roughening of the surface along the entire post length regardless of the surface treatment performed. ⇨ **G2**, **G3**: resulted in minimal modification of the fiber post surface when compared with **G1** and the exposed glass fibers were not damaged or fractured by the oxidative action of H_2O_2 or the ethyl alcohol. Longitudinal views of both groups revealed very small surface dissolution of the UDMA resin matrix. The underlying UDMA resin remained intact and exhibited no signs of cracking or damage regardless the surface treatment performed. Surface treatments on UDMA fiber posts presented no benefits in terms of surface roughness, thus, should not be performed. For all groups, specimens, adhesive failure is predominant.
Silva F.P. et al. (2017) [20]	In vitro study	Evaluate the effects of surface	Glass fiber posts (White Post DC3; FGM, Joinvile, SC, Brazil)	**G1**: Control (no treatment) **G2**: Experimental Coating of thermally deposited siloxane-methacrylate coating for 60s	Laser interferometry: (Microfocus Expert IV, UBM		All of the treatments significantly increased the values of the topographic parameters compared with **G1** but no significant differences were observed between the treatments.

		treatment of glass fiber on the following response-variables: the contact angle of the water or adhesive on the glass-fiber surface, the surface roughness, and the bond strength between the glass-fiber and the composite.	Cylindrical, of 2 mm in diameter and 20 mm in length.	**G3:** 35% H_2O_2 for 60s **G4**: CH_2Cl_2 for 60s Experimental coating: Immersion in 2mL. Slight air-stream was applied for 60 s + heated at 120°C for 1 h. H_2O_2: application, (Whiteness HP Max, FGM) CH_2Cl_2: application, (Synth, Diadema, SP, Brazil)	Corporation, Sunnyvale, CA, USA), surface roughness. Two-dimensional images yielded the average roughness: **Ra** (μm) **G1**: 3.6 **G2**: 4.9 **G3**: 5.0 **G4**: 5.6 confidence interval of 95%.	SEM analyse: (TM 3000 Tabletop Microscope, Hitachi, Closter, New Jersey, USA), topography, morphology and chemical surface alteration, x500. X-ray energy dispersive spectroscopy (EDS): chemical surface. Tensiometer: (Theta Lite TL101, Biolin Scientific, Espoo, Uusimaa, Finland), contact angle between GFP and water or adhesive drop Optical microscopy: fractures interfaces, x40.	⇨ **G1**: epoxy resin covering the glass fiber and some areas with exposed fibers. ⇨ **G2**: fewer exposed glass fibers. ⇨ **G3, G4**: selectively removed the epoxy resin and increased the numbers of exposed fibers. Regarding roughness: the surface treatments significantly affected all of the surface roughness parameters. All of the treatments resulted in increased Si and O contents at the surfaces. Significant effects of surface treatment about the contact angle. For both contact angles, significant effects of surface treatment were observed. ⇨ **G1**: lowest adhesive contact angle. No differences were observed between the treatments. ⇨ **G2** produced the lowest water contact angle, and was significantly different from **G1** and **G3**. ⇨ **G4**: intermediate values. Adhesive failures were predominant irrespective of the post surface treatment
Aksornmu-ang J. et Al. (2017) [21]	In vitro study	Evaluate the flexural properties and surface topography of three types of fiber post, when surface treated with select	3 types of fiber posts: 1.RelyX Fiber Post size #2 (3M ESPE, St. Paul, MN, USA):	**G1:** control (no treatment) **G2:** 4,5% HF for 60s **G3:** 4.5% HF for 120s **G4:** 9.6% HF for 15s **G5:** 9,6% HF for 60s **G6:** 9.6%HF for 120s **G7:** 24% H_2O_2 for 10 min The post was entirely submerged	-	SEM analysis: (Quanta400, FEI, Hillsboro, OR, USA), surface topographies,	The surface topographies of all the tested fibers post types were very similar to the **G1** but SEM of surface topography showed differences between the protocols tested. RelyX Fiber post:

		etching protocols.	<u>Composition</u>: Glass fibers, epoxy-resin matrix containing zirconia fillers. 2.Tenax Fiber Trans size TFT 15 (Coltène/ Whaledent, Altstätten, Switzerland) <u>Composition</u>: Glass fiber, methacrylate resin. 3.D.T. Light-Post Illusion X-Ro size #1 (RTD, St. Egrève, France) <u>Composition</u>: Quartz fibers, epoxy resin, catalyst, colored pigment.	into the surface treatment agent HF 4,5%: IPS Ceramic Etching Gel (Ivoclar Vivadent, Schaan, Liechtenstein), water thickener, Pigment. HF 9,6%: Porcelain Etch Gel (Pulpdent, Watertown, MA, USA), ethyl alcohol, gel base. H_2O_2: (Vidhyasom, Bangkok, Thailand), Hydrogen Peroxide Sol. 35% diluted to 24%.		x500, gold sputter-coated.	⇨ **G1**: surface mostly covered by the resin matrix, with a few fibers exposed on the outer surface. ⇨ **G2, G4, G5, G7**: no obvious changes compared to **G1.** ⇨ **G3**: glass fibers were broken into small pieces by etching. ⇨ **G6**: all the etched fibers were dislodged from the surface, leaving fiber imprint lines on the zirconia-filled matrix. Tenax Fiber Trans: ⇨ **G1**: surface tightly covered by the resin matrix with only few fibers exposed on the outer surface. ⇨ **G2**: Some glass fiber bundles were removed. ⇨ **G2,G5**: Several micro-pores inside the resin matrix were observed. ⇨ **G3, G5, G6**: glass fibers on the outer surface of a post were mostly wiped out. ⇨ **G4, G7**: surface appeared intact. D.T. Light-Post: ⇨ **G1**: surface covered by the resin matrix with some fibers exposed on the outer surface. ⇨ **G2, G3, G4, G5**: show many crack lines in the fibers. ⇨ **G6**: several pores and cracks have appeared on the post surface. ⇨ **G7**: surfaces treated seemed unchanged compared **G1.** The results of this study indicate that fiber post surface pre-treatments with HF and H_2O_2 are acceptable practices
Prado M. et al.	In vitro study	Evaluate the	Fiberglass epoxy resin posts (White	**G1**: Control (no treatment) **G2**: Silane coupling agent for 1 min	-		

(2017) [22]		effect of different surface treatments on fiber post cemented with a self-adhesive system.	Post DC3, FGM, Joinville, SC, Brazil) 2 mm in diameter and 20 mm in length.	**G3**: 24% H_2O_2 for 1 min **G4**: Blasting with 50 μm aluminum oxide particule for 30s **G5**: NH_3 plasma for 3 min **G6**: HMDSO plasma for 15 min Silane coupling agent: (Prosil, FGM, Joinville, SC, Brazil) H_2O_2: immersion **G4** treatment: (Microetcher II; Danville Engineering, San Ramon, CA, USA)		SEM analysis: (JSM 6460 LV (JEOL, Tokyo, Japan). topographical analysis, x500, gold sputter coated. Spectroscopy: (Nicolet 6700, Thermo Scientific, Waltham, MA, USA) FTIR Analysis for chemical modifications on fiber post surface. Stereomicroscopy: (SMZ800, Nikon Instruments, São Paulo, SP, Brazil), failures modes	⇨ **G1** showed similar topography to **G2** and **G6**, with slightly removal of epoxy resin after treatment. ⇨ **G3** and **G4** showed the degradation of the epoxy resin matrix and exposed fibers with no apparent fiber damage. ⇨ **G5** presented smoother surfaces without change in the fiber exposition. Chemical analysis: ⇨ **G2, G6:** improvement of functionals groups. ⇨ **G3, G4, G5**: Reduction of functionals groups. Failures were predominantly cohesive post and cement in all groups
Cadore-Rodrigues AC. et al. (2019) [23]	In vitro study	Compare the effect of different surface treatments pre-treatments and bonding agents) on the bond strength between glass-fiber post and composite resin, and the topographic alterations of the treated post surface.	Glass-fiber reinforced composite (FRC) blocks (FGM Dental, Joinville, Brazil) Composition: Glass fiber epoxy resin, inorganic filler, silane, polymerization promoters. Block of 12mm x 10mm x8mm with a rectangular shape.	Pre-treatment: **G1**: control (no treatment) **G2**: 35% H_2O_2 for 1 min **G3**: Air-abrasion, 30 μm silica-coated aluminum oxide particles for 10s Post-treatment: Followed or not by the application of 3 different agents for each treatment H_2O_2: (Whiteness HP Maxx, FGM) G3 treatment: (CojetTM System, 3M Espe AG, Seefeld, Bavaria, Germany)	Surface roughness analysis: roughness tester (Mitutoyo SJ-410, Mitutoyo Corporation, Takatsu-ku, Kawasaki, Kanagawa, Japan) The analyses were performed before and after the pre-treatment (μm) For **G2**: Before = 3.0 After = 3.1	SEM analysis: (FE-SEM, Inspect F50, FEI, North America Nano Port, Hillsboro, Oregon, USA), topographic analysis after each surface pre-treatment, x1000 and x5000, gold-palladium sputter coated. Stereomicroscopy: (Stereo Discovery V20; Carl Zeiss AG, Oberkochen,	⇨ **G1**: smooth pattern in the cleaning group, with unaltered glass-fibers and resin matrix. ⇨ **G2**: slight surface alteration can be seen, without great impact on resin matrix degradation and little impact on roughness. Some glass-fibers were exposed. ⇨ **G3**: intense surface alteration can be noted with irregularities owing to the impact of particles and deposition of silica particles onto the FRC surface, which probably generated more surface roughness and more defects. The main failure type was adhesive at the resin-post interface and only one cohesive failure was observed.

					For **G3**: Before = 3,4 After = 4.3 confidence interval of 95%.	BadenWürttemberg, Germany), fracture analysis, x40	
Alshahrani A. et al. (2021) (24)	In vitro study	Access the impact of different surface treatments on the push-out bond strength between fiber post and a composite resin core material.	Glass-fiber posts (RelyX Fiber Post, size 2; 3 M ESPE, St. Paul, MN) Glass fibers in a parallel alignment to the length of the post and surrounded by a matrix of high cross linked epoxy resin.	**C** - control (no treatment) **S** - Silane for 60s **SBS**: SB aluminum oxide particles for 10s + silane for 60s **HFS**: 9% HF for 90s + Silane for 60s **HPS**: 24% H_2O_2 for 60s + silane for 60s **HPSBS**: 24% H_2O_2 for 60s + silane for 60s + SB aluminum oxide particles for 10s + silane for 60s Silane: (Ultradent Silane; Ultradent Products, Inc. South Jordan, UT) SB: sandblasting at 10 mm distance HF: (Ultradent Porcelain Etch; Ultradent Products, Inc. South Jordan, UT) H_2O_2: (Loba Chemie Pvt. Ltd., India), immersion	-	<u>SEM analysis</u>: (JEOL JSM-6360 LV) For surface changes longitudinally and cross-sectionally + failures modes, x300, Gold-sputter coated	Surface modifications differed between the groups. ⇨ **C**: micropores and grooves features on the surface of untreated FP with superficial glass fibers covered by resin matrix. ⇨ **S**: impregnated micromechanical features of the post by silane. ⇨ **SBS**: Rough surface with exposed and intact superficial glass fibers. ⇨ **HFS**: Rough etched surface of FP ⇨ **HPS**: had a partially dissolved matrix. ⇨ **HPSBS**: Rough surface with partially dissolved matrix and exposed cracked glass fibers. All groups showed predominantly adhesive failure except for the **HPSBS** (cohesive failure). Application time and materials used for surface treatments are possible to be performed in chairside. The combined method of H_2O_2 and sandblasting could weaken the fiber post and lead to clinical fracture.

The main results are as follows:

- ⇨ All studies performed microscopic analysis of the surface with different instruments and magnifications. A recurring finding was that post surface microscopy and morphology was modified after surface pre-treatment. The same observation in favour of increasing as values of topographic parameters was made for Silva [20]. However, study of Aksornmuang J. is in contrast with others because he says that the surface topographies of all the tested fibers post types were very similar to group control and only have differences between the protocols tested according to SEM images [21].

- ⇨ The studies measuring surface roughness have used three different methods which are the profilometer, the laser or the roughness tester to obtain their values [14,20,23].

  Concerning the roughness results, articles noted difference in term of rough surface and significant differences were found between treatment methods with an augmentation of roughness before and after H_2O_2 treatment [14,20,23]. Kulunk S. observed an average surface roughness for the H_2O_2 treatment of 1.44 µm with a standard deviation of 0,07 µm [14]. In the study realized by Silva F.P., the average surface roughness was 5,0 µm. Finally, for the last study carried out by Cadore-Rodrigues AC., the average surface roughness was 3.1 µm [23]. The 3 studies mentioned below have conducted their measurements with a confidence interval of 95%. The average roughness obtained with these 3 studies is 3.18 µm after treatment with hydrogen peroxide and 2.62 µm for the control groups. The standard deviation of the mean roughness results after H_2O_2 treatment for these 3 studies is 1.45 µm.

- ⇨ In the study of Kulunk S., with a quartz fiber post, a roughness increased from 0,16 µm after 24% of H_2O_2 treatment for 10 min (1,28 µm vs 1,44 µm before and after surface treatment respectively) [14]. This result was similar with the study of Cadore-Rodrigues AC. who observed a slight difference before and after treatment (3,0 µm and 3,1 µm respectively) with 35% of H_2O_2 for 1 min but in this case with glass fiber post [23]. The largest difference in roughness between the control group and the H_2O_2

treated group was in the study of Silva F.P. were the difference before and after treatment was from 1,4 µm (3,6 µm vs 5 µm respectively) following an 35% H_2O_2 treatment for 1 min on a glass fiber post [(20)]. A very small roughening change after treatment is observed in the study of Roperto R. but without real benefit in term of surface roughness [(19)].

⇨ With regard to the surface pre-treatment procedure with H_2O_2 itself: for Naves L. and others it is a rapid, easier, inexpensive protocol and also an efficient technique [(10,13,16)]. The H_2O_2 treatment has been established as a useful and acceptable technique to be used in chairside by several authors [(10,18,21)]. In contrast with Roperto R., which, with his post type, does not recommend to pre-treat with H_2O_2 [(19)]. However, this procedure facilitates a bonding interaction, improve retention post, while, at the same time help to stress distribution [(13)] and increase performance of fiber post [(13,16)]. The 1 min time is preferred for chairside application because application times of 10 or 20 minutes are not clinically feasible [(10,16,24)].

⇨ Other factors, other than treatment, may influence the results. For storage times, it was observed that after treatment with H_2O_2, storage for at least 3 months, showed voids and disintegrated parts [(12)]. Moreover, viscosity and composition of all materials, study methodology used can alter the results according to Menezes MS. and other authors [(18,24)].

⇨ The protocol could be further facilitated if the surface treatment was carried out directly by the industries that manufacture the fiber post [(13,20,24)].

5. DISCUSSION

The studies selected according to the method mentioned above were analysed to determine the relevant information about the effect on the microscopic surface and roughness of the surface treatment with hydrogen peroxide on the fiber-reinforced posts.

Thus the null hypothesis: surface treatment with hydrogen peroxide does not affect the roughness surface of the fiber reinforced post and that its microscopic analysis is not altered after this type of conditioning is not accepted.

The following discussion synthesizes the ideas and concepts developed in all studies to explain how we achieved to these findings.

5.1. Endodontic posts

Caries, former restorations, attrition or fractures can lead to extreme coronal loss. This type of case is a real challenge for the treated teeth restorations (7,12,16).

Teeth with a severe loss of coronal structure often need endodontic treatment prior to restoration (7,16). In some cases, the restoration needs an intracanalar retention given by an endodontic post (7). This is this device who makes proper retention possible, can be custom made, pre-fabricated, laboratory or chair side made and help to cope with masticatory forces (12,24,25). The main objective of intra radicular pre-fabricated Fiber-Reinforced Posts (FRP) is a creation of a "monoblock" through bonding between materials and dental components (10).

The long-term success of a restoration of a tooth with severe loss of coronal structure depends on several elements such as the type of materials used for the reconstruction (12).

There are several material systems used for post fabrication like metal, zirconium and fiber (24). Rigid posts, such as those made of metal, generate a lot of stress between the post and the dentin (13). It is for this reason that metallic post were substituted in favour of fiber posts [17]. Today, fiber posts are the most commonly used materials for the restoration of an extensively destroyed tooth as an option to metal and zirconia post [12-16,22].

Fiber posts have qualities such as aesthetics coloration, reduce hypersensitivity allergic risks, corrosion resistance, ease to place and to remove, chairside time restorative procedure reduced and requires less removal of remnant tooth structure [19,21,24]. Moreover their have interesting biomechanical characteristics which allow to improve the resistance tooth fracture as an elastic modulus very close to that of dentin and materials like composite or resin cement [13-17]. Thus the distribution of the occlusal functions is uniformly distributed like the stress distribution who is favourable and more similar to original tooth [13-17].

The modulus of elasticity is a characteristic in relation with the diameter of the post. These two properties are inversely proportional meaning that the larger the diameter of the post, the lower the modulus of elasticity and inversely [15].

The metal post, which has a different modulus of elasticity than dentin, will generate high stresses between the dentin/post interface, generating a higher risk of fracture [13]. Whereas, the fiber-reinforced posts have a modulus of elasticity very close to that of dentin. This characteristic of FRPs is a major advantage for the distribution of occlusal loads along the root, this reducing the fracture risks. This specificity of fiber posts makes it possible to obtain results close to those obtained on an untreated tooth [13,14,15].

Thus the surface treatments of the post can affect its diameter and therefore inevitably its modulus of elasticity [15].

As illustrated in Figure 3, the organic element of these posts are usually in epoxy resin polymers highly crosslinked with a high degree of conversion creating a polymer matrix system which is generally a methacrylate or an epoxy resin matrix where is a high proportion of continuous reinforcing fibers [10,13,24]. This system is unlikely to react with the resin monomers or the silane agent to established an efficient adhesion and to create a homogeneous structure [10,15,18].

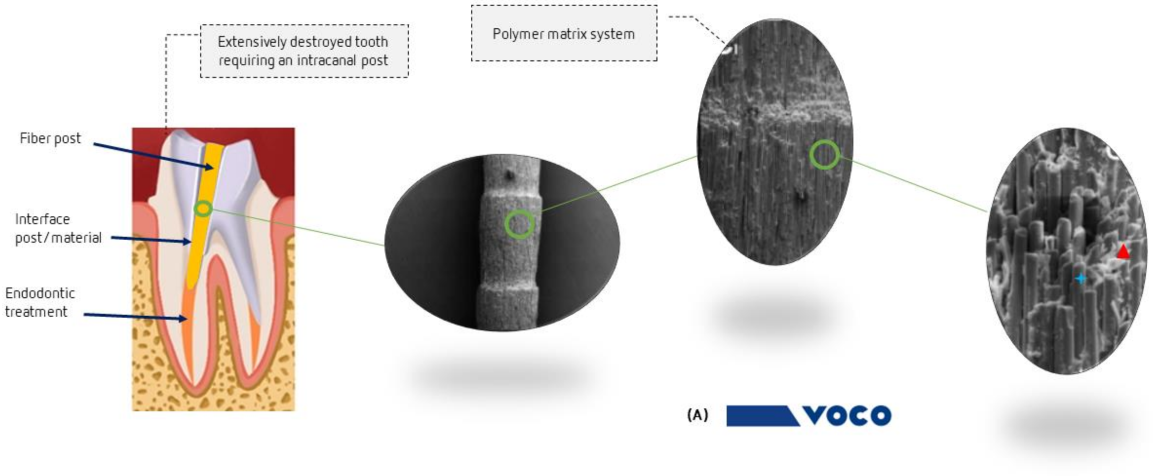


Figure 3 : Microscopic surface of a glass fiber post. Without surface treatment at different magnification, high proportion of continuous reinforcing fibers (blue star) and epoxy resin polymer highly crosslinked with a high degree of conversion (red triangle) are visible. Example of fiber post manufacturers, (A) VOCO. Microscopic images from the Naves L. study [13].

5.2. Pre-treatment of fiber post surface

5.2.1. Aims of post surface modification

The quality and strength of the bonding between the different surfaces influences the success, durability and efficient distribution of the functional stresses of the restoration [15,16,22].

Two interfaces of bonding are important in term of adhesion, the fiber post-resin interface and the resin-root interface [22]. The materials, the preparation and the adhesion of the different interfaces in contact are important elements to consider to obtain a successful restoration [7,22]. Thus, to meet with occlusal pressures and tensions, dissipation of forces is essential and can be achieved with a proper choice of materials (posts and composite resin) and the correct bonding technique [7,10,18].

Common types of failures of restorations with FRP are debonding between the various interfaces and less frequently post fracture [17,18,21].

A failure of bond on these interfaces can alter the formation of the unity of the desired radicular restoration monobloc. Thus the post-resin bond has a vital function for the restoration [10,14]. It should be strong to cope with the stresses and loads applied by the restoration and the occlusion. The ideal adhesion is not always achieved due to difficulties on the adhesion of different materials [19].

Bonds are achieved via micromechanical and chemical actions. To obtain a chemical or micromechanical bonding with the silane coupling agent or with the cement respectively, surface treatments are performed in order to modify a post surface [7,10]. The objective is to obtain a rough surface and expose the post fibers to create retention and permit a higher adhesion between parts [10,12,16]. Therefore the stability of the system are essential [13,14].

The retention of the post is modified according to several elements including the post space, the bonding, the cementation and the post parameters [17].

Surface treatments must be feasible in the office [7,24]. In this context the procedure should be easily performed with available products and an acceptable chairside procedure time [7].

5.2.2. Post surface modification types

To extend and modify surface, expose the fibers, improve roughness and bonding between different parts, different type of surface treatment post: chemical and mechanical treatment are available [12-15,18]. The practices can be classified in 3 categories: mechanical methods, chemical methods and combination of both [13,21,24]. Choosing the optimal surface treatment for the fiber post is a crucial step. It is necessary to know the composition of the post that is going to be treated and the impact that this treatment can have. Moreover, the indications must be scrupulously known and respected [13].

For mechanical methods, sandblasting is used but it is a practice which can affect the post itself [10,21]. Airborne particle abrasion method is used with different type of particle [14-16,23]. This technique produce a rough surface but is very aggressive, damaging the fibers, exposed them by removal of resin matrix to expose the silica of reinforced fibers [10,15,24]. It also affect the post form and surface, it resistance and can cause problems for root post adaptation [12,15,21]. The laser techniques also exist and were developed rapidly in endodontics as an alternative to other post surface treatments to allow more adhesion between interfaces. There are lasers with different wavelengths and characteristics such as Er:YAG, Er;Cr:YSGG or diode laser [22,24,26].

Considering chemical techniques, the main aim is to create surface roughness to helping retention [12,21]. Hydrofluoric acid initially employed for dental glass ceramics, is used for this type of action, creating a surface roughness [13,21,24]. It is a weak acid but who can be aggressive for the post according to some authors depending on several variables like concentration or application time [10,17,21]. Phosphoric acid could be employed because is also used in other dental procedures and therefore available in the practice but mainly recognized to have a cleaning power more than anything else [7,13,24]. Potassium permanganate, ethyl alcohol, plasma, sodium ethoxide, methylene chloride, hydrochloric acid and above all the hydrogen peroxide with various concentration and time are safer substances for the post as they selectively dissolve the epoxy matrix by breaking the bond of the post and exposed fiber with creation of roughness and consequent augmentation of retention for some [14-17,19]. Without negatively impact about fiber and post itself, these methods are effective but can take times especially the plasma which is the least appropriate for daily clinical practice because it requires materials and is an expensive method [10,14,19].

Silane can be additionally applied to support the chemical bonding between interfaces [7,18-20]. Removing the surface layer of epoxy resin and exposed fibers by one of the surface treatments seen above is essential for the silane application to be effective [7,10,14].

Hydrogen peroxide or H_2O_2 is used in various fields. It can be used in immunological transmission electron microscopy as it allows partial dissolution of the epoxy resin on surfaces or tissues subjected to the immunolabelling method [13,14]. In dentistry, H_2O_2 is frequently used in dental clinic for consultations of tooth bleaching or for root canal irrigation, thus hydrogen peroxide is safe and easy to use [10,16,21]. This soft surface pre-treatment technique with H_2O_2 is simple, efficient and easily achievable in chairside to improve bonding between material and fiber post [17,18].

Hydrogen peroxide has the ability to expose the fibers by selectively dissolving the epoxy resin of the post by splitting the epoxy resin bonds and without damage fibers post surface [12-15,23]. This has several positive effects, like exposing post resin matrix that allows easier chemical bonding, and creating spaces and voids that will promote mechanical engagement and retention between parts [18,20,23]. This enhancement of surface roughness at the post is considered to be effective to obtain retention between post and others materials [13,20].

5.3. Effects of hydrogen peroxide on the surface and roughness of fiber reinforced posts

For all studies, different protocols were applied in glass, quartz or carbon fiber reinforced post. As showed in Figure 4, various concentrations of hydrogen peroxide were tested in application or immersion on the post considering several time periods.

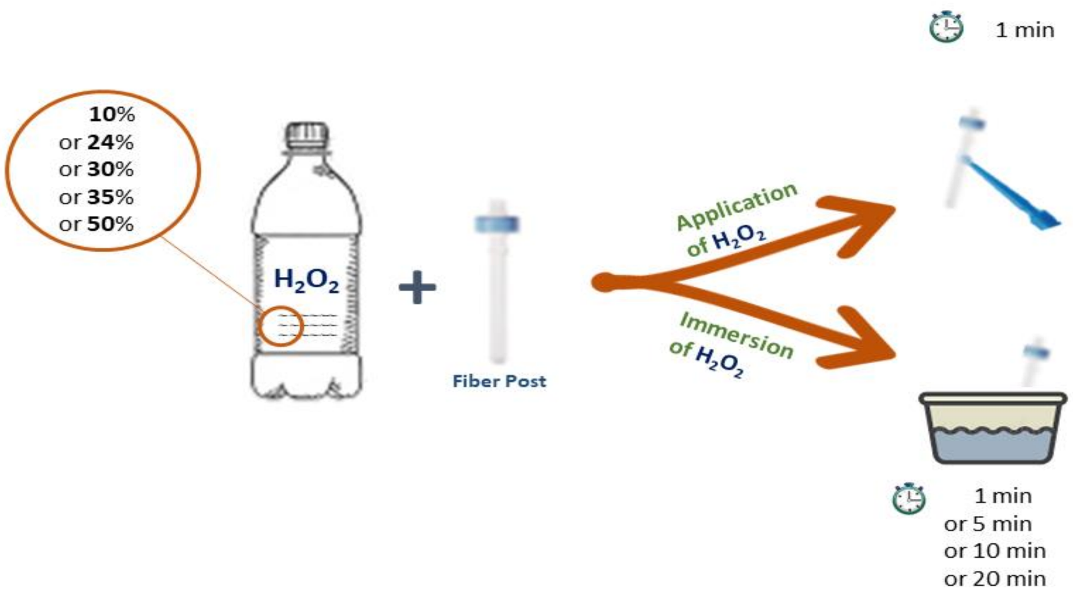


Figure 4 : H_2O_2 post surface protocol treatment

Before treatment, generally, the posts had a relatively continuous smooth surface without fiber exposure and entirely covered by epoxy resin (10,14-16,23). Sometimes, control groups have epoxy resin covering the fibers of the post and some areas with exposed fibers and/or flaws, groove or micropores (18,20,21,24). Three others studies also use fiber posts who have relatively rough surface before any treatment with epoxy resin among fibers or dislocked and cracked fibers (7,13,16).

All microscopic surface analysis was done using a SEM. The summary set of images obtained after treatment with H_2O_2 as a function of concentration and time is shown in Figure 6.

Studies using 10% H_2O_2 for 5 min, 10 min or 20 min conclude that for 10 min exposure, the fiber posts is slight exposed whereas for 20 min, dissolution of the epoxy resin is observed with exposition of superficial fibers and sometimes micro gaps (13,15,17). This induces a modification in the morphology of the surface post (17). Figure 5 shows an example of exposure to the treatment and its impacts.

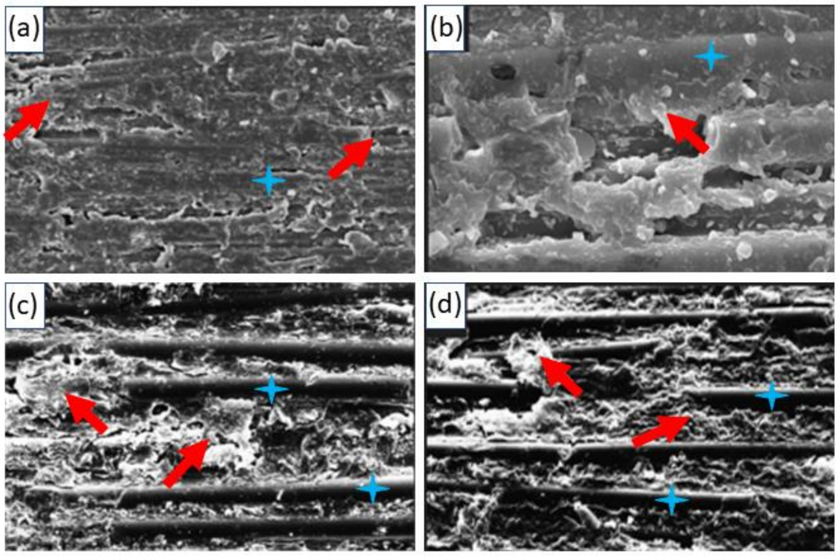


Figure 5 : Effect on microscopic surface before and after various concentration of H_2O_2 treatment. After 5 min treatment, the microscopic aspect of fiber post: (a and b) control, without surface treatment x500 and x1500 respectively, (c) 24% H_2O_2, (c) 50% H_2O_2. The matrix resin is shown in red (arrow) and the fibers in blue (stars). Microscopic images from the De Sousa Menezes M. study (10).

Concerning the concentration of 24% of H_2O_2, it is the concentration most represented in all studies with various periods times like 1 min, 5 minor 10 min. For the 1 min exposure time, the main conclusions are that the matrix is more or less partially dissolved depending on the studies which allows the fibers to be exposed sometimes discontinuous (10,15,22). This period time of 1 min produced the lowest dissolve matrix (10). Depending on the technique: immersion or application, the study of Menezes MS found a difference in the quantity of exposed fibers that was higher for the immersion method (18). Indeed, H_2O_2 application does not expose the fibers as effectively as immersion with the same concentration (18). For the highest time: 10 min, one study observed no change, the others observed a more or less superficial dissolution of the superficial epoxy resin or among the fibrils (12-14,21). Finally, the fibers are exposed resulting in a minimal surface modification and a cleaner surface (12-14,19). The later method is a feasible technique with safe product for clinical utilisation according to Naves L. et al. (13).

One study states that the 30% H_2O_2 treatment is not recommended, because shows displaced and cracked superficial fibers after 1 or 5 min of treatment but also undamaged fibers (7). Whereas in the study of Elsaka S. it was observed an effectiveness in modifying the surface of the post fibers after 5 or 10 min. Moreover, this procedure is efficient, clinically practicable and easy to perform in the author opinion (16).

Treatment with 35% H_2O_2 for 1 min was tested in three studies in application or immersion (18,20, 23). It was observed that the fibers were exposed with selective degradation of the epoxy resin which creates spaces (18,20,23). However, the study of Cadore-Rodrigues AC. observed a slight alteration of the surface without significant impact on the degradation of the resin (23). According to Menezes MS. et al., more is concentrated the H_2O_2, more effects are visible. This is why in his study there is no difference between the application and immersion technique for 35% H_2O_2 as opposed to 24% (18).

Finally only one study tested the 50% H_2O_2 concentration for 1, 5 or 10 min and the 1 min option was able to partially dissolve the epoxy resin to expose the fibers [10].

The fiber posts tend to have similar results whatever the type of fiber used in the manufacture, quartz, glass or carbon fibers.

Many authors conclude that treatments with H_2O_2 exposed the fibers without damaging or fracturing them [10,16,22].

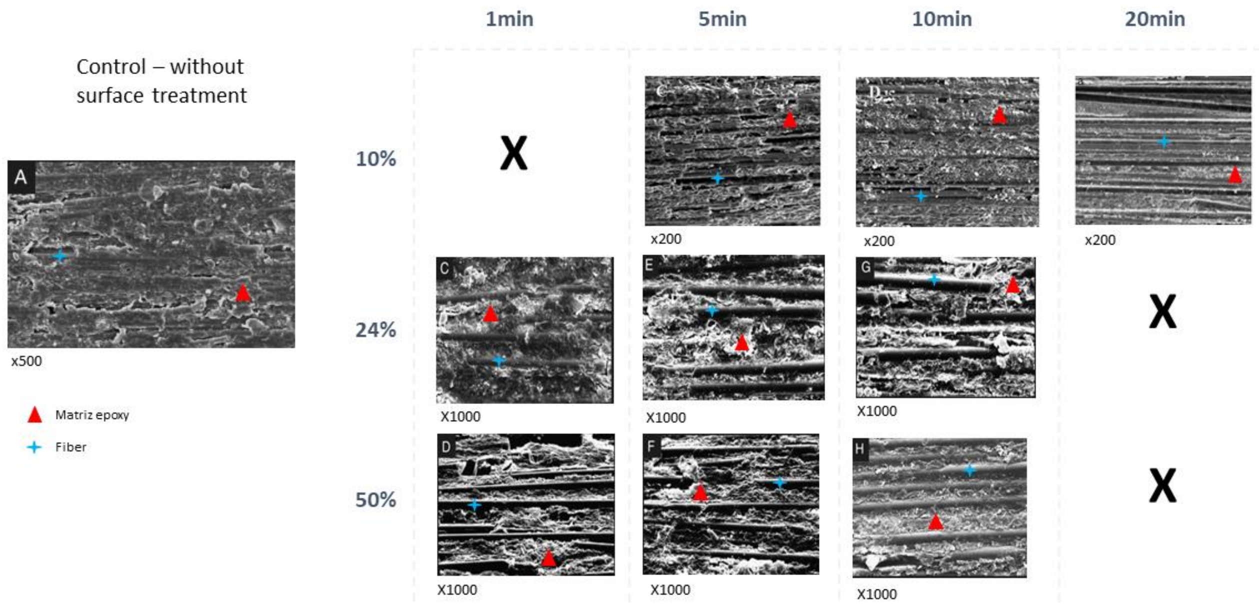


Figure 6: Microscopic alterations of resin matrix and fibers after various surface treatment with H_2O_2, variable in their concentration and time application. Microscopic images from the De Sousa Menezes M. study [10], the Elsaka S. study [16] and the Samimi P. study [17].

For the two studies investigating the change in surface chemistry, the spectrometry technique was used [20,22].

H_2O_2 treatment can changes the composition surface. Indeed treatment results in increased Si and O contents at the surfaces with an increase of Si-O-Si bonds due to the fact that the hydrogen peroxide selectively dissolves the resin to expose the fibers containing themselves Si [20]. Whereas, in the study of Prado, it has been demonstrated a reduction of functionals groups and bonds constituted by Si and CH_3 who connect epoxy resin with fiber [22].

These surface changes provoked by surface treatment can have significant effects about the contact angle with the post surface. This parameter is measured using a tensiometer and its results depend on several factors such as the chemical surface and its topography among others. A surface is considerate hydrophilic if its contact angle is less than 30°. In the study of Silva F.P., treatment with H_2O_2 maintained the hydrophobic surface of fiber post and this is probably due to the increase of roughness after treatment [(20)].

At last, in the microscopic study of the failures, authors observed in majority adhesive failures after H_2O_2 treatment in their studies. Unlike Samini P., puts this type of failure in second place [(17)]. In other studies a small portion or a majority of mixed failures are present [(14-16)]. Cohesive failure is in minority except in the Prado M. study [(16,17,22)].

In conducting this scoping review, limitations were identified regarding the selected studies.

Some studies lack information about the manufacturing process of posts, so, there are control groups with pre-existing surface roughness [(7,13,16)]. This may influence the results obtained after H_2O_2 treatment and under or overestimate the effect of the product.

Furthermore, the results obtained depend on the composition of the materials [(7,18)]. As sometimes only one type of post is evaluated, the comparison between studies is more complex.

Finally, with regard to the study of roughness. Different measuring tools are used between the studies, which makes it more difficult to compare the results. More study on roughness measurement is needed in order to validate the results of this study.

All studies are in vitro studies. Applying the protocols in clinical conditions would allow a better understanding of this treatment are realisable in real conditions and if they have the same effect on surface modification and roughness in these clinical conditions.

6. CONCLUSION

Taking into account the limitations of our study, the main conclusions are:

- Surface treatment with H_2O_2 affects the microscopic surface of the post by exposing more of the fibers through partial dissolution of its matrix resin. However, this does not have a detrimental effect on the structure of the post or the fibers. These results are visible regardless of the concentration and application time of the product.
- The H_2O_2 treatment has an effect on the surface roughness with an increase in surface roughness. Despite these positive results, more comparable studies with different times and concentrations are needed to support this conclusion.
- More studies are needed to compare the different treatments in terms of concentration and time on a post in similar conditions with different fiber reinforced post type on the microscopic aspect of the surface and the roughness of these fiber posts.

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