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Influence of the operator and clinical protocols on the cementation of fiber post : an Integrative review

Charles-Adrien Joseph Florent Buttigieg

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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Eu, **Charles-Adrien Joseph Florent Buttigieg**, declaro ter atuado com absoluta integridade na elaboração deste trabalho, confirmo que em todo o trabalho conducente à sua elaboração não recorri a qualquer forma de falsificação de resultados ou à prática de plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria do trabalho intelectual pertencente a outrem, na sua totalidade ou em partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores foram referenciadas ou redigidas com novas palavras, tendo neste caso colocado a citação da fonte bibliográfica

AGRECEDIMENTOS

Aos meus pais, Gaëlle e Adrien, que sempre estiveram presentes durante estes 5 anos e que me ofereceram esta oportunidade,

Ao meu irmão Alexandre,

À minha avó, Mano, que tem estado ao meu lado desde o início,

A toda a minha família,

À minha binomia na universidade e na minha vida durante estes 5 anos, Jeanne, desejo-lhe as maiores felicidades.

A todos os meus amigos que conheci em Portugal: Malek, Agathe, Geoffrey, Valentin, Niko, Charles, Louise ... e todos os outros.

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RESUMO

A restauração de dentes com perda significativa de estrutura é um tratamento comum na prática medicina dentária. A falta de estrutura dentária ao nível da coroa, coloca um desafio para o operador restaurar o dente de uma forma conservadora e duradoura de modo a poder recuperar a função e estética do dente. Por vezes é necessário a utilização de meios de retenção intracanalar para ajudar a retenção ao nível coronal.

Objetivo : esta revisão integrativa avalia a influência da experiência do operador na cimentação de espigões de fibra vidro, utilizando técnicas adesivas.

Método : Realizou-se uma pesquisa na base de dados PubMed, utilizando combinações de palavras-chave e abrangendo artigos entre 2011 e 2021 na língua inglesa.

Resultados : a pesquisa identificou 354 artigos, dos quais 14 foram considerados relevantes para este estudo. Variações anatómicas do sistema de canais radiculares, o controlo da humidade ou a fraca visibilidade, podem condicionar a cimentação do espigão de fibra de vidro. A conicidade criada pelo sistema de instrumentação, vai ser importante para preservar uma maior quantidade de tecido dentário são na zona pericervical. A forma e tipo de espigão a utilizar deve ser apropriado a cada anatomia canalar. A utilização de EDTA antes da cimentação pode ajudar no processo adesivo, assim como o tipo de cimento adesivo a usar pode influenciar o protocolo de cimentação.

Conclusão : existem várias particularidades em todo o procedimento, desde o tratamento endodôntico até à cimentação adesiva intraradicular que vão influenciar a qualidade e durabilidade da restauração pós endodôntica.

PALAVRAS CHAVES : Espigão de vidro, Operador, Protocolo, Preparação do canal radicular, Espessura coronal.

ABSTRACT

Restoration of teeth with significant loss of structure is a common treatment in dental practice. The loss of dental structure at the crown level makes it difficult for the operator to restore the tooth in a conservative and long-lasting way, restoring tooth function and esthetics.

Purpose : The aim of this integrative review is to evaluate the influence of operator experience in cementing fiberglass posts using adhesive techniques.

Methods : a search of the PubMed database was conducted using keyword combinations and covering articles between 2011 and 2021 in English.

Results : the search identified 354 articles, of which 14 were considered relevant to this study. Anatomical variations of the root canal system, moisture control or poor visibility may condition the cementation of the glass fiber post . The taper created by the instrumentation system will be important in preserving a greater amount of healthy tooth tissue in the pericervical area. The shape and type of post to be used should be appropriate for each canal anatomy. The use of EDTA prior to cementation can help the adhesive process, and the type of adhesive cement used can influence the cementation protocol.

Conclusion : there are several particularities in the entire procedure from endodontic treatment to intraradicular adhesive cementation that will influence the quality and durability of the post-endodontic restoration.

KEYWORDS : Fiber post, Cementation, Operator, Protocol, Post space preparation, Coronal thickness.

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List of acronyms and abbreviations

ETT- Endodontically Treated Teeth

GFRP - Glass Fiber Reinforced Posts

BS - Bond Strength

US – Ultra Sonic

EDTA - Ethylenediamine Tetraacetic Acid

ER – Etch and Rinse

SE – Self-etch

SARC – Self-adhesive resin cement

NaOCl – Sodium hypochlorite

DW – Distilled water

NS – Normal saline

SM – Smear Layer

1. Introduction

Endodontically treated teeth (ETT) restoration with significant loss of structure are an important aspect of clinical dental practice. [1] These teeth often suffer from major structural defects for several reasons: the decay process and the removal of carious tissue, previous restorations, trauma or non-conservative endodontic treatment access cavity and root canal shaping. The durability and survival of endodontic treated tooth with significant loss of coronal structure, depends on the one hand, the sealing of the root canal, which must resist bacterial infiltration apical and coronally. On the other hand, aesthetics and resistance to fracture under occlusal constraints must be assured by an effective restoration. [2]

Retention of the restorative material often requires the use of a intracanal retention. These are called coronal-radicular restorations. There are two types of coronal-radicular restorations: corono-radicular reconstructions in indirect technique, cast, which require a laboratory step (inlay-core with or without key), corono-radicular reconstructions in direct technique, made in one step with a chair side fiber reinforced matrix posts and injected resin. These types of posts were introduced in the 90's and became popular with the advent of adhesive techniques and changed the way of restoring endodontically treated teeth. [2]

The materials used for this type of restoration have physical and mechanical properties very similar to dentin, which promotes an aesthetic and functional one-piece system. The modulus of elasticity of Glass Fiber Reinforced Posts (GFRP) is so close to that of dentin that it results in a biomimetic property that allows for an almost perfect distribution of tangential forces and promotes a conservative and durable treatment. [1] Experimental studies have shown that the mechanical and functional characteristics of GFRP contribute to a reduction in root fractures due to better stress distribution in the root dentin. [3] The nature of the resin matrix of the posts and the use of resin-based cements with similar properties allow for a strong bond between the dentin and the post. The use of different types of etchants, adhesives and cements and their correct application are crucial for successful treatment. [3]

Another critical aspect that affects the majority of ETT restorations should be highlighted in order to approach coronal-root restorations with posts: the ferrule effect. It corresponds to the preservation of circular tooth structure at the cervical margin of the crown. The importance of the quantity of remaining tooth structure on the fracture resistance of endodontically treated teeth has been well studied in research, and a height of at least 1.5 mm has been suggested for the long-term effectiveness of post-endodontic restorations. [4,5] Teeth prepared without a ferrule are more likely to fracture favorably if they fail. [6]

The adhesion of fiber posts can be compromised by various factors, such as the difference in structure between coronal and root dentin, alteration of this dentin by the irrigation phases of endodontic treatment, unfavorable intra-canal C-factor, cementing protocols for different adhesives. [2,3] As these protocols are technically sensitive, the selection of the correct cement and adhesive and the experience of the dentist can affect the different treatment results.[1]

The choice of adhesive system, types of cements, influence of dentin pretreatments, protocols and operator experience can also influence quality and durability of intrararticular restorations

In this research, we will discuss the direct restoration approach protocol, employing GFRP for retention of coronal restorations, also known as chair side procedures.

2. Materials and methods

Information sources and search strategy

A literature search was performed on PubMed (via National Library of Medicine) considering such database includes the major articles in the field of dentistry and biomaterials. The following combination of search terms were applied in this study: (fiber post) AND (cementation) AND (operator), (fiber post) AND (cementation) AND (protocol), (post space preparation) AND (coronal thickness) AND (fiber post). The inclusion criteria involved studies in English , in the last teen years, between 2011 and 2021, that evaluate clinical process of adhesion of fiber post and dentin bond strength of different fiber posts system on human teeth. The exclusion criteria are those that did not meet the defined inclusion criteria, that is, studies that were not written in English, published with more than ten years, that did not report clinical protocol, did not concern fiber post adhesion and the bond strength parameter, and tested on non-human teeth. Exclusion criteria also include papers without abstract, systematic reviews, bibliography review, theses and dissertations, where the full text was not available; studies testing endodontic posts other than fiber, i.e., metal posts. Also, a hand-search was performed on the reference lists of all primary sources and eligible studies of this integrative review for additional relevant publications. Studies based on publication date were not restricted during the search process.

Study selection and data collection process

Three of the authors (JCMS, VF, CAB) independently evaluated the titles and abstracts of potentially relevant articles. The total of articles was compiled for each combination of key terms and therefore the duplicates were removed using Zotero citation manager. Selected full-length articles were individually read and analyzed concerning the purpose of this study. The following variables were collected for this review: author names; journal; publication year; root canal post types; resin-matrix cements; and the operator experience.

3. Objectives And Hypotheses

The objective of this integrative review is to evaluate the influence of the operator's experience on the success of fiber post cementation using different adhesive techniques.

The null hypothesis tested was that the efficacy of adhesive cementation of fiber posts to root canal dentin is not influenced by the operator.

Another objective of this study would be to find the best reproductible cementation protocol of fiber post.

4. Results

As shown in Fig. 1, the literature search yielded 354 publications in PubMed. A total of 91 publications were removed from eligibility because they did not match the inclusion criteria. After reading and analyzing the titles and abstracts of the scientific publications, 35 were chosen, and 228 were rejected because they did not match the inclusion criteria. Two of these articles were duplicates. Following that, the remaining 33 possibly relevant papers were examined. Nineteen of the studies were removed because they did not offer comprehensive data in context of the present study's goal. Finally, this review included 14 studies.

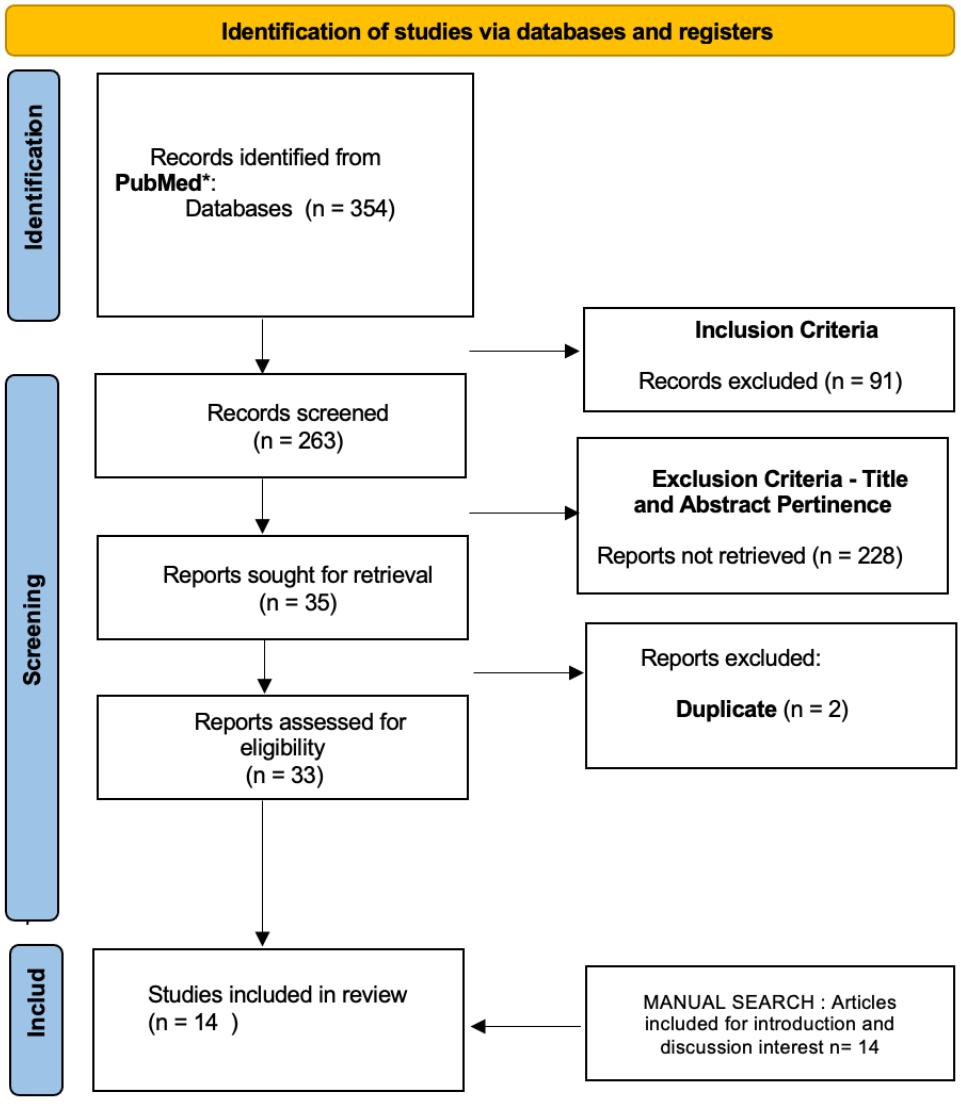

Figure 1. Schematics of the selection of studies

Regarding the publishing period, the years 2016 and 2018 reported the highest number of articles on the issue in question, with 6 articles (42,9%), followed by the years 2011 and 2013 with 2 papers each (28,6%), and lastly the years 2012, 2015, 2019, and 2020 with one article each (28,6%).

With the exception of one in vivo study , all of the studies in the publications examined are in vitro studies.

Among the 14 investigations, 4 dealt with post space preparation (29%), 4 with irrigation procedures (28%), 5 with adhesion protocols (36%), and one with operator experience's effect during cementation (7%). One article describing the operator experience was added to this work for the purpose of the research, even though it did not meet the inclusion criteria.

In those 14 trials, a total of 12 resin cement brands were evaluated, with traditional resin matrix being used in 12 experiences (52 %) and self-adhesive cement being used in 11 experiences (43 %).
The 7th generation of adhesive (self-etch system) was most commonly utilized (40%) in the included research, followed by the 5th (etch and rinse) generation (34%), and lastly by the 6th (self-etch system) and 4th (etch and rinse) generation (13%).

The major findings from the selected articles are shown in Table 1 and briefly described as follow:

- Push-out bond strength values for MTwo drill were greater (12.11±1.65 MPa) than for Largo (0.98±3.96 MPa) and calibrated drill (10.41±3.56 MPa). [7] Furthermore, the thickness of the resin cement has no effect on the push-out bond strength. [8] Indeed, Er *et al* revealed that there were no significant variations in the push-out test findings of the cervical, middle, and apical specimens of the oval and circular fiber-post groups (P>.05). Finally According to Park *et al* no significant variations in push-out bond strength were detected across posts of different sizes: S: 3.11±1.54 MPa, M: 3.39±1.4 MPa, and L: 4.15±1.75 MPa.

- The addition of 18% EDTA and 5.25 % NaOCl increased the self-adhesive resin cement's bond strength. Conversely, 18% EDTA and 5.25% NaOCl decreased the bond strength of the etch-and-rinse adhesive system, while 1% NaOCl improved the bond strength. [9]

- According to Jah *et al* the apical sections had the highest push-out strength (14.690± 298 MPa), followed by the intermediate sections (10.66 ±0.34 MPa), and finally the coronal sections (9.73 ±0.42 MPa). Marcos *et al* reported that the resin cement thickness had a significant influence on the bond strength of prefabricated glass fiber posts, with a value of 7.07 MPa for thick layers of resin cement and 7,85 MPa for thin layers, whereas Aksornmuag *et al* reported that changing the canal width had no significant effect on bond strength.

- Self-adhesive (RelyX Unicem) and standard resin cements (RelyX ARC) are viable choices for cementing glass fiber posts with satisfactory restorative survival. [10] According to Alhajj *et al*, among self-adhesive resin cements, RelyX ARC appears to be more adhesive than other cements such as GC-CEM.

- According to the study of Gomes *et al* Regardless of the cementation system chosen, expert operators showed higher bond strength means than undergraduate students, however the self-adhesive cement RelyX Unicem was not responsive to the operator's expertise. According to Simonetti *et al*, the amount of operator skill in luting fiber posts has no impact on post retention.

Autor/Year	Purpose	Teeth and method of preparation for study	Typxxe of post and canal prep	Post Surface preparation	Resin Matrix	Etching and adhesive strategie	Method of test	Results	Irrigation of post space	Main Outcome
Aksornmuag *et al.* (2011)	Evaluate the effects of C-factor and resin volume on the regional bond strength of dual-cure luting resin to root canal dentine.	12 single root premolar 6 teeth : 1,5mm ø (3 without post : G1 and 3 with post :G2) 6 teeth : 1,75 mm ø (3 without post : G3 and 3 with post : G4)	1,4mm **Snowlight Post** (12mm length) Groupe 1 : 6 premolar with 1,5mm ø cylindric FiberKor drills Groupe 2: 6 premolar with 1,75mm ø cylindric FiberKor drills Both depth of 8mm	Silane coupling bonding agent, a mixture of Clearfil Photo Bond and Clearfil Porcelain Bond Activator + air blowing.	Dual cured Resin : Clearfil DC Core Automix	Self-etch adhesive : Clearfil DC bond	Push out test	G1 : coronal 39,8MPa / Apical 20,4 MPa G2 : coronal 9,6MPa / Apical 7,3MPa G3 : coronal 36,4MPa / Apical 23,2 MPa G4 : coronal 8,7MPa / Apical 8,6 MPa	Distilled water	The high cavity configuration factor created by inserting a fiber post impaired the micro- tensile bond strength to root canal dentine, whereas the alteration of resin volume by changing the canal width had no significant effect on bond strength.
Jah *et al.* (2011)	The aim of this study was to evaluate the influence of different regions of dentin within the post space	10 maxilary incisors >14mm Crowns sectioned at CEJ.	Angelus Fiber Post Gates Gliden #3	Cleaning with 70% isopropyl alcohol	RelyX	Self-etch adhesive : Self Etch Primer+ Bonding (3M ESPE)	**Group I:** Cervical **Group II:** Middle **Group III:** Apical	Push out test (MPa) : **apical** (14.69±0.298 MPa)> **middle** (10.66±0.34 MPa) > **cervical** (9.73±0.42 MPa).	5mL of 5,2% NaOCl during post space prep, Final rinsing with EDTA 17% + 5,2% NaOCl	The best push-out strength was obtained with the apical sections, followed by middle

	on the retention of fiber posts.	Apical cone obturation #55	(desobturation) and #5 Peasoreamer				Push out bond strength test in apical-coronal diretcion (MPa)			sections and then coronal sections. More studies are required to determine the mode of failure
Zicari *et al.* (2012)	To evaluate the influence of the ferrule effect (1) and the fibre-post placement (2) on the fracture resistance of endodontically treated teeth subjected to cyclic fatigue loading.	40 upper premolar No carie, no tooth cracked, no previous endondotic treatment, no crown. Root length 15 +/-1mm Groupe a : No ferrule/No post Groupe b : No ferrule/ Post Groupe c : Ferrule 2mm/No Post Groupe d : Ferule 2mm/Posr	RelyX size 2 Fiber Post 1,4mm ø Gates Gliden #2,3,4 RelyX Bur	Clean with alcohol but no pre treatment	Panavia F 2.0 for post cementation and Supreme XT for core build	Self-etch adhesive(ED Prmier II) for post cementation and etching with 37% phosphoric acid + Optibond Kerr for composite core build	Fatigue loading test simulating 5 years of clinical function. Fracture resistance Test (N) Failure classified in 2 groups : reparable and not reparable	NF-NP : 361.5 N NF-P : 577.0 N F-NP : 785.5 N F-P : 647.6 N 2 way ANOVA significance level of 5%	2,5% NaOCl	Endodontically treated teeth with a circumferential ferrule of 2 mm height and restored without a post may survive fatigue loading as well as teeth restored with a fibre post. However, in teeth where a ferrule is not preserved, a post may eventually improve retention of the restoration.
Bitter *et al.* (2013)	The aim of the study was to investigate the effects of	150 maxilary central incisors stored in 0.5% chloramine-T for	G1 : FRC Postec - FRC post drill size 3		G1: multicore flow G2 : Core X flow	G1 : Self-etch adhesive AdheSE DC	Push out test	Bond strength was significantly affected by the	**IP 1** : 5mL distilled water (DW)1 min. **IP 2**: 5 ml of 5.25% NaOCl in	Each adhesive strategy may need to be

	various irrigation protocols (IPs) on the push-out bond strengths of fiber posts.	at least 1 yr after extraction. Randomly divided in 3 groups(n=50) G1 : Self Etch adhesive system G2 : Etch and rinse G3 : Self-adhesive resin cement	G2 : X post - drill x post size 4 G3 : X post - drill x post size 4		G3: SmartCem 2	G2 : etch and rinse XP bond G3 : self adhesive cement		luting material ($P < 0.0005$) and the IP ($P=0,001$) **ER (8.5 +/- 4.2 MPa)** and **SAR (9.2 +/- 4.7 MPa)** significantly lower bond strengths compared with **SE (16.2 +/- 6.9 MPa)** 18% EDTA+ 5.25% NaOCl increased the bond strength of the self-adhesive resin cement . **Higher** Bond strength observed with **SE** and **IP3 (1% NaOcl+PUI)** : 18,4+/-9,4 MPa	intermittent flush (2x2,5mL)+ passive ultrasonic activation (2x 30s) + rinse 5mL DW **IP 3** : 5mL of 1% NaOCL + US activation + rinse 5mL DW **IP 4** : 18% EDTA 1 min. + 5mL of 5,25% NaOCL 1 min + 5mL of DW **IP 5** : 2% CHX + 5mL DW	adapted to a specific IP.
Gomes *et al.* (2013)	To evaluate the influence of the operator experience (dentist vs student) and ce-mentation system on the push-out bond strength (BS) of fiber post to radicular dentin.	48 human maxillary central incisors No carie, no tooth cracked, no previous endodontic treatment, no crown and no severe curvature. 14mm from apex to CEJ Divided in 6 groups of 8 tooth :resulting from the combination of, operator	cylindrical with tapered end: Tenax Fiber Trans Esthetic Post space prepared up to 10mm depth from CEJ with low speed bur provided by post manufacturer 4 mm of gutta to provide apical seal	Clean with alcohol but no pre treatment	Cementation System : 1-Adper Schotch bond Multi Purpose + RelyX ARC 2- Adper Single Bond + RelyX ARC 3- RelyX U100 (Unicem)	1 and 2 etch and rinse adhesive system : Adper Schotch bond Multi Purpose (1) Adper Single Bond (2) 3- self etch adhesive cement	Push out test 0,5mm/mi n apical coronal direction	1)Higher push-out BS means (MPa) were observed for expert operators (12.9 6 7.6) in comparison with the undergraduate students (10.6 6 6.7) <u>irrespective cementation system</u> 2)With regard to the cement, higher BS means were observed for U100 (13.9 6 7.3) <u>irrespective of the operator's experience</u> 3)The Student t-test revealed that the push-out means of U100 were not affected by the	10 mL of distilled water	Higher BS means were observed for expert operators in comparison with the undergraduate students, irrespective of the cementation system used. The self-adhesive cement used (RelyX U100) was not

		experience (two levels) and cementation system (three levels)						operator's experience (p.0.05). 4)No significant difference in the fracture pattern was observed among materials in the undergraduate student group		sensitive to the operator's experience.
Tsintsadze *et al.* (2015)	To assess the effect of three different drills used for post space preparation on fiber post retention after Reciproc endodontic treatment.	30 upper incisors No carie Crown removed 1mm above CEJ	G1 : Calibrate Illusion drill G2 : Largo drill G3 : MTwo drill Illusion fiber Post #1 for each group 4 mm of gutta to provide apical seal		Grandia Core (dual)	Self-adhesive cement	Push out test	**G1 :** 10.41 ± 3.56, **G2 :** 10.98 ± 3.96, **G3 :** 12.11 ± 1.65 Failure mode : <u>Adhesive</u>: (1) P-C - 23.3%, D-C - 21.7%; (2) P-C - 20%, D-C – 10%; (3) P-C - 46.7%, D-C – 13.3%; <u>Cohesive</u>: (1) 0.0%, (2) 3.3%; (3) 0.0%; <u>Mixed</u>: (1) 55.0%; (2) 66.7%; (3) 40.0%		In conclusion, when MTwo drills were used for post space preparation after root canal treatment by Reciproc, significantly greater post retention was obtained than when utilizing Largo and calibrated drills.
Er *et al.* (2015)	The aim of this study was to evaluate whether the push-out bond strength varies between oval	18 mandibular first premolar with oval shape canal without restorations	G1 : #2 Gates Glidden bur/ D.T. #0.5 and D.T. #2 G2 : #2 Gates Gliden / oval-	Alcohol and DW in both groups	Panavia F2.0	ED Primer II Self Etch adhesive	Push out test	No significant differences were observed in terms of push-out bond strength between the oval and circular fiber posts (*P*>.05*)*	G1 : 2,5% NaOCl G2 : Water	It can be stated that resin cement ***thickness does not affect*** the

	and circular fiber posts, and to examine the effect on the resin cement thicknesses around the posts.	caries. Crown removed at CEJ. Uniform root length 14mm 2 groups (G1 et G2) for oval and circular fiber post	shaped medium- grit (76-µm) diamond-coated ultrasonic tip					The resin cement thicknesses of the oval posts were greater than those of the circular posts group in the coronal, middle and apical specimens (*P*<.05*).*		push-out bond strength
Khoroushi *et al.* (2016)	The aim of the present study was to compare the bond strength of two resin cements to root dentin +two root dentin irrigation protocols using three push-out, shear and modified pull-out tests.	96 single-rooted anterior maxillary teeth. <u>For each test : 2 groups with 2 irrigation strategies</u>	#1 dentorama fiber post ∅ 1mm	Silane	For each irrigation group : 1st half : **Duo-link** 2nd half : **BisCem** (self-adhesive resin cement)	Phosphoric acid + All bond 3 adhesive + Duo-Link	→ Push Out test →Modified pull out bond strength test → Shear bond test	<u>PUSH OUT TEST :</u> **Duo Link** + **NS** : 18.98 ± 6.15 **Duo Link** + **NaOCl** : 13.73 ± 3.90 **BisCem** + **NS** : 18.42 ± 8.72 **BisCem** + **NaOCl** : 15.70 ± 6.94	<u>2 groups for each type of test</u> → Normal Saline solution (NS) → Sodium hypochlorite 2,5% (NaOCl)	Cement type and irrigation protocol resulted in similar variations with all the tests. Push-out and shear tests exhibited more coherent results.
Marcos *et al.* (2016)	The objective of the present study was to evaluate the influence of resin cement thickness on the	30 uniradicular teeth (maxillary incisors, canines and premolars) with fully developed root apex, free of	G1 : THIN : drill #0.5, Ø 1.4 mm coronal and apical Ø 0.65 mm, + prefabricated #0.5 glass	cleaned with 37% phosphoric acid for 15 s , washed and dried.	Self-Adhesive resin cement : SeT	Self-adhesive cement	Push-out test	Bond strengths were significantly higher for CUSTOM (9.37 MPa), than for THIN (7.85 MPa) and THICK (7.07 MPa), which were statistically similar. Considering the thirds,	DW	It may be concluded that there was an influence of the resin cement thickness in the BS of customized and

	bond strength of prefabricated and customized glass fiber posts	decay, fractures or root anomalies and without endodontic treatment Root at least 14mm long	fiber post (FGM); G2 : THICK : drill #1, Ø 1.6 mm coronal and apical Ø 0.85 mm (FGM), + prefabricated #0.5 glass fiber post (FGM); G3 : CUSTOM : drill #1 and customized glass fibre post	+ silane for 60 s.				the bond strength varied in the sequence: apical (7.13 MPa) < middle (8.22 MPa) = coronal (8.94 MPa). Bond strength for 24 h storage was significantly higher (8.80 MPa) than for 90-day storage (7.40 MPa).		prefabricated glass fiber posts, and customized post showed higher BS values. The storage in distilled water for 90 days affected negatively the BS values, especially in the apical third when thick cement layers were used

Park *et al.* (2017)	The purpose of this in vitro study was to evaluate the push-out bond strength of fiber- reinforced composite resin posts to root dentin with cement layers of varying thickness.	30 premolar, single root and canal 3 groups (S,M,L) n=10	S : #2 Gates gliden + Green LuxaPost prep drill at length of 8mm. LuxaPost 1,25mm (black) M : #2 Gates gliden + Green LuxaPost prep drill at length of 8mm. LuxaPost 1,375 mm (violet) L : #2 Gates gliden + Green LuxaPost prep drill at length of 8mm. LuxaPost 1,5mm (green)		Groups S,M, L : LuxaCore Z dual	Groups S M L : LuxaBond Total Etch	**Push Out bond strength test**	**No significant differences were found in the push-out bond strength among posts of different sizes** (P>.05). S: 3.11 ±1.54 MPa, M: 3.39 ±1.4 MPa, and L: 4.15 ±1.75 MPa The differences between the **apical** (26.43 ±10.72 N) and **coronal** (31.57 ±12.03 N) areas were **not significant** (P>.05). The differences in between the **apical** (4.27 ±1.73 MPa) and **coronal** areas (2.83 ±1.08 MPa) were **significant** (P<.05).		Widening of post spaces and the consequent in-crease in cement thickness did not affect the bond strength of fiber-reinforced composite resin posts to root dentin. A significant difference was found in the mean push-out bond strength and standard deviation between the apical and coronal areas.
Bitter *et al.* (2017)	To analyze the effects of ethanol for final post space irrigation and etching mode on the bond strength of fiber posts luted with a mild	80 maxilary cental incisors Randomly divied 2 groups (n=40)	Rebilda Post drill (VOCO) + Rebila post (yellow) Depth of 9mm		Each irrigation group divided in four : Grandio Core (x3) and RelyX Unicem (x1)	-**Futurabond Universal Self etch** + Grandio Core -**Fuurabond Universal Etch And rinse** -$self etch) + Gandio Core	Push Out Test Failure Mode : 1)adhesive between dentin and luting agent	Mean Push out bond strengths significantly affected by LUTING SYSTEM but NOT by irrigation FU E&R 4,34 MPa RX 7,32 MPa FU SE 6,02 MPa F DC 6,9 MPa	Both groups : Intermittent flush technique with twice 2,5ml 1% NaOCl with passive ultrasonic activation (Irri Trip) for 30s + 5ml of DW	Mild multimode adhesives show mean bond strengths com-parable to those of a self -adhesive cement, if applied in the

	multimode adhesive (pH 2.3) as compared with a reference group using a self-adhe-sive resin cement (SAR).					-RelyX Unicem : self etch	2)between post and luting agent 3) mixed 4) cohesive within the post	FU E&R and RX signif. Higher bond compared to FU SE whereas F DC did not differ significantly from other groups	**Control group** : no further irrigation **In the 2nd group** : 99% ethanol 1min and when etch and rinse adhesive protocol was used, ethanol after acid for 15s.	etch-and-rinse mode. Within this application mode, **ethanol use had no positive effects** on BS inside the root canal, whereas self-etch adhesive strategies benefit from ethanol application in the apical part of the post space preparation.
Bergoli *et al.* (2018)	This **prospective randomized multicenter clinical trial** evaluate the survival rate of glass FB cemented with self-adhesive or regular resin cements.	Patients who needed post placement and single crowns in any tooth n=76 per groups	White Post DC system + drill whitepost	cleaned with 70% alcohol, air dried, silanized (ProSil)	**G1** : RelyX U100 **G2** : RelyX ARC	**G1** : self adhesive cement **G2** : total etch phosphoric acid 37% for 15s + single bond adhesive	Clinical study follow-up	There was no statistically significant difference in survival rates between the two strategies assessed (p=0.991), with a 92.7% survival rate for the self-adhesive cement (5 failures/70) and 93.8% for the regular cement (4 failures/65).		Self-adhesive and regular resin cements are feasible options to cement glass fiber posts, with an adequate survival of the restorations.
Jalali *et al.* (2018)	The aim was to investigate the effect of intracanal	72 single root premolars All the premolars were	#2 DT light post + drill Peeso#2 and then black, red		Panavia F2.0		Push-out bond strength test	The mean shear bond strengths of etched (53.21±12.11 MPa), MTAD (52.47±14.75 MPa) and	**G1:** 5 ml of normal saline **G2:** 5 ml of 5.25% NaOCl 15 s	Irrigation of prepared post spaces with **EDTA** or **MTAD**

	irrigants and agents on the bond strength of intraradicular fiber posts to dentin.	decoronated at 1mm coronal to the (CEJ)	and yellow DT light drills.					EDTA (49.08±10.19 MPa) groups were significantly higher than that of the control group (39.82±10.04 MPa). The difference was marginally significant for CHX group (49.8±13.57 MPa) and not significant for NaOCl group (47.15±17.64 MPa).	**G3**: 5 ml of 17% EDTA 60 s **G4:** 5 ml of 2% chlorhexidine 5 minutes **G5**: 5ml of MTAD (a mixture of tetracycline, citric acid, and detergent) for 5 minutes **G6**: Etching with 37% phosphoric acid for 15 seconds and rinsing with normal saline.	or **etching** the canals with 37% phosphoric acid **significantly increase the bond strength** of Panavia F2.0 to dentin. The increase is marginally significant for CHX. However, irrigation with **normal saline** or **NaOCl** solutions has **no positive** effect on the bond strength.
Alhajj *et al.* (2020)	The objective of this study was to evaluate and compare the push-out bond strength between different types of post cemented with different types of luting ce-ment at	48 single root human permanent teeth	**G1 (PF-G):** Parapost® Fiber LuxTM **G2 (PF-R):** Para- post Fiber LuxTM I **G3 (ES- G):** GC everSticPOST **G4 (ES-R):** GC everStickPOST Gates gliden #2 #3		**G1 (PF-G):** G-CEMTM, **G2 (PF-R):** RelyXTM Unicem , **G3 (ES- G):** G-CEMTM, **G4 (ES-R):** RelyXTM Unicem.	All groups self adhesive resin cements	Push out test	Push-out bond strength of samples at the middle level (11.38±10.31 MPa), with PF posts (11.18±9.98 MPa), and of those luted with RelyXTM Unicem cement (13.26±8.73 MPa) was higher than that of their counterparts. The PBS means of RelyXTM Unicem cement at both root levels were much higher than PBS means of G-CEMTM cement. Three-	Saline water	The type of cement had a significant effect on push-out bond strength with RelyX Unicem cement being significantly more adhesive than GC- CEM cement. How-ever, the type of post and

	different types of root level							way ANOVA test revealed a significant effect for each variable with a higher effect of cement (Sum of Squares= 1310.690; P< 0.001). No significant difference (P= 0.153) was found between the coronal and middle parts and between ES and PF posts (P= 0.058). However, a highly significant difference (P< 0.001) was found between RelyXTM Unicem and G-CEMTM cements.		root level had no significant effect on PBS
Simonetti *et al.* (2066)	Evaluate the operator's experience on the outcome of fiber post cementation using E&R adhesive systems.	15 human anterior teeth 3 groups of 5 teeth with 3 operators of different level of experience.	DT light post #1 or #2 + calibrated drills		Calibra dual cured resin	34% phosphoric acid + Prime and Bond NT	Push-out tets	**Group 1 EXPERT** : 12,44 MPa **Group 2 MODERATE :** 11,68 MPa **Group 3 UNEXPERIENCED** : 11,18 MPa The one-way ANOVA revealed that no statistically significant differences in push-out strengths existed among the three groups (p > 0.05).		Given the parameters of this investigation, the level of operator experience in luting fiber posts does not affect post retention under laboratory conditions.

Table 1. Relevant data gathered from the selected studies.

5. Discussion

Endodontically treated teeth (ETT) restoration is a challenge in dentistry due to the properties of intracanal anatomy and cementation. Endodontic therapy is commonly required for teeth with extensive loss of dental structure, and in the majority of cases, these teeth's will need the use of intra-radicular retainers and filling cores to maintain the final restoration. [1,8,9,10] The limits of traditional metallic posts such as poor stress distribution leading to unpreparable fracture or a poor biomimetics [13] have been solved by the development of Glass/ QUARTZ/ CARBON fiber REINFORCE resin matrix posts, which have enhanced the posts flexibility and achieved a comparable modulus of elasticity to dentin. [8] The long term prognosis of this therapy is dependent on the effectiveness and precision of the treatment procedure, including post cementation, and subsequent coronal restoration. A fiber post is constituted by a variable percentage of continuous fibers embedded in a polymer matrix. They cure quickly, and the matrix can be either a cross-linked epoxy resin matrix or a Bis-GMA matrix with fillers. The fiber composition gives the post exceptional tensile characteristics, while the resin matrix helps it resist compressive loads. [8,11] Our integrative review highlighted the findings of relevant prior research on the various phases of fiber post cementation procedures in order to understand where and how the operator's expertise and decisions might affect the final restoration and prognosis of endodontically treated teeth. The null hypothesis evaluated was that the operator has no effect on the effectiveness of adhesive cementation of fiber posts to root canal dentin.

5.1 Post Space

Considering the differences in root canal morphology, such as an oval shape, post space size and cement thickness may vary. The canal needs to be shaped to ensure good post adaptation and retention. As a result, increasing the cement thickness surrounding the post, as well as the kind and size of the post, may have an effect on the bonding strength between the post and the dentin. [1,10]

According to our findings, a larger post gap had no effect on the bond strength (BS) of the fiber-reinforced composite resin posts to root dentin.[1,14] These findings are similar with Er *et al* recent investigation on the bond strength of fiber-reinforced composite resin posts. The push-out BS and resin cement thicknesses of two post systems were investigated in this prior research. The push-out BS of oval and circular fiber posts did not differ significantly. [10,15] Increasing the cement thickness between the dentin and the fibrous post, on the other hand, might have negative consequences. Fernandes *et al* demonstrated defects such as pores, voids, micro-gaps, and fractures can occur in thick layers of adhesive and resin-matrix cement. This causes stress concentrations and mechanical failures, allowing oral fluids and bacteria to pass through the restoration and accelerating the degeneration of the interface and the occurrence of secondary caries. [16]

Canal post space was prepared using Gates Glidden #2 in both Er *et al* and Park *et al* experiments , and appears to be a viable choice for canal shape prior to post insertion. However, the Gates, Largo, and calibrated drills systems have their limitations while faster, these systems are quite aggressive, removing a lot of dentin and therefore significantly reducing root strength. [7] In Tsintsadze *et al* investigation's the canal shaping for post space preparation was conducted with MTwo burs (VDW, Munich, Germany) after the canal was treated with Reciproc files (VDW, Munich, Germany) for endodontic therapy. It demonstrated the efficiency of the MTwo drill in removing gutta and sealant while maintaining dentin tissue by comparing its aggressivity to Largo and calibrated drills. MTwo group had fewer dentin-cement failure than the other groups, such as Largo, suggesting improved post retention with MTwo burs. Using a 6% or 8 % taper file, the canal walls are already enlarged to allow for the insertion of a smaller taper size post while preserving adequate dental tissue to ensure root strength. Avoiding extra-removal of sound tooth structure on pericervical region can protect ETT against the fracture. It is

preferable not to prepare the canal much larger than the original canal size since the fracture resistance of the entire tooth structure would be much reduced. [7]

Long-term success restorations may take into account tissue loss at both the root and coronal levels. [5] Shaping post space causes damage of the inner root walls in addition to instrumentation damage. [17] The use of rotary devices in post-prosthetic preparation considerably increases dentin remaining wall fissures, with the increase in fissures proportional to the amount of dentin removed. [18,19] Changes in root canal morphology, including as loss of circumferential dentin, changed canal curvature, and altered root canal configuration, may affect the nature of root stress distribution, increasing fracture susceptibility. [13] Furthermore, the risks of root perforations and root fractures during root canal post insertion should not be underestimated. [7,15,18]

Zicari *et al* found that when a ferule (sound tooth structure left to reduce the danger of tooth fracturing) is not possible, inserting a post may eventually improve restoration retention. The "ferule" corresponds to the preservation of circular tooth structure at the cervical margin of the crown. [14] The importance of the quantity and quality of remaining tooth structure on the fracture resistance ETT has been very well documented in literature. A height of at least 1.5 mm has been suggested for the long-term effectiveness of post-endodontic restorations. [5,7,18] Teeth prepared without a ferrule are more likely to fracture and fail.

There is now a consensus that the residual tooth structure is critical to the survival of ETT, and criteria for ETT restoration may be changed as a result of considerable improvements in adhesive dentistry. The fundamental question should not be which style of post works better, but whether a post is required or not. Short posts have recently been examined as an effective alternative to usually lengthy posts, in accordance with the principle of minimal invasiveness of adhesive restorations. Furthermore, according to certain research, the quantity of axial dentin encompassed by the crown is more crucial than the length of the post. [13,17]

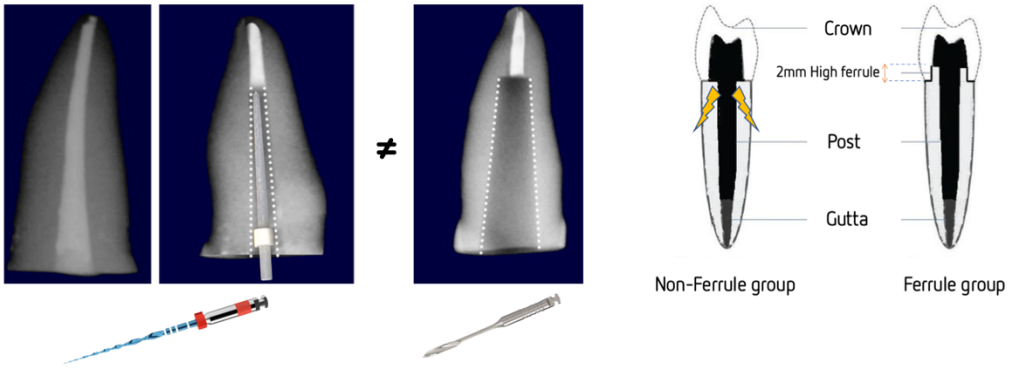

Figure 2. Schematic illustration of canal conicity and ferrule effect

5.2 Irrigation

The objective of irrigation during primary endodontic treatment is improve in the delivery of antimicrobials to the inaccessible areas of the root canal system, in order to achieve a good disinfection and preparation for the further obturation and post cementation. [20]

Mechanical instrumentation alone will not clean and eradicate all root canal pathogens during endodontic treatment, regardless of the system used (rotary or manual files). We may take in consideration that :

- instruments cannot reach the complex anatomy of the root canal system.
- in these inaccessible areas, complex biofilms that are difficult to remove can grow and accumulate.
- Instrumentation forms a smear layer charged with inorganic debris, which further limits cleaning of the canal surface dentine and obturation material adaption to the canal wall. [20,21]

We can find sodium hypochlorite (NaOCl), EDTA, chlorhexidine (CHX), or ethanol in the most often used irrigation solutions, each with its own set of properties.

Sodium hypochlorite (between 1% -5% concentration) is the most used endodontic irrigation solution. NaOCl has a high dissolving capacity as well as a broad antibacterial

spectrum. It works by braking bacterial lipid membranes and DNA tanks to Hydroxyl ions, and the high pH it produces denatures proteins. However, NaOCl cannot dissolve inorganic particles and may have an unfavorable effect on bond strengths. [20,22]

The chelating agent Ethylenediamine Tetraacetic Acid (EDTA) (17%) eliminates inorganic debris such as the smear layer (remaining sealant, gutta percha). It eliminates hydroxyapatite and non-collagenous proteins selectively, avoiding substantial changes to the natural collagen fibrillar structure.[4] It should be used in conjunction with sodium hypochlorite, not in substitute of itIt has low toxicity. 10-50% citric acid is another option. [20]

CHX at 2% has antibacterial and antifungal action against both Gram positive and Gram negative microorganisms. Its antibacterial effect is caused by the breaking of bacterial cell walls, however it cannot dissolve necrotic tissue remains. [20,21]

Another irrigant can be employed, and it appears to be useful for bonding. The ethanol wet bonding concept. The water frequently used for final canal cleaning or the application of an etch and rinse adhesive has the benefit of preserving the structure of the dentin's collagen network, allowing for greater resin infiltration. Due to the hydrophobic nature of the resin monomers, bonding issues may arise. Rinsing with ethanol appears to improve hydrophobic resin penetration and hence the formation of a higher quality hybrid layer. [13,23]

Following post-space preparation, the dentin walls are coated with a thick smear layer including debris and sealer and gutta-percha residues that may interfere with bonding to the root-canal dentin. [9] Irrigating post spaces with chemical irrigants might eliminate the smear layer and improve the adhesion to radicular dentin, trough to the formation of a hybrid layer.

The BS of fiber posts within the root canal changed significantly depending on the adhesive approach and irrigation protocols used. [24] According to Bitter *et al* 2013 's study, the irrigation protocol of using 18% EDTA and 5.25 % NaOCl provides various benefits.

First and primarily, this irrigation technique appears to efficiently eradicate the smear layer, allowing for the future formation of a hybrid layer and reducing failures between dentin and cement. EDTA is a moderate chelating agent that selectively eliminates hydroxyapatite and non-collagenous proteins while causing no major changes to the native collagen fibrillar structure. [24] However, this irrigation strategy does not appear to be appropriate for etch-and-rinse cements since it induces excessive quelation of the dentin due to the use of phosphoric acid, affecting the chemical structure of the root dentin and, as a result, the root's strength. [10,20]

The optimal irrigation for the etch and rinse system would be NaOCl 1 % + passive activation, which would result in a rise in BS. As a result, each adhesive technique may need to be adapted to a particular irrigation strategy.[10,19] Jalali *et al* also concluded that EDTA or MTAD considerably improve the BS to dentin of Panavia F2.0 (Kuraray, Tokyo, Japan) in association with a self-etch adhesive ED Primer II (Kuraray, Tokyo, Japan). However, according to Khoroushi *et al*, the use of NaOCl slightly reduces the BS of both self-adhesive cements and etch and rinse conventional cements.

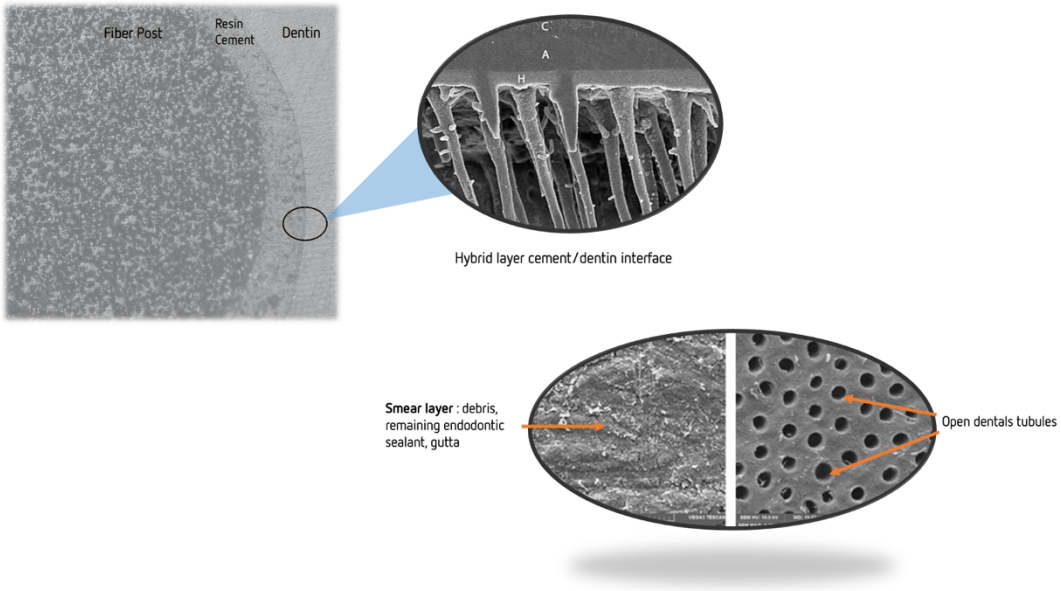

Figure 3. Root canal dentine before/after EDTA treatment and FP-Cement Resin-dentin interface with hybrid layer

Indeed, Cement type and irrigation protocols resulted in similar variations of the bond strength. [25] For self-etch cements, the combination of EDTA and NaOCl appears to be appropriate for the majority of adhesive strategies and does not require additional final irrigation such as a final ethanol rinse, which would dry out the dentin and collagen network too much and prevent the adhesive from penetrating further and forming a good hybrid layer. [23]

5.3 Adhesive protocols and operator's influence

A resin cement is a material used in a plastic phase that hardens by an addition or condensation polymerization reaction, the activation of which can be chemical (chemopolymerizable), light (photopolymerizable), or a combination of the two (dual cured).

Cements are made from composite resins, which are organic resin matrices reinforced with fillers. The organic phase is mostly made up of Bis-GMA and polyurethane derivative matrix resins. These are the composites chemically active components. The fillers (or inorganic phase) are bonded to the matrix by a silane and therefore improve the mechanical and physical properties (compressive strength) of the resins. Composite resin don't have bonding proprieties to dental tissue. The utilization of resin cements requires the use of an adhesive system. The main steps of an adhesive system are first the orthophosphoric acid etching, which removes the smear layer and opens the dentin microtubule orifices, then the primer, which keeps the exposed collagen network sufficiently porous; and finally the adhesive resin, which penetrates the tubule to create the resin tags and the hybrid layer. The etching procedure initially causes micro-roughnesses and micro-porosities, which are subsequently penetrated by the monomers, forming an adherent and perfectly sealed interphase between the tooth tissue and the restorative biomaterial following polymerization. As a result, the adherence is both mechanical and chemical. [2,11,12]

Enamel is mostly made up of mineral (calcium hydroxyapatite crystals), and very few organic components and water. Whereas dentine contains more organics components (18%) and water (12%) The functional groups of certain monomers are likely to create primary chemical connections, according to Yoshida *et al*'s study, especially with the

calcium in hydroxyapatite. Adhesion to enamel appears to be more durable and stronger than adhesion to dentin, which is more organic and humid. [26]

The adhesion of fiber posts can be compromised by various factors, such as the difference in structure between coronal and root dentin (higher quantity of tubules in apical part of the root, unfavorable intra-canal C-factor, cementing protocols for different adhesives. As these protocols are technically sensitive, the selection of the correct cement and adhesive can affect the different treatment outcome. [13] Considering the high C factor, which is defined as the ratio of the resin's bonded to unbonded surfaces. When polymerization shrinkage occurs under confinement, as when bonding inside a root canal, contraction stress develops inside the material and can cause failures in the resin-dentin interfacial adhesion. [18] The C factor in the canal is exceptionally high, among 200, thus Inserting a fiber post into the root canal significantly reduces the percentage of cement that contracts , enhancing the micro-tensile BS to root canal dentine. [16,21]

Convencional resin cement, on the other hand, might be an option and has demonstrated strong BS, although it has significant limitations. [10,11,16] Those are classified as total-etch (etch-and-rinse strategy) and self-etch (self-etch primer).

Etch-and-rinse adhesive techniques associated with dual cure cements eliminate the smear layer and provide improved dentin hybridization. However, this method requires the use of a moist dentin substrate, which is extremely difficult to regulate inside the canal area. Furthermore, the studies demonstrates the limits of light transmission decreasing via the root. [8,10,12,13] Furthermore, a little amount of adhesive could remain in the canal space, resulting in incompatibility between the uncured acidic monomer and the chemically activated resin in the apical section, resulting in lower tensile properties. [8,11]

In consideration of this issue, self-adhesive resin cements appear to be a viable option for minimizing clinical time and the incidence of dentin hybridization errors. [10] Self-adhesive resin cements, such as RelyX Unicem (3M ESPE, Saint Paul, USA), do not require any dentin preparation before cementation, and are widely used in investigations reported [1,10–12,23]. The demineralization process provided by the multifunctional phosphoric acid methacrylate material contents, followed by infiltration of the cements into the tooth structure and formation of chemical bonds with the hydroxyapatite structure of the tooth, may result in the formation of a strong hybrid layer prior to good bonding. [1,3,9,18,24] It also provides for greater humidity control, fewer stages, and lower contraction stress when

attaching to root walls, and its dual polymerization properties allow it to cure completely even in tight locations where light curing cannot reach. [13]

Because the treatment is technically difficult, the operator's experience may have a direct impact on the quality of this restorative procedure, as shown in Fig. 4. Indeed, it was observed before that several specific factors might influence the ultimate outcome. The root canal space's variations and special characteristics , such as a high C factor, which results in increased polymerization stress, problematic moisture management, difficult light curing control, or poor access and view of the working area, made procedure technically delicate. [1,3,7,8]

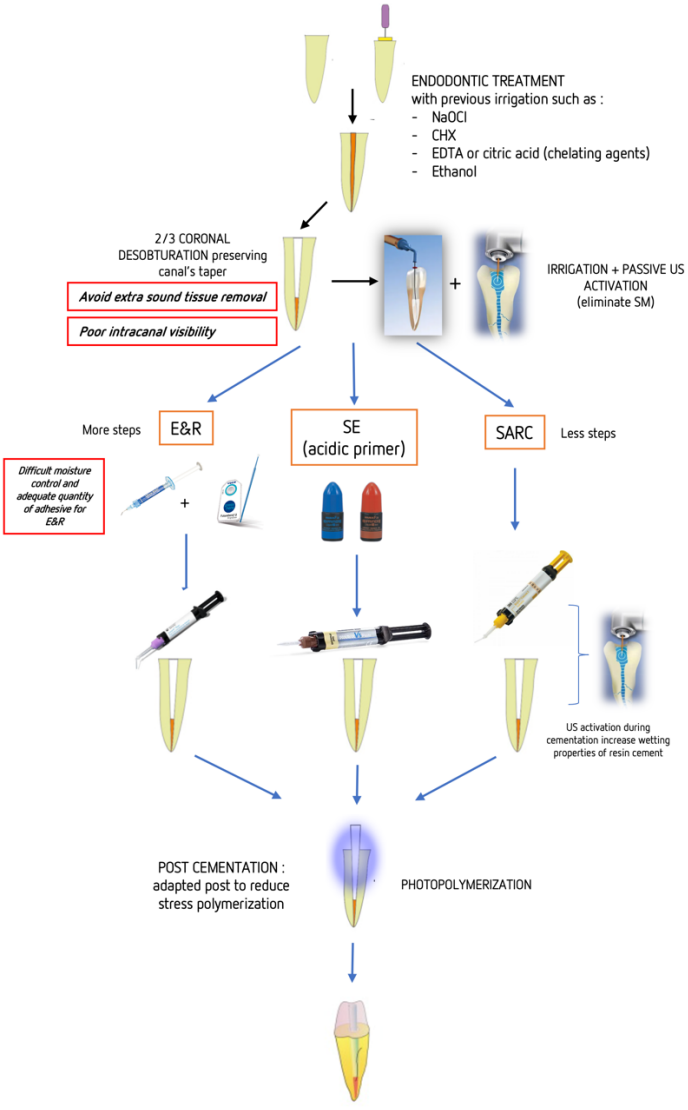

Figure 4 - Cementation steps of GFRP with various adhesive system and critical steps

According to Gomes *et al* investigation's, expert operators had greater BS means than undergraduate students, regardless of the cementation system utilized. In contrast, Simonetti *et al* found no statistically significant variation in retention assessed for fiber posts luted by operators with different degrees of clinical competence for convencional etch and rinse resin cement such as RelyX ARC (3M ESPE, Saint Paul, USA) or Panavia F2.0 (Kuraray, Tokyo, Japan). However, Gomes *et al's* investigation showed that, unlike traditional resin cement (3M ESPE, Saint Paul, USA) the self-adhesive cement employed (RelyX U100-3M ESPE) was not sensitive to the operator's experience. [8,18]

Regarding cementation protocols, it has been observed that the ultrasonic (US) cementation process alters the thixotropic characteristics of the luting agents, resulting in a reduction in the viscosity of the resin composites. This may improve in the wetting and adaption of densely packed resin cements to the tooth substrate. Cantoro et al. reported a rise in BS while activating the resin with a US device. [27]

In the Caceres et al investigation, the US device created voids predominantly at the apical section of the posts, which contributed in the creation of gap regions. The use of an US device (Smart-sonic; FGM Dental Product, Brazil) did not provide an advantage in the cementation of fiber posts, as it did not reduce the percentage of voids or the creation of gaps during the cementation operation in this present study. [16,28]

There are certain limitations to this integrative review. Language restrictions may have contributed to the loss of some potentially relevant articles. However, English is unquestionably the worldwide language, and the majority of the articles discovered throughout the research were written in that language. As a result, we see this parameter as the least problematic and conditioning.

Because we employed a single database (PubMed), the search approach may have eliminated pertinent items. When searching the bibliographic references of the selected articles, this difficulty was minimized.

In terms of the included studies, the majority of published publications are based on in vitro research. The data does not provide a perfect forecast of whether the fiber posts' in vitro performance is the same as their in vivo performance. [10] As a result, in vivo investigations are required to determine whether the favorable performance of the treated fiber posts is comparable to the performance in vitro. [1,3]

Future research with larger study groups is also essential for further investigation of this area of restorative dentistry in order to provide solid and accurate guidelines in this regard. [10]

Finally, several characteristics must be considered, such as the variety of materials (adhesives systems, resin matrix, fiber post...) and their association within a proper protocol. [3]

6. Conclusion

Previous research's important findings on the several processes of fiber post cementation and the influence of the operator on those technical steps have been reported in this integrative review. The following are the key findings of the examined studies :

- The conservative approach of shaping the post space by conserving and using prior endodontic file conicity has proven the best outcomes in terms of root resistance as well as preserving a tooth's ferrule.
- Although the thickness of the resin cement has no effect on bond strength, filling the majority of the post space with a suitable adapted post should help to reduce polymerization stress.
- Using EDTA before post-cementation may promote the formation of the hybrid layer, which is required for optimal bond strength may improve the creation of the hybrid layer essential for a good bond strength
- Self-adhesive resin cements appear to be less technical dependent, with fewer processes and appropriate bond strength values. These cements allow to get rid of specific root canal conditions such as high C factor, moisture management, light curing dispersion, or poor visibility.
- An appropriate individualized protocol based on the operator' and canals needs should be prepared by following the manufacturer's instructions and training until adequate integration of the various processes.

Further studies are needed to determinate how fiber reinforced composite posts and resin-matrix cements' behave with different treatment protocols and also more in vivo studies with more levels of experience.

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