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Performance of Fiberglass Posts Versus Fiber-Reinforced Resin Composites in Endodontically Treated Anterior Teeth Without Ferrule: A Systematic Review

Keywords

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ABSTRACT

Objective: To perform a systematic review of in vitro studies examining endodontically treated anterior teeth restored with fiberglass posts versus composite posts reinforced with: polyethylene fibers (Ribbond), fiber-reinforced resin (everStick) and composite resin (everX). Methods: The search was performed using PubMed, Scopus, Web of Science and LILACS. The studies were selected by two independent reviewers. To assess the risk of bias of each study, the QUIN tool was used. We analyzed the data using a narrative synthesis. Results: Five articles were retained for final analysis. The risk of bias was moderate to high. Most studies reported non-catastrophic failures. With 72 non-catastrophic failures for the glass fiber group and 60 for the fiber-reinforced resins. Catastrophic failures were more prevalent in fiber-reinforced composite, especially in the Ribbond-treated group. Conclusion: Within the limitations of this study, the use of fiber-reinforced composites as custom intracanal posts is still questionable, with controversial results. It is not possible to establish the superiority of one approach over the other in endodontically treated anterior teeth without ferrule. Clinical relevance: It was not possible to identify a superior performance among the approaches analyzed for the restoration of endodontically treated anterior teeth without ferrule.

INTRODUCTION

Loss of tooth structure can occur due to factors such as abrasion, erosion, carious lesions, age of the patient or trauma.[1,2] However, the main reasons are related to extensive cavity preparations and endodontic treatment.[1,3–5] When significant reduction of tooth structure is performed, it can result in increased susceptibility to fracture.[6,7] Therefore, endodontically treated teeth usually present a loss of structural integrity,[8,9] presenting a higher risk of biomechanical failure than vital teeth.[6,8–10] In addition, it has been reported that when the dental pulp is removed, teeth lose a protective feedback mechanism, which may also contribute to tooth fracture.[11]

Clinical evidence of the placement of posts in the roots of damaged teeth has been available for about 250 years.[12] For this reason, clinicians have opted for this treatment, which consists of placing an intraradicular post to improve the retention of a crown.[13,14] Posts and core build-ups are used to protect the tooth against intraoral stresses by distributing forces within the root dentin,[15,16] also generating retention for the core build-up, whose function is to replace the lost coronal structure in order to retain the restoration.[15,17]

The treatment of endodontically treated teeth, however, has undergone significant changes in the last 20 years and most of them are associated with the preservation of tooth structure.[18] With the advancement of adhesive technology, it is possible to condition existing residual tooth tissue to achieve better adhesive retention[18,19] relying much less on macromechanical retention.[18,20] In addition, the use of materials such as resins and fibers has shown promising results in terms of performance and fewer biomechanical failures.[18,21]

Lately, minimally invasive approaches, or so-called biomimetic approaches, have gained popularity, even allowing restorative techniques without the use of posts.[22] In this line, fiber-reinforced composites (FRC) have been considered as alternatives to posts, whether metal, carbon fiber or fiberglass.[23] These materials have been noted for having an elastic modulus similar to that of dental tissues, allowing a favorable biomechanical behavior.[24] Accordingly, the use of composite resin together with less rigid posts and/or fibers might become an effective technique to restore endodontically treated teeth.[25] However, there is currently no consensus in the literature demonstrating that these approaches are superior to the use of intraradicular posts.[26]

Therefore, the aim of this study was to systematically answer the research question “In endodontically treated anterior teeth without ferrule, does the restorative approach with fiber-reinforced resin composites as polyethylene fibers (Ribbond), fibers reinforced resin (everStick) and composite resin (everX) present a superior performance compared to anterior teeth treated with intraradicular fiberglass posts?”

METHODS

PROTOCOL AND REGISTRATION

This protocol was developed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA P).[27] The protocol has been registered in the International Prospective Register of Systematic Reviews (PROSPERO) under number: CRD42023437451 and is publicly available. The report of this article follows the guidelines of the PRISMA checklist (Appendix 1).

ELIGIBILITY CRITERIA

The research question was formulated based on the PICOS acronym (Population, Exposure, Outcome and Studies), in which: P) Anterior human teeth (central incisors, lateral incisors and canines) treated endodontically that did not have a clinical crown and therefore did not present a ferrule effect; I) Restorative approach with fiber-reinforced composites posts: polyethylene fibers (Ribbond), fibers reinforced resin (everStick) and composite resin (everX); C) Restorative approach with fiberglass posts; O) Resistance to fracture and failure mode; S) *In-vitro* Studies.

The exclusion criteria were as follows: (1) Studies that included teeth with a ferrule; (2) Studies that do not specify the region (anterior/posterior) that was studied; (3) Studies involving only posterior teeth; (4) Studies involving other types of posts (other than fiberglass posts); (5) Studies that do not include the intervention of interest; (6) Studies that used non-human teeth; (7) Immature teeth; (8) Studies that did not use posts or fibers; (9) Studies focused on any other type of mechanical property (other than fracture resistance); (10) Studies that report only failure or survival mode; (11) Studies with duplicate data from another included study; (12) Systematic reviews, Finite Element Studies, Reviews, letters, books, conference abstracts, cases and controls, case reports, case series, opinion articles, technical articles, posters and guidelines; (13) If the full text is not available, even after attempting to contact the corresponding authors (three attempts in a 3-week period).

INFORMATION SOURCES

A comprehensive search strategy was carried out in scientific databases to find relevant studies on the topic. A systematic search was carried out in the following databases: Latin-American and Caribbean Literature in Health Sciences (LILACS), PubMed/Medline, Scopus and Web of Science. The search for additional literature was conducted through Google Scholar, ProQuest Dissertation and Theses Global, consultation with experts and also manual searches of bibliographies of included studies. All search strategies used are presented in Appendix 2. All references were imported and organized using the software Zotero 6.0.30® (USA).

SELECTION PROCESS

Two independent reviewers (J.F.C and D.E.B) selected the included articles in two phases. Firstly (phase-1), the two reviewers evaluated the titles and abstracts according the eligibility criteria. Secondly (phase-2), the same reviewers have read full-texts and selected articles by the same criteria as phase-1. Then, they crosschecked all the information found. In case of disagreements, the third reviewer (S.K.G) participated before a final decision of both phases. If important data for the review was missing or unclear, an attempt was made to contact the study corresponding author to resolve or clarify the problem. To carry out these steps, the electronically available application, Rayyan® (Qatar Computing Research Institute, Data Analytics, Doha, Qatar), was employed to facilitate collaborative screening processes.[28]

DATA COLLECTION PROCESS AND DATA ITEMS

Two independent reviewers (J.F.C and D.E.B) collected data from the selected articles into a Microsoft Excel® table. Once all the important data of each article were found within the table, discrepancies were discussed and resolved with the third reviewer (S.K.G).

From the studies found, the following data were collected: Study characteristics (authors and year of publication); Characteristics of the studied population (teeth and total sample); Data from outcomes (control group, test group, mean failure loads, failure mode, cement, mechanical testing, force angulation) and main conclusions. If any important data was unclear or missing, it was requested from the corresponding authors, enabling the retrieval of unpublished data.

STUDY RISK OF BIAS ASSESSMENT

Risk of bias of the *in vitro* studies was assessed using the QUIN tool.[29] Two authors (S.K.G and T.R) reviewed the included studies and assessed the following criteria established by the tool: Clearly stated aims/objectives; Detailed explanation of sample size calculation; Detailed explanation of sampling technique; Details of comparison group; Detailed explanation of methodology; Operator details; Randomization; Method of measurement of the outcome; Outcome assessor details; Blinding; Statistical analysis and Presentation of results. Each criterion was judged with the following possibilities: adequately specified (score 2); inadequately specified (score 1), not specified (score 0) and not applicable. The studies were classified as high, moderate, or low risk of bias (>70%=low risk of bias, 50% to 70%=moderate risk of bias, and <50% =high risk of bias). The final score was calculated in the following way: Final score = (Total score×100) / (2 × number of criteria applicable).

EFFECT MEASURES AND SYNTHESIS METHODS

Due to the high level of heterogeneity between the studies, it was not possible to conduct a meta-analysis. The results are described in a narrative format, with the main results shown in a color-coded table.

RESULTS

STUDY SELECTION

Based on the selection process, 2,174 articles were found, of which 262 were gray literature. At the Zotero 6.0.30® (USA) application, duplicate articles were eliminated, leaving a total of 1,111 articles. Subsequently the analysis of the titles and abstracts was carried out, obtaining 140 articles included in the phase-1. Using the inclusion and exclusion criteria, 5 articles[30–34] were included for the development of this systematic review (*Figure 1*). Only *in vitro* studies and anterior teeth were taken into account. A list of the excluded articles is available in Appendix 3.

STUDY CHARACTERISTICS

The main characteristics of the studies are listed in Table 1. All included studies are *in vitro* studies and were conducted in the following countries: United States of America (EUA),[30] Canada,[31]

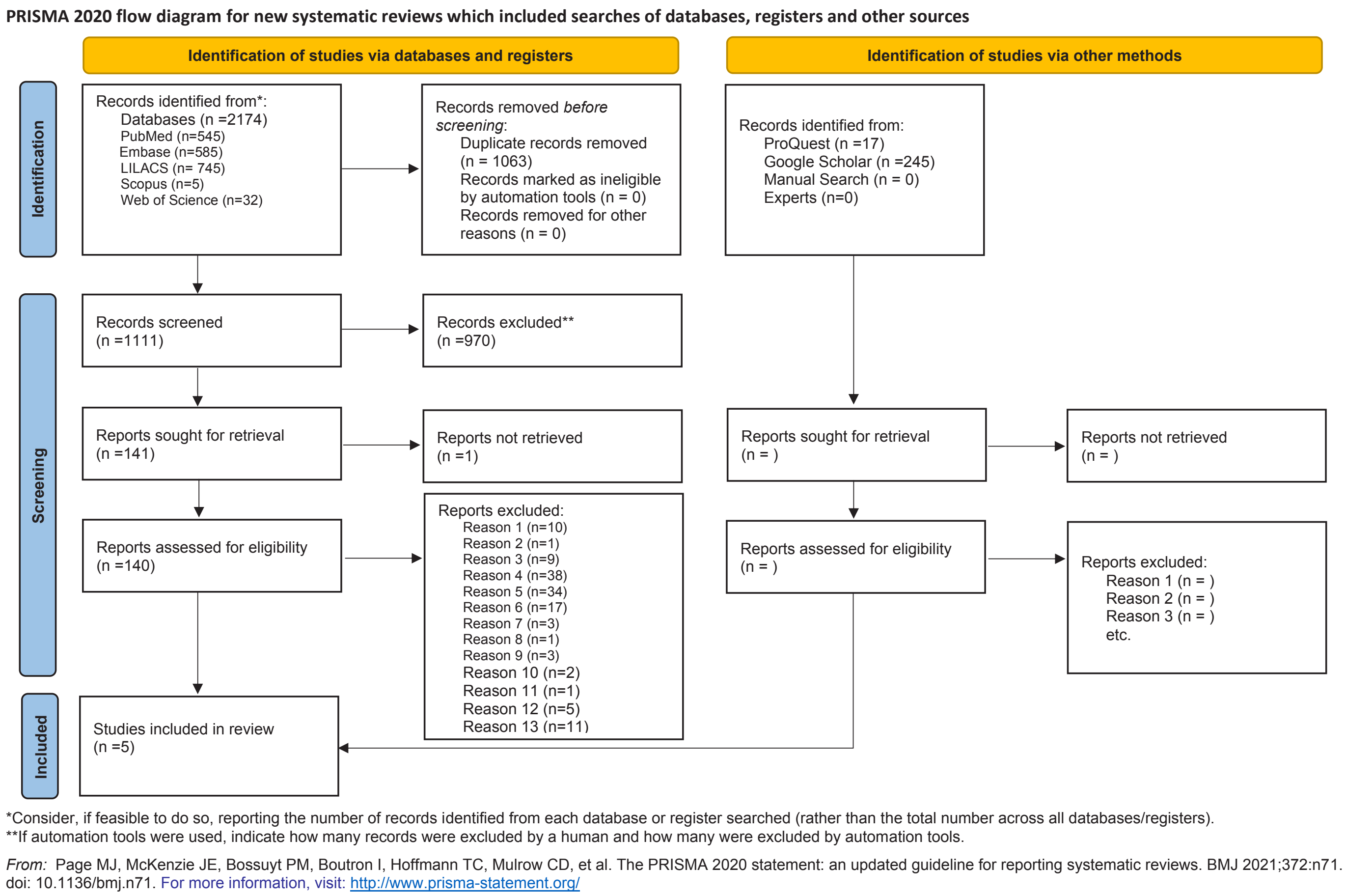

Figure 1: Flow Diagram of Literature Search and Selection Criteria.

Table 1. Summary of descriptive characteristics of included articles (n=5).

Author, year, country	Teeth Sample	Control Group	(Newtons) (±SD)	Failure Mode			Test Group	Mean failure loads (Newtons) (±SD)	Failure Mode (Test Group)			Cement	Cross-head speed of fracture resistance test / Force Angulation	Conclusion
				Root Fracture	Core Fracture	Core Dislodgment			Root Fracture	Core Fracture	Core Dislodgment			
Newman M et al., 2003 USA	Maxillary Central Incisors 40	Narrow canal - Dentalus Luscent Anchors 1,6mm Ø (10)	12.9 ± 1.64 kg	0	10	0	Narrow canal - Ribbond standard 1,6mmØ (10)	4.55 ± 1.49 kg	0	0	10	Flow-It (Pentron; California, USA)	0.5 mm/min 45	In spite of the significantly lower load values achieved for all fiber-reinforced composite posts tested, their perfomance may be considered favorable beacuse none of the estethic post failures in this study resulted in root fracture. The use of these new generation post systems is promising; however, lomg-term, controlled clinical trial are required to evaluate their performance.
		Flared canal - Dentalus Luscent anchors 1,6mm Ø (10)	12.87 ± 2.69 kg	No exix0	10	0	Flared canal - Ribbond standard 2,0mmØ (10) Flared	12.87 ± 3.54 kg	0	0	10			
Abo El Ela, Atta O & El-Mowafy O, 2008 Canada	Maxillary Anterior Teeth (central, lateral, canine) 32	ParaPost Fiber White + SE Bond (8)	1,548.5 ± 290.0 N	2	6	0	everStick post + SE Bond (8)	1,711.7 ± 516.7 N	1	7	0	Panavia-F	2 mm/min 135	The use of a new fiberglass post (the everStick post) was associated with the highest mean fracture strenght fot the maxillary anterior teeth, regardless of the bondig agent used, while the satinless steel post was associated with the highest average fracture strenght fot the maxillary anterior teeth, regardless of the bonding agent used.
		ParaPost Fiber White + Xeno-III (8)	1,171.3 ± 296.9 N	1	7	0	everStick post + Xeno-III (8)	1,825.7 ± 527.3 N	1	7	0			
Yunzhi F & Yachong W, 2009 China	Maxillary Central Incisors 10	Glass Fiber Posts	202.10 ± 12.20 N	0	0	5	Plastic Fiber Reinforced Resin (Everstick)	214.35 ± 10.72 N	0	0	5	Zinc Phosphate	0.5 mm/min 130	For restoration of residual dental root with horn-shaped orifice, fiber-reinforced composites posts and pre-fabricated fiberglass posts present advantages in residual root protection.
Jindal S et al., 2012 India	Maxillary Central Incisors 60	Glass Fiber Post (Fibrapost) 10mm (15)	740.21 ± 29.87 N	3	12	0	Ribbond Fiber Post-10mm (15)	216.93 ± 53.39 N	14	1	0	Monocem	0.5 mm/min 130	The use of polyethylene fiber reinforced composites as customized intracanal posts is questionable and needs further research. Glass fiber posts can efficiently increase the fracture resistance of an endodontically treated tooth but the determination of optimal post length is also essential.
		Glass Fiber Post (Fibrapost) 5mm (15)	425.18 ± 42.73 N	12	3	0	Ribbond Fiber Post-5mm (15)	299.62 ± 53.42 N	15	0	0			
Doshi P, et al.,2019 India	Maxillary Central Incisors 40	Glass Fiber Post (Coltene Whaledent) (20)	343.89 ± 10.44 N	1	0	19	everStick Post (E-glass fiber) (20)	452.32 ± 14.35 N	0	0	20	Rely X Ultimate	2 mm/min 135	The E-glass fiber post showed a significantly higher fracture resistance than the glass fiber or carbon fiber posts, which may be attributed to its minimal preparation of post space, lower modulus of elasticity. There was no catastrophic failure in this group. The mode of failure of the samples was considered favorable as it can be repaired.

Legend: et al = and others; USA= United States of America; SD = Standard Deviations; N = Newtons ; kg = kilograms; mm= millimeters; min= minutes; SE= Self Etch.

China[32] and India.[33,34] In the selection of studies for this review, through databases, only those that provided information about the fracture resistance in anterior teeth that have been endodontically treated and their subsequent reconstruction with fiberglass posts versus polyethylene fibers (Ribbond) and fiber-reinforced resin (everStick) were included. No studies were found comparing fiberglass posts with composite resin (ever X).

RISK OF BIAS IN STUDIES

In this study, 4 studies were considered with moderate risk of bias and 1 study was considered with high risk of bias. Of which, the items that presented the highest risk of bias in each article were: the detailed explanation of the sample size calculation, the details of the operator, the details of the outcome evaluator, and blinding. Table 2 contains the complete QUIN Tool scores.

RESULTS OF INDIVIDUAL STUDIES

Newman *et al*.[30] used 90 maxillary central incisors, which were divided into 8 experimental groups and 1 control group, each with 10 specimens. In this study, in order to promote a direct comparison of glass fiber posts with fiber-reinforced composite posts. We decided to include only 4 interest groups (40 specimens) in the results in order to meet the objectives of this study. Included were 10 specimens belonging to the group of narrow canals with fiberglass posts, 10 specimens of Ribbond fibers, 10 specimens of flared canals with fiberglass posts and 10 specimens of Ribbond fibers. The samples were subjected to a universal testing with cross-head speed of 0.5 mm/min and force angulation of 45º. The authors conclude that in spite of significantly lower load values, the use of fiber-reinforced composite posts is promising and may be considered favorable because the absence of root fracture. However, many more long-term clinical trials are required for a better evaluation of their performance.

Abo El-Ela *et al*.[31] divided 32 maxillary anterior teeth into 4 groups of 8 specimens each. As control group: fiberglass post + SE Bond; and fiberglass post + Xeno-III. As a study group: everStick post + SE Bond; and everStick post + Xeno-III. The fracture resistance of the specimens was determined by a universal testing machine with cross-head speed of 2 mm/min and force angulation of 135º, resulting in the everStick post obtaining high resistance, regardless of the adhesive agent used.

In the study by Yun-zhi *et al*.[32], 10 maxillary central incisors were used, 5 fiberglass posts and 5 everStick posts were placed, being subjected to a universal testing machine with cross-head speed of 0.5 mm/min and force angulation of 130º to test its fracture resistance. The authors concluded that for restoration of residual dental root with horn-shaped orifice, fiber-reinforced composites posts and pre-fabricated fiberglass posts present advantages in residual root protection.

In the Jindal *et al*. study[33] the fracture resistance of 60 maxillary central incisors were measure, divided them into 4 groups of 15 specimens each and subjected them to a universal testing machine with cross-head speed of 0.5 mm/min and force angulation

Table 2. QUIN Tool Scores of *in vitro* studies.

Study [Ref.]	Clearly stated aims/ objectives	Detailed explanation of sample size calculation	Detailed explanation of sample technique	Details of comparison group	Detailed explanation of methodology	Operator details	Randomization	Method of measurement of outcome	Outcome assessor details	Blinding	Statistical analysis	Presentation of results	Score	%	Risk of Bias
Newman et al. 2003	2	0	1	2	2	0	0	2	0	0	1	2	12 (100)/24	50	Medium
Abo et al. 2008	2	0	1	2	2	0	1	2	1	0	2	2	15 (100)/24	62.5	Medium
Yunzhi et al. 2009	1	0	1	1	1	0	1	1	0	0	1	1	8 (100)/24	33.33	High
Jindal et al. 2012	1	0	2	1	2	0	1	1	1	0	2	2	13 (100)/24	54.16	Medium
Doshi et al. 2019	2	0	1	2	2	0	0	2	1	0	1	2	13 (100)/24	54.16	Medium

Specified (Score=2); Inadequately Specified (Score=1); Not Specified (Score=0); Not Applicable of 130º. In the group 1 were placed fiberglass posts of 10 mm, in the group 2 were placed fiberglass posts of 5 mm. In the test group were placed 10 mm polyethylene fiber group and 5 mm polyethylene fiber posts. The group of fiberglass post showed significantly higher fracture resistance. The authors concluded that fiberglass posts can efficiently increase the fracture resistance of an endodontically treated tooth but the determination of optimal post length is also essential. They also concluded that the use of polyethylene fiber reinforced composites as customized intracanal posts is questionable and needs further research

Doshi *et al.*[34], evaluated the fracture of the treated teeth endodontically (maxillary central incisors) restored with fiberglass posts (20 samples) and everStick posts (e-glass) (20 samples) mounted in a test block and subjected to static load up to fracture with cross-head speed of 2 mm/min and force angulation of 135º. The study showed that the group of e-glass posts had a fracture resistance significantly greater than the fiberglass post and that the main fracture mode was favorable since core debonding was reported in all fiber posts, therefore, allowing for repairments.

RESULTS OF SYNTHESES

Table 1 provides detailed information on the interventions and comparisons retrieved from the studies. FRC posts groups were considered as test groups (Ribbond; Ribbond Inc, USA / everStick, StickTech, Finland), while conventional fiber posts were considered control groups. Three studies had four study groups,[30,31,33] being two interventional and two comparisons; while two studies presented one interventional and one comparison study groups.[32,34] In summary the current systematic review reports the result of two treatment arms (eight conventional fiber posts and eight FRC posts) in the five included *in-vitro* studies.

FRACTURE RESISTANCE

All included studies reported on fracture resistance.[30–34] A summary of the results can be seen in Table 3.

Newman M *et al*, 2003[30] compared two clinical situations, a narrow and a flared canal. While in the flared canals both conventional fiber posts and FRC posts performed similarly, in the narrow canals, the fracture resistance of the conventional fiber posts was superior to that of those restored with FRC posts.

Abo El Ela, Atta O and El-Mowafy O, 2008[31] tested different adhesive strategies for both the test and control groups. The conventional fiber post groups reported lower fracture resistance than the groups restored with FRC. Similar results were reported by Yunzhi F and Yachong W, 2009[32] and Doshi P, *et al.*, 2019[34] where groups restored with FRC posts reported higher fracture resistance values.

On the other hand, Jindal, S. *et al.*, 2012[33] reported lower fracture resistant values for the FRC posts groups. Overall, Ribbond performed inferior in terms of fracture resistance when compared to the conventional fiber post groups. EverStick, conversely, demonstrated higher values than conventional fiber posts.

Table 3. Summary of results of Resistance of Fracture.

Author and year	Control Group	Mean failure loads (±SD)	Test Group	Mean failure loads (±SD)
Newman M et al., 2003	Narrow canal - Dentalus Luscent Anchors 1,6mm Ø	12.9 ± 1.64 kg (126,42 N) *	Narrow canal - Ribbond standard 1,6mmØ	4.55 ± 1.49 kg
	Flared canal - Dentalus Luscent anchors 1,6mmØ	12.87 ± 2.69 kg **	Flared canal - Ribbond standard 2,0mmØ (10) Flared	12.87 ± 3.54 kg **
Abo El Ela, Atta O & El-Mowafy O, 2008	ParaPost Fiber White+SE Bond	1,548.5 ± 290.0 N	everStick post + SE Bond	1,711.7 ± 516.7 N *
	ParaPost Fiber White+ Xeno-III	1,171.3 ± 296.9 N	everStick post + Xeno-III	1,825.7 ± 527.3 N *
Yunzhi F & Yachong W, 2009	Glass Fiber Posts	202.10 ± 12.20 N	Plastic Fiber Reinforced Resin (Everstick)	214.35 ± 10.72 N *
Jindal S et al., 2012	Glass Fiber Post (Fibrapost) 10mm	740.21 ± 29.87 N	Ribbond Fiber Post - 10mm	216.93 ± 53.39 N *
	Glass Fiber Post (Fibrapost) 5mm	425.18 ± 42.73 N *	Ribbond Fiber Post - 5mm	299.62 ± 53.42 N
Doshi P, et al.,2019	Glass Fiber Post (Coltene Whaledent)	343.89 ± 10.44 N *	everStick Post (E-glass fiber)	452.32 ± 14.35 N

Legend: et al = and others; SD = Standard Deviations; N = Newtons; kg = kilograms; mm= millimeters; min= minutes; SE= Self Etch; *Highest fracture resistence between control group and test group; ** No differences between control group and test group

MODE OF FAILURE

A summary of the failure mode results is shown in Table 4. The failure mode was described by all included studies.[30–34] Most studies reported predominantly non-catastrophic failures (core fracture or core dislodgement), with 72 non-catastrophic failure for the fiber glass group and 60 for the study group. Catastrophic failures such as root fracture were more prevalent in the study group (fiber-reinforced composites posts), especially in the group treated with Ribbond.[33]

DISCUSSION

Although there are several *in vitro* studies that have evaluated the mechanical properties of the different treatment approaches used in the restoration of endodontically treated teeth in the anterior region, to date there are no randomized controlled clinical trials (RCTs) or systematic reviews that provide clear guidance on which approach is the most appropriate. This lack of evidence leaves decision making in the hands of subjective criteria such as commercial influence, ease of implementation or time required in the office. In addition, the term biomimetic dentistry has unfortunately been misunderstood lately, ignoring the purpose of mimicking the behavior of natural tissues. On the other hand, the use of certain materials, such as fiber-reinforced resin composites, has been promoted as if they were the most suitable and the only way to perform biomimetic dentistry, disregarding the absence of sufficient scientific data in this regard. Therefore, the present systematic review seeks to fill this gap and answer the focused question: "In endodontically treated anterior teeth without ferrule, does the restorative approach with fiber-reinforced resin composites as polyethylene fibers (Ribbond), fibers reinforced resin (everStick) and composite resin (everX) present a superior performance compared to anterior teeth treated with intraradicular fiberglass posts?" The results of this investigation did not show superior performance in any of the groups studied. It was not possible to determine a more favorable approach in terms of fracture toughness or failure mode.

Although fiber-reinforced resin composites have demonstrated certain advantages such as biocompatibility, esthetics and ease of handling,[35,36] they are not able to avoid catastrophic failures, which is crucial to avoid complications. This lack of efficacy can be attributed to disparities in the modulus of elasticity of each material. For example, Ribbond fibers have a high modulus and molecular weight[36] which could alter the biomechanical behavior of the tooth.[35–37] On the other hand, although fiberglass posts have a modulus of elasticity somewhat similar to that of dentin,[38–40] catastrophic failures have also been reported. Therefore, this parameter would not be the only one responsible for the performance of restorations in endodontically treated teeth.

The results of this systematic review are in agreement with the study of Yun-zhi and Ya-chong,[32] who suggest that there is no significant difference between the use of fiberglass posts vs. resin-reinforced fiber posts in anterior teeth. However, reports in the literature are not conclusive. Studies[31,34,41] mention that the everStick post was associated with higher fracture resistance values regardless of the bonding agent used and that these results may be due to the fact that this type of fibers open in a fan shape on the coronal face, increasing the

Table 4. Summary of results of Failure Mode.

Author, year	Failure Mode (Fiber Glass)			Failure Mode (Fiber-reinforced Composite)			
	Root Fracture	Core Fracture	Core Dislodgment	Root Fracture	Core Fracture	Core Dislodgment	Type
Newman M et al., 2003	0	10	0	0	0	10	Ribbond
	0	10	0	0	0	10	Ribbond
Abo El Ela, Atta O & El-Mowafy O, 2008	2	6	NR	1	7	NR	everStick
	1	7	NR	1	7	NR	everStick
Yunzhi F & Yachong W, 2009	0	0	5	0	0	5	everStick
Jindal S et al., 2012	3	12	0	14	1	0	Ribbond
	12	3	0	15	0	0	Ribbond
Doshi P, et al., 2019	1	0	19	0	0	20	everStick
Total	19	48	24	31	15	45	

Legend: NR = Not Reported

area of adhesion with the core. In addition, this type of post is placed in an unpolymerized form within the canal, allowing the resin monomer on the surface to react positively with the monomers in the resin cement. On the other hand, it has also been described that fiberglass posts can efficiently increase the fracture resistance of endodontically treated anterior teeth.[30,33] This may be due to the concept of monoblock formation given by fiberglass posts, as a single biomechanical complex is created through adhesion between the tooth structure and the reconstruction material, which gives it the ability to resist higher forces.[33] However, this may vary depending on the composition of the fiberglass posts, since the higher the fiberglass content, the greater the resistance shown by these posts.[30]

Similarly, inconclusive data have been reported when restoring endodontically treated teeth in the posterior region. In agreement with the data of the present study, Braga *et al.*,[42] measured the fracture resistance in posterior teeth and concluded that both the use of fiber and polyethylene fiber post provided similar results in fracture resistance tests. On the other hand, Cimpean *et al.*,[43] when comparing the use of fiberglass posts vs. short-fiber-reinforced composite (EverX Posterior), described an increase in fracture resistance in the short-fiber-reinforced composite group, suggesting a better performance of these fibers in comparison with conventional fiberglass.

It is important to note that the main findings on this subject are based on *in vitro* studies, which limits the extrapolation of the results. In addition, great heterogeneity is evident among the studies due to the different variables in methodology employed, such as post types, lengths, cements and adhesives used, as well as angles and forces of test application. This heterogeneity had a direct impact on the present study by preventing the execution of meta-analyses. It should be noted that the test used in the included studies was the compression test; however, according to King and Setchell, fatigue tests under cyclic loading would be the most appropriate to determine the resistance of these materials in a more reliable way.[44]

The risk of bias of the included studies was assessed using the QUIN tool.[29] The studies presented a moderate to high risk of bias. This is related to the insufficient control of variables such as the lack of standardization of the experimental tests and the absence of sample size calculation, blinding of the testing machine operator and calibration of the universal testing machine, which resulted in a wide range of results among the included studies.

Based on the results of this systematic review, it was not possible to identify superior performance among the approaches analyzed for the restoration of endodontically treated anterior teeth. Further studies are needed to compare the effectiveness of these approaches, with standardized experimental designs, using comparable adhesive protocols and appropriate tests to analyze mechanical performance. However, it is important to emphasize that relying on *in vitro* studies alone is insufficient to justify the adoption of a new therapy.[45] Therefore, clinical data with controlled experimental designs in this field are highly necessary and expected, so that the efficacy and survival of these "new" techniques can be analyzed over time, in order to make reliable clinical decisions. In the meantime, it is advisable to base our clinical practice on consolidated concepts with sufficient scientific and clinical support.[45,46]

The strengths of this systematic review include: the broad search for scientific articles, the use of a transparent and reproducible methodology, the selection of articles and the assessment of the risk of bias by independent reviewers. Assessment of the risk of bias of the included studies. Some limitations of this systematic review need to be highlighted, mainly the scarcity of literature on the subject, and the methodological variability between the studies included.

CONCLUSION

Within the limitations of this study, the use of fiber reinforced composites as customized intracanal posts is still questionable, with controversial results. It is not possible to establish the superiority of one approach over the other in endodontically treated anterior teeth without ferrule. Clinicians should support their practice with evidence-based information.

AUTHOR CONTRIBUTIONS

Guzmán Silvia: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; validation; visualization; writing –review and editing. Brito Daniel: Conceptualization; data curation; formal analysis; funding acquisition; investigation; supervision; writing –review and editing. Calle Juan: Conceptualization; data curation; formal analysis; methodology; project administration; resources; supervision; writing –review and editing. Tannya Romero: Conceptualization; investigation; methodology; project administration; supervision; validation; writing–review and editing. Edwin Ruales Carrera: Conceptualization; formal analysis; methodology; supervision; validation; writing–review and editing. Bolívar Delgado: Conceptualization; formal analysis; methodology; supervision; validation; writing–review and editing. Patrícia Pauletto: Conceptualization; formal analysis; methodology; project administration; supervision; validation; visualization; writing –review and editing.

CONFLICT OF INTEREST

Authors have no conflicts of interest to declare.

SUPPORTING INFORMATION / DATA AVAILABILITY STATEMENT

Additional supporting information may be found in the online version of the article on the publisher's website.

REFERENCES

1. Soares, A.P. The structural integrity of post-and-core (root canal) restorations: a 3D high-resolution *in vitro* study [PhD Thesis]. Charité-Universitätsmedizin Berlin; 2022.
2. Tang, W., Wu, Y. and Smales, R.J. Identifying and reducing risks for potential fractures in endodontically treated teeth. *J Endod* 2010; **36**:609-617.
3. Eakle, W.S. Fracture resistance of teeth restored with class ii bonded composite resin. *J Dent Res* 1986; **65**:149-153.
4. Saberi, E.A., Pirhaji, A. and Zabetiyan, F. Effects of endodontic access cavity design and thermocycling on fracture strength of endodontically treated teeth. *CCIDE 2020*; Volume 12:149-156.
5. Chirila, M., Dimitriu, B., Bartok, R.I., *et al*. Fracture resistance of endodontically treated teeth restored with resin post reinforced with glass fiber. *J Med Life* 2021;**14**:81-85.
6. Reeh, E.S., Messer, H.H. and Douglas, W.H. Reduction in tooth stiffness as a result of endodontic and restorative procedures. *J Endod* 1989; **15**:512-516.
7. Özyürek, T., Ülker, Ö., Demiryürek, E.Ö., *et al*. The effects of endodontic access cavity preparation design on the fracture strength of endodontically treated teeth: traditional versus conservative preparation. *J Endod* 2018; **44**:800-805.
8. Shu, X., Mai, Q.Q., Blatz, M., *et al*. Direct and indirect restorations for endodontically treated teeth: a systematic review and meta-analysis, IAAD 2017 consensus conference paper. *J Adhes Dent* 2018; **20**:183-194.
9. Guo, J., Wang, Z., Li, X., *et al*. A comparison of the fracture resistances of endodontically treated mandibular premolars restored with endocrowns and glass fiber post-core retained conventional crowns. *J Adv Prosthodont* 2016; **8**:489.
10. Linn, J. and Messer, H.H. Effect of restorative procedures on the strength of endodontically treated molars. *J Endod* 1994; **20**:479-485.
11. Schwartz, R. and Robbins, J. Post placement and restoration of endodontically treated teeth: a literature review. *J Endod* 2004; **30**:289-301.
12. al-Qarni, F.D. Customized post and cores fabricated with CAD/CAM technology: A literature review. *IJGM* 2022; Volume 15:4771-4779.
13. Perel, M.L. and Muroff ,F.I. Clinical criteria for posts and cores. *J Prosthet Dent* 1972; **28**:405-411.
14. Atlas, A., Grandini, S. and Martignoni, M. Evidence-based treatment planning for the restoration of endodontically treated single teeth: importance of coronal seal, post vs no post, and indirect vs direct restoration. *Quintessence Int* 2019; **50**:772-781.
15. Assif, D. and Gorfil, C. Biomechanical considerations in restoring endodontically treated teeth. *J Prosthet Dent* 1994; **71**:565-567.
16. Prakash, J., Golgeri, M.S., Haleem, S., *et al*. A comparative study of success rates of post and core treated anterior and posterior teeth using cast metal posts. *Cureus* 2022; **14**:e30735.
17. Mamoun, J. Post and core build-ups in crown and bridge abutments: Bio-mechanical advantages and disadvantages. *J Adv Prosthodont* 2017; **9**:232.
18. Mannocci, F. and Cowie, J. Restoration of endodontically treated teeth. *Br Dent J* 2014; **216**:341-346.
19. Magne, P., Goldberg, J., Edelhoff, D., *et al*. Composite resin core buildups with and without post for the restoration of endodontically treated molars without ferrule. *Oper Dent* 2016; **41**:64-75.
20. Rocca, G.T. and Krejci, I. Crown and post-free adhesive restorations for endodontically treated posterior teeth: from direct composite to endocrowns. *Eur J Esthet Dent*. 2013; **8**:156-179.
21. Lassila, L., Oksanen, V., Fráter, M., *et al*. The influence of resin composite with high fiber aspect ratio on fracture resistance of severely damaged bovine incisors. *Dent Mater J* 2020; **39**:381-388.
22. Carvalho, M.A., Lazari, P.C., Gresnigt, M., *et al*. Current options concerning the endodontically-treated teeth restoration with the adhesive approach. *Braz Oral Res* 2018; **32**:e74.
23. Kimble, P., Stuhr, S., McDonald, N., *et al*. Decision making in the restoration of endodontically treated teeth: effect of biomimetic dentistry training. *Dent J* 2023; **11**:159.
24. Casanova, T.P. and Özcan, M. Can fiber-reinforced resin composites alone substitute adhesively luted intraradicular post and core materials under static and dynamic loading? *Journal of Adhesion Science and Technology* 2021; **35**:2064-2078.
25. Dietschi, D., Duc, O., Krejci, I., *et al*. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies). *Quintessence Int* 2008; **39**:117-129.
26. Ozcan, M. and Valandro, L. Fracture strength of endodontically-treated teeth restored with post and cores and composite cores only. *Oper Dent* 2009; **34**:429-436.
27. Moher, D., Shamseer, L., Clarke, M., et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015; **4**:1.
28. Ouzzani, M., Hammady, H., Fedorowicz, Z., *et al*. Rayyan—a web and mobile app for systematic reviews. *Syst Rev* 2016; **5**:210.
29. Sheth, H., Shah, N.P., Jain, R., *et al*. Development and validation of a risk-of-bias tool for assessing *in vitro* studies conducted in dentistry: The QUIN. *J Prosthet Dent* 2024; **131**:1038-1042.
30. Newman, M.P., Yaman, P., Dennison, J., *et al*. Fracture resistance of endodontically treated teeth restored with composite posts. *J Prosthet Dent* 2003; **89**:360-367.
31. Abo El-Ela, O.A., Atta, O.A. and El-Mowafy, O. Fracture resistance of anterior teeth restored with a novel nonmetallic post. *J Can Dent Assoc* 2008; **74**:441.
32. Yun-zhi, F. and Ya-chong, W. An experimental study on repairing horn-shaped root canal orifice by different materials. *West China Journal of Stomatology* 2009; **27**:405-407.
33. Jindal, S., Jindal, R., Mahajan, S., *et al*. *In vitro* evaluation of the effect of post system and length on the fracture resistance of endodontically treated human anterior teeth. *Clin Oral Investig* 2012; **16**:1627-1633.
34. Doshi, P., Kanaparthy, A., Kanaparthy, R., *et al*. A comparative analysis of fracture resistance and mode of failure of endodontically treated teeth restored using different fiber posts: An *In Vitro* Study. *J Contemp Dent Pract* 2019; **20**:1195-1199.
35. Sirimai, S., Riis, D.N. and Morgano, S.M. An *in vitro* study of the fracture resistance and the incidence of vertical root fracture of pulpless teeth restored with six post-and-coresystems. *J Prosthet Dent* 1999; **81**:262-269.
36. Karaman, E., Keskin, B. and Inan, U. Three-year clinical evaluation of class II posterior composite restorations placed with different techniques and flowable composite linings in endodontically treated teeth. *Clin Oral Investig* 2017; **21**:709-716.

37. Zarone, F., Sorrentino, R., Apicella, D., *et al.* Evaluation of the biomechanical behavior of maxillary central incisors restored by means of endocrowns compared to a natural tooth: A 3D static linear finite elements analysis. *Dent Mater* 2006; **22**:1035-1044.
38. Novais, V.R., Rodrigues, R.B., Simamoto, P.C., *et al.* Correlation between the mechanical properties and structural characteristics of different fiber posts systems. *Braz Dent J* 2016; **27**:46-51.
39. Barcelos, L.M., Bicalho, A.A., Veríssimo, C., *et al.* Stress distribution, tooth remaining strain, and fracture resistance of endodontically treated molars restored without or with one or two fiberglass posts and direct composite resin. *Oper Dent* 2017; **42**:646-657.
40. Chang, Y.H., Wang, H.W., Lin, P.H., *et al.* Evaluation of early resin luting cement damage induced by voids around a circular fiber post in a root canal treated premolar by integrating micro-CT, finite element analysis and fatigue testing. *Dent Mater* 2018; **34**:1082-1088.
41. Chhabra, N., Desai, K. and Singbal, K. Comparative evaluation of fracture resistance of endodontically treated maxillary premolars reinforced by customized glass fiber post in two different ways: An *in vitro* study. *J Conserv Dent* 2022; **25**:555.
42. Braga, M.R., Sena, N. and Paulo, M., *et al.* Avaliação da resistência à fratura de dentes restaurados e tratados endodonticamente com diferentes retentores intrarradiculares. *RSD* 2023;**12**:e0112441336.
43. Cimpean, S.I., Pop-Ciutrila, I.S., Buduru, S., *et al.* Assessing fracture resistance of non vital teeth using two different composite systems: short-fibre-reinforced composite and glass fibre post with microfilled hybrid composite. *Mater Plast* 2021; **57**:286-296.
44. King P. and Setchell, D. An *in vitro* evaluation of a prototype CFRC prefabricated post developed for the restoration of pulpless teeth. *J Oral Rehabil* 1990; **17**:599-609.
45. Lima A.F. and Watts D.C. Upholding scientific integrity in dental materials adoption. *Dent Mater* 2024; S0109564124000654.
46. Reis, A., Feitosa, V.P. and Chibinski, A.C., *et al.* Biomimetic Restorative Dentistry: an evidence-based discussion of common myths. *J Appl Oral Sci* 2024; **32**:e20240271.

Appendix 1. PRISMA Checklist 2020.

Section and Topic	Item	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	4-5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	5-6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	5-6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	5-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	5-6

Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	6
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7-8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	7
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	6
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	7
Study characteristics	17	Cite each included study and present its characteristics.	7
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	7
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	7-8
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	8-9
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	10
	23b	Discuss any limitations of the evidence included in the review.	11
	23c	Discuss any limitations of the review processes used.	11
	23d	Discuss implications of the results for practice, policy, and future research.	12
OTHER INFORMATION			

Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	4
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	4
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	4
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	13
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	13

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

Appendix 2. Database search strategy.

Database	Database Search 2023, May 7th
LILACS (n =745)	"endodontically treated tooth" OR "dente tratado endodonticamente" AND "composite resins" OR "resinas compostas"
PUBMED (n = 545)	((((((((((((((((nonvital tooth[MeSH Terms]) OR (nonvital teeth[MeSH Terms])) OR (tooth nonvital[MeSH Terms])) OR (teeth nonvital[MeSH Terms])) OR (devitalized tooth[MeSH Terms])) OR (devitalized teeth[MeSH Terms])) OR (tooth devitalized[MeSH Terms])) OR (teeth devitalized[MeSH Terms])) OR (pulpless teeth[MeSH Terms])) OR (pulpless tooth[MeSH Terms])) OR (tooth pulpless[MeSH Terms])) OR (teeth pulpless[MeSH Terms])) OR (endodontically treated teeth[MeSH Terms])) OR (endodontically treated tooth[MeSH Terms])) OR (teeth endodontically treated[MeSH Terms])) OR (tooth endodontically treated[MeSH Terms])) AND (((((((((((((((((dental materials[MeSH Terms]) OR (composite resins[MeSH Terms])) OR (resins synthetic[MeSH Terms])) OR (dental resins[MeSH Terms])) OR (everX Posterior[MeSH Terms])) OR (everStick[MeSH Terms])) OR (fiber reinforced composite)) OR (short fiber reinforced composite)) OR (nano-hybrid composite)) OR (micro-hybrid composite)) OR (nanocomposites[MeSH Terms])) OR (resin composite core)) OR (core paste composite resin[MeSH Terms])) OR (RIBBOND[MeSH Terms])) OR (Polyethylene[MeSH Terms])) OR (Polyethylenes[MeSH Terms])) OR (polyethylene fibers)) OR (Composite impregnated glass fiber))) AND (((((((((((Lightpost[MeSH Terms]) OR (fiberglass post)) OR (glass fiber post)) OR (Fiberglass[MeSH Terms])) OR (fiberglass reinforced polymers[MeSH Terms])) OR (Post and core technique[MeSH Terms])) OR (GLASS[MeSH Terms])) OR (Prefabricated post)) OR (Fiber post)) OR (Fiber Reinforced composite)) OR (Direct post and core))) AND ((((((((((((fracture resistance) OR (fracture strength)) OR (dental restoration failure[MeSH Terms])) OR (tooth fractures[MeSH Terms])) OR (fracture tooth[MeSH Terms])) OR (fractures tooth[MeSH Terms])) OR (tooth fracture[MeSH Terms])) OR (teeth fractures)) OR (fracture teeth)) OR (fractures teeth)) OR (teeth fracture)) OR (dental stress analysis[MeSH Terms]))
SCOPUS (n = 5)	(TITLE-ABS-KEY (("nonvital tooth" OR "nonvital teeth" OR "tooth nonvital" OR "teeth nonvital" OR "devitalized tooth" OR "devitalized teeth" OR "tooth devitalized" OR "pulpless teeth" OR pulpless AND tooth " OR " tooth AND pulpless " OR " teeth AND pulpless " OR endodontically treated teeth" OR "endodontically treated tooth" OR "teeth endodontically treated" OR "tooth endodontically treated"))) AND (TITLE-ABS-KEY (("dental materials" OR "composite resins" OR "resins synthetic" OR "dental resins" OR "fiber reinforced composite" OR "short fiber reinforced composite" OR "nano-hybrid composite" OR "micro-hybrid composite" OR "resin composite core" OR "ribbond" OR "polyethylene" OR "polyethylenes" OR "polyethylene fibers" OR "composite impregnated glass fiber"))) AND (TITLE-ABS-KEY (("lightpost" OR "fiberglass post" OR "glass fiber post" OR "fiberglass" OR "fiberglass reinforced polymers" OR "post and core technique" OR "glass" OR "prefabricated post" OR "fiber post" OR "fiber reinforced composite post" OR "direct post and core"))) AND (TITLE-ABS-KEY (("fracture resistance" OR "fracture strength" OR "dental restotation failure" OR "tooth fractures" OR "fracture tooth" OR "fractures tooth" OR "tooth fracture" OR "teeth fractures" OR "fracture teeth" OR "fractures teeth" OR "teeth fracture" OR "dental stress analysis")))
Web of Science (n = 32)	TS=("nonvital tooth" OR "nonvital teeth" OR "tooth nonvital" OR "teeth nonvital" OR "devitalized tooth" OR "devitalized teeth" OR "tooth devitalized" OR "pulpless teeth" OR pulpless AND tooth " OR " tooth AND pulpless " OR " teeth AND pulpless " OR endodontically treated teeth" OR "endodontically treated tooth" OR "teeth endodontically treated" OR "tooth endodontically treated") AND TS=("dental materials" OR "composite resins" OR "resins synthetic" OR "dental resins" OR "fiber reinforced composite" OR "short fiber reinforced composite" OR "nano-hybrid composite" OR "micro-hybrid composite" OR "resin composite core" OR "ribbond" OR "polyethylene" OR "polyethylenes" OR "polyethylene fibers" OR "composite impregnated glass fiber") AND TS=("lightpost" OR "fiberglass post" OR "glass fiber post" OR "fiberglass" OR "fiberglass reinforced polymers" OR "post and core technique" OR "glass" OR "prefabricated post" OR "fiber post" OR "fiber reinforced composite post" OR "direct post and core") AND TS=("fracture resistance" OR "fracture strength" OR "dental restotation failure" OR "tooth fractures" OR "fracture tooth" OR "fractures tooth" OR "tooth fracture" OR "teeth fractures" OR "fracture teeth" OR "fractures teeth" OR "teeth fracture" OR "dental stress analysis")
Google Scholar (n = 245)	"endodontically treated teeth" AND "fiber reinforced composite" AND "fiberglass post" AND "fracture resistance"
ProQuest (n = 17)	noft("nonvital tooth" OR "nonvital teeth" OR "tooth nonvital" OR "teeth nonvital" OR "devitalized tooth" OR "devitalized teeth" OR "tooth devitalized" OR "pulpless teeth" OR pulpless AND tooth " OR " tooth AND pulpless " OR " teeth AND pulpless " OR endodontically treated teeth" OR "endodontically treated tooth" OR "teeth endodontically treated" OR "tooth endodontically treated") AND noft("dental materials" OR "composite resins" OR "resins synthetic" OR "dental resins" OR "fiber reinforced composite" OR "short fiber reinforced composite" OR "nano-hybrid composite" OR "micro-hybrid composite" OR "resin composite core" OR "ribbond" OR "polyethylene" OR "polyethylenes" OR "polyethylene fibers" OR "composite impregnated glass fiber") AND noft("lightpost" OR "fiberglass post" OR "glass fiber post" OR "fiberglass" OR "fiberglass reinforced polymers" OR "post and core technique" OR "glass" OR "prefabricated post" OR "fiber post" OR "fiber reinforced composite post" OR "direct post and core") AND noft("fracture resistance" OR "fracture strength" OR "dental restotation failure" OR "tooth fractures" OR "fracture tooth" OR "fractures tooth" OR "tooth fracture" OR "teeth fractures" OR "fracture teeth" OR "fractures teeth" OR "teeth fracture" OR "dental stress analysis")

Appendix 3. Articles excluded and the reasons for exclusion (n=135).

Author	Reasons for Exclusion*
Saupe WA et al.,1996 (1)	4
Sirimai S et al., 1999 (2)	5
Karna JC, 1996 (3)	13
Dinato JC et al., 2000 (4)	13
Baratieri LN et al., 2000 (5)	1
Pene JR et al., 2001 (6)	7
Raygot C et al., 2001 (7)	4
Heydecke G et al., 2001(8)	4
Akkayan B & Gulmez T, 2002 (9)	4
Heydecke G et al., 2002 (10)	4
Pontius O et al., 2002 (11)	4
Maccari PCA, Conceição EM & Nunes MF, 2003 (12)	4
Melo MP, 2003 (13)	11
Zhi-Yue L & Yu-Xing Z., 2003 (14)	4
Hu YH et al., 2003 (15)	4
Wen-yun Zhang et al, 2004 (16)	5
Akkayan B, 2004 (17)	4
Hu S et al., 2005 (18)	4
Melo MP et al., 2005 (19)	4
Toksavul S et al., 2005 (20)	4
Pereira J.R et al., 2005 (21)	4
Barjau Escribano A et al., 2006 (22)	5
Friedel W & Kern M, 2006 (23)	4
Ng CCH et al., 2006 (24)	4
Thongthammachat S, et al., 2006 (25)	13
Zhang Y xing et al., 2006 (26)	4
Naumann M, Preuss A & Frankerberg R, 2006 (27)	5
Maccari PC et al., 2007 (28)	4
Qing H et al., 2007 (29)	4
Garoushi S, Vallitu PK & Lassila LVJ, 2007 (30)	4
Clavijo VGR, 2008 (31)	6
Moosavi H et al., 2008 (32)	4
Sendhilnathan D & Nayar S , 2008 (33)	4
Nishimura Y, Tsubota Y & Fukushima S, 2008 (34)	6
Santos-Filho PCF et al., 2008 (35)	6
D'Arcangelo C et al., 2008 (36)	1
Salameh Z et al., 2008 (37)	4
Hinckfuss S & Wilson PR, 2008 (38)	4
de Oliveira JR et al., 2008 (39)	4
Ramalho ACD et al., 2008 (40)	5
Cho H et al., 2009 (41)	8
Kaizer OB et al., 2009 (42)	4
Mekayarajjananonth T, et al., 2009 (43)	4
Pereira JR et al., 2009 (44)	4
Rosentritt M et al., 2009 (45)	5
Giovani AR et al., 2009 (46)	5
Ozcan M & Valandro L, 2009 (47)	4
Hemalatha, H et al., 2009 (48)	7
D'Arcangelo C et al., 2010 (49)	1
Santos MAF, 2010 (50)	13
Destro A, Uemura ES & Yamamoto ETC, 2010 (51)	6
Cecchin D, et al., 2010 (52)	6
Toman M et al., 2010 (53)	5
Chuang SF et al., 2010 (54)	5
Silva GR et al., 2011 (55)	6
Dejak B & Miotkowski A, 2011 (56)	12
Li Q, Yan P & Chen Z, 2011 (57)	7
Aghdaee N, Darban JG & Mohajeri A, 2011 (58)	5
Solomon CS & Osman YI, 2011 (59)	5
Li Q, Xu B & Cai Y, 2011 (60)	5
Zicari F et al., 2011 (61)	12
Zogheib LV et al., 2011 (62)	5
Queiroz VS, et al., 2011 (63)	13
Alsamadani KH, Abdaziz ESM & Gad ES, 2012 (64)	5
Costa RG et al., 2012 (65)	3
Flores DSH et al., 2012 (66)	2
Rosa R et al., 2012 (67)	6
Fragou T et al., 2012 (68)	5
Watanabe UM et al., 2012 (69)	12
Castro CG et al., 2012 (70)	5
Valdivia ADCM et al., 2012 (71)	1
Wandscher VF, et al., 2012 (72)	13
Borelli B, et al., 2012 (73)	13
Ambica K et al., 2013 (74)	5
Balkaya MC & Birdal IS, 2013 (75)	5
Evangelinaki E et al., 2013 (76)	5
Kumar BS et al., 2013 (77)	3
Sagsen B et al., 2013 (78)	3
Franco EB, et al., 2014 (79)	5
Santos-Filho PCF et al., 2014 (80)	6
Abdulrazzak SS et al., 2014 (81)	5
Amin RA et al., 2014 (82)	5
Tey KC & Lui JL, 2014 (83)	4
Pereira JR et al., 2014 (84)	5

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Appendix 3. Articles excluded and the reasons for exclusion (n=135).	
Zhou W mei & Huang G mei, 2014 (85)	13
Celik K & Belli S, 2015 (86)	3
Clovis LDMMN et al., 2015 (87)	5
Gencel Z, Ersu B & Senyilmaz DP, 2015 (88)	5
Vacchani KA & Asnani MM, 2015 (89)	5
Maroulakos G et al., 2015 (90)	4
Kurthukoti AJ et al., 2015 (91)	4
Abduljawad M et al., 2016 (92)	1
Fontana PE et al., 2017 (93)	6
Kaushalya P, 2017 (94)	3
Spina DRF, et al., 2017 (95)	3
Maksimovskaya LN et al., 2017 (96)	13
Aggarwal A, 2017 (97)	13
Sungur DD et al., 2017 (98)	3
Abduljawad M et al., 2017 (99)	1
Magne P et al., 2017 (100)	9
Haralur SB et al., 2018 (101)	4
Santos Pantaleón D et al., 2018 (102)	4
Khiavi HA et al., 2018 (103)	4
Lazari PC et al., 2018(104)	9
Medrano CB, 2019 (105)	3
Pinto CL et al., 2019 (106)	6
Santos T, 2019 (107)	6
von Stein-Lausnitz M, et al., 2019 (108)	5
Santos Pantaleón D, et al., 2019 (109)	5
Cimpean SI et al., 2020 (110)	3
Alshahrani AS et al., 2020 (111)	5
Sarkis- Onofre R et al., 2020 (112)	12
Xie W et al., 2020 (113)	4
Lassila L et al., 2020 (114)	6
Tavano KTA et al., 2020 (115)	5
Sugano K et al., 2020 (116)	5
Santos Pantaleón D et al., 2021 (117)	1
Resende TH, 2021 (118)	6

Appendix 3. Articles excluded and the reasons for exclusion (n=135).

Chirila M et al., 2021 (119) Londrina, PR, Brazil	5
Eid R et al., 2021 (120)	4
Spicciarelli V et al., 2021 (121)	1
Fráter M et al., 2021 (122)	9
Özarslan M, 2021 (123)	5
Comba A et al., 2021 (124)	1
Bergamo ET et al., 2022 (125)	10
Rabelo TL et al., 2022 (126)	6
Oliveira CR et al., 2022 (127)	6
Popescu AD et al., 2022 (128)	12
Ranjkesh B et al., 2022 (129)	4
Santos T da SA et al., 2022 (130)	6
Garcia-Conteras R et al., 2022 (131)	5
Kawasaki T et al., 2022 (132)	1
Oliveira GR et al., 2022 (133)	10
Moura FB, 2023 (134)	6
Sharma S et al., 2023 (135)	13

***Legend: 1) Studies that included teeth with a ferrule. 2) Studies that do not specify the region (anterior/posterior) that was studied. 3) Studies involving only posterior teeth. 4) Studies involving other types of posts (other than fiberglass posts). 5) Studies that do not include the intervention of interest (Ribbond). 6) Studies that used non-human teeth. 7) Immature teeth. 8) Studies that did not use posts or fibers. 9) Studies focused on any other type of mechanical property (other than fracture resistance). 10) Studies that report only failure or survival mode. 11) Studies with duplicate data from another included study. 12) Systematic reviews, Finite Element Studies, Reviews, letters, books, conference abstracts, cases and controls, case reports, case series, opinion articles, technical articles, posters and guidelines. 13) The full text is not available, even after attempting to contact the corresponding authors (three attempts in a 3-week period).**

REFERENCES

1. Saupe WA, Gluskin AH, Radke RAJ. A comparative study of fracture resistance between morphologic dowel and cores and a resin-reinforced dowel system in the intraradicular restoration of structurally compromised roots. *Quintessence Int Berl Ger* 1985. 1996;**27**(7):483-91.
2. Sirimai S, Riis DN, Morgano SM. An *in vitro* study of the fracture resistance and the incidence ofvertical root fracture of pulpless teeth restored with six post-and-coresystems. *J Prosthet Dent*. 999;**81**(3):262-9.
3. Karna JC. A fiber composite laminate endodontic post and core. *Am J Dent*. 1996;**9**(5):230-2.

4. Dinato JC, Fortuna CR, Menin MLF, Quintas AF. Restauração de dentes tratados endodonticamente com pinos pré-fabricados. 2000;409-42.
5. Baratieri LN, De Andrada MA, Arcari GM, Ritter AV. Influence of post placement in the fracture resistance of endodontically treated incisors veneered with direct composite. *J Prosthet Dent*. 2000;**84**(2):180-4.
6. Pene JR, Nicholls JI, Harrington GW. Evaluation of fiber-composite laminate in the restoration of immature, nonvital maxillary central incisors. *J Endod*. 2001;**27**(1):18-22.
7. Raygot C, Chai J, Jameson L. Fracture resistance and primary failure mode of endodontically treated teeth restored with a carbon fiber-reinforced resin post system *in vitro*. *Int J Prosthodont*. 2001;**14**(2):141-5.
8. Heydecke G, Butz F, Strub JR. Fracture strength and survival rate of endodontically treated maxillary incisors with approximal cavities after restoration with different post and core systems: an *in-vitro* study. *J Dent*. 2001;**29**(6):427-33.
9. Akkayan B, Gülmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. *J Prosthet Dent*. 2002;**87**(4):431-7.
10. Heydecke G, Butz F, Hussein A, Strub JR. Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and-core systems. *J Prosthet Dent*. 2002;**87**(4):438-45.
11. Pontius O, Nathanson D, Giordano R, Schilder H, Hutter JW. Survival rate and fracture strength of incisors restored with different post and core systems and endodontically treated incisors without coronoradicular reinforcement. *J Endod*. 2002;**28**(10):710-5.
12. Maccari PCA, Conceição EN, Nunes MF. Fracture resistance of endodontically treated teeth restored with three different prefabricated esthetic posts. *J Esthet Restor Dent Off Publ Am Acad Esthet Dent Al*. 2003;**15**(1):25-30; discussion 31.
13. Melo MP de. Avaliação da resistência à fratura de dentes tratados endodonticamente com pinos pré-fabricados e resinas compostas variando a quantidade de remanescente dentário coronal. 2003;123-123.
14. Zhi-Yue L, Yu-Xing Z. Effects of post-core design and ferrule on fracture resistance of endodontically treated maxillary central incisors. *J Prosthet Dent*. 2003;**89**(4):368-73.
15. Hu YH, Pang LC, Hsu CC, Lau YH. Fracture resistance of endodontically treated anterior teeth restored with four post-and-core systems. *Quintessence Int Berl Ger* 1985. 2003;**34**(5):349-53.
16. Wen-yun Zhang, Ji-hua Chen, Chang-xi Shi, An-qi Jia, Li-dou Yang. Comparison of fracture resistance of pulpless teeth restored with fiber reinforced composite posts and three kinds of resin core material. *West China J Stomatol*. 2004;(6):404-14.
17. kkayan B. An *in vitro* study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with fiber-reinforced and zirconia dowel systems. *J Prosthet Dent*. 2004;**92**(2):155-62.
18. Hu S, Osada T, Shimizu T, Warita K, Kawawa T. Resistance to cyclic fatigue and fracture of structurally compromised root restored with different post and core restorations. *Dent Mater J*. 2005;**24**(2):225-31.
19. Melo MP de, Valle AL do, Pereira JR, Bonachela WC, Pegoraro LF, Bonfante G. Evaluation of fracture resistance of endodontically treated teeth restored with prefabricated posts and composites with varying quantities of remaining coronal tooth structure. *J Appl Oral Sci*. 2005;**13**(2):141-6.
20. Toksavul S, Toman M, Uyulgan B, Schmage P, Nergiz I. Effect of luting agents and reconstruction techniques on the fracture resistance of pre-fabricated post systems. *J Oral Rehabil*. 2005;**32**(6):433-40.
21. Pereira JR, Mendonça Neto T de, Porto V de C, Pegoraro LF, Valle AL do. Influence of the remaining coronal structure on the resistance of teeth with intraradicular retainer. *Braz Dent J*. 2005;**16**(3):197-201.
22. Barjau-Escribano A, Sancho-Bru JL, Forner-Navarro L, Rodríguez-Cervantes PJ, Pérez-González A, Sánchez-Marín FT. Influence of prefabricated post material on restored teeth: fracture strength and stress distribution. *Oper Dent*. 2006;**31**(1):47-54.
23. Friedel W, Kern M. Fracture strength of teeth restored with all-ceramic posts and cores. *Quintessence Int Berl Ger 1985*. 2006;**37**(4):289-95.
24. Ng CCH, Dumbrigue HB, Al-Bayat MI, Griggs JA, Wakefield CW. Influence of remaining coronal tooth structure location on the fracture resistance of restored endodontically treated anterior teeth. *J Prosthet Dent*. 2006;**95**(4):290-6.
25. Thongthammachat S, Platt JA, Katona TR, Hovijitra S, Moore BK. Fracture resistance and fracture resistance after fatigue loading of 4 different post and cores in endodontically treated teeth. *Compend Contin Educ Dent Jamesburg NJ 1995*. 2006;**27**(7):396-401; quiz 402, 421.
26. Zhang Y xing, Zhang W hong, Lu Z yue, Wang K li. Fracture strength of custom-fabricated Celay all-ceramic post and core restored endodontically treated teeth. *Chin Med J (Engl)*. 2006;**119**(21):1815-20.
27. Naumann M, Preuss A, Frankenberger R. Load capability of excessively flared teeth restored with fiber-reinforced composite posts and all-ceramic crowns. *Oper Dent*. 2006;**31**(6):699-704.
28. Maccari PC, Cosme DC, Oshima HM, Burnett LHJ, Shinkai RS. Fracture strength of endodontically treated teeth with flared root canals and restored with different post systems. *J Esthet Restor Dent Off Publ Am Acad Esthet Dent Al*. 2007;**19**(1):30-6; discussion 37.
29. Qing H, Zhu Z, Chao Y, Zhang W. *In vitro* evaluation of the fracture resistance of anterior endodontically treated teeth restored with glass fiber and zircon posts. *J Prosthet Dent*. 2007;**97**(2):93-8.
30. Garoushi S, Vallittu PK, Lassila LVJ. Direct restoration of severely damaged incisors using short fiber-reinforced composite resin. *J Dent*. 2007;**35**(9):731-6.
31. Clavijo VGR. Avaliação da resistência à fratura de raízes fragilizadas reabilitadas por diferentes técnicas de construção de núcleos intra-radiculares. 2008;
32. Moosavi H, Maleknejad F, Kimyai S. Fracture resistance of endodontically-treated teeth restored using three root-reinforcement methods. *J Contemp Dent Pract*. 2008;**9**(1):30-7.
33. Sendhilnathan D, Nayar S. The effect of post-core and ferrule on the fracture resistance of endodontically treated maxillary central incisors. *Indian J Dent Res Off Publ Indian Soc Dent Res*. 2008;**19**(1):17-21.
34. Nishimura Y, Tsubota Y, Fukushima S. Influence of cyclic loading on fiber post and composite resin core. *Dent Mater J*. 2008;**27**(3):356-61.
35. Santos-Filho PCF, Castro CG, Silva GR, Campos RE, Soares CJ. Effects of post system and length on the strain and fracture resistance of root filled bovine teeth. *Int Endod J*. 2008;**41**(6):493-501.
36. D'Arcangelo C, De Angelis F, Vadini M, Zazzeroni S, Ciampoli C, D'Amario M. *In vitro* fracture resistance and deflection of pulpless teeth restored with fiber posts and prepared for veneers. *J Endod*. 2008;**34**(7):838-41.
37. Salameh Z, Ounsi HF, Aboushelib MN, Sadig W, Ferrari M. Fracture resistance and failure patterns of endodontically treated mandibular molars with and without glass fiber post in combination with a zirconia-ceramic crown. *J Dent*. 2008;**36**(7):513-9.
38. Hinckfuss S, Wilson PR. Effect of core material and restoration design on strength of endodontically treated bovine teeth: a laboratory study. *J Prosthodont Off J Am Coll Prosthodont*. 2008;**17**(6):456-61.
39. de Oliveira JA, Pereira JR, Lins do Valle A, Zogheib LV. Fracture resistance of endodontically treated teeth with different heights of crown ferrule restored with prefabricated carbon fiber post and composite resin core by intermittent loading. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2008;**106**(5):e52-57.

40. Ramalho ACD, Mariz AL de A, Beatrice LC de S, Silva CHV, Menezes Filho PF. Estudo comparativo da resistência radicular à fratura em função do comprimento e da composição do pino. *RFO UPF*. 2008;**13**(3):42-6.
41. Cho H, Michalakis KX, Kim Y, Hirayama H. Impact of interproximal groove placement and remaining coronal tooth structure on the fracture resistance of endodontically treated maxillary anterior teeth. *J Prosthodont Off J Am Coll Prosthodont*. 2009;**18**(1):43-8.
42. Kaizer OB, Bonfante G, Pegoraro LF, Kaizer R de OF, Reis KR. Resistência à fratura de dentes tratados endodonticamente, reconstruídos com pinos de fibras de polietileno e com pinos biológicos. *RGO*. 2009;**57**(1):19-25.
43. Mekayarajjananonth T, Chitcharus N, Winkler S, Bogert MC. The effect of fiber dowel heights in resin composite cores on restoration failures of endodontically treated teeth. *J Oral Implantol*. 2009;**35**(2):63-9.
44. Pereira JR, Valle AL do, Shiratori FK, Ghizoni JS, Melo MP de. Influence of intraradicular post and crown ferrule on the fracture strength of endodontically treated teeth. *Braz Dent J*. 2009;**20**(4):297-302.
45. Rosentritt M, Reill M, Naumann M, Nowak A, Handel G. Strength investigation of artificial substitutes for human teeth in *in vitro* studies. *Int J Prosthodont*. 2009;**22**(1):62-4.
46. Giovani AR, Vansan LP, de Sousa Neto MD, Paulino SM. *In vitro* fracture resistance of glass-fiber and cast metal posts with different lengths. *J Prosthet Dent*. 2009;**101**(3):183-8.
47. Ozcan M, Valandro L. Fracture strength of endodontically-treated teeth restored with post and cores and composite cores only. *Oper Dent*. 2009;**34**(4):429-36.
48. Hemalatha H, Sandeep M, Kulkarni S, Yakub SS. Evaluation of fracture resistance in simulated immature teeth using Resilon and Ribbond as root reinforcements--an *in vitro* study. *Dent Traumatol Off Publ Int Assoc Dent Traumatol*. 2009;**25**(4):433-8.
49. D'Arcangelo C, De Angelis F, Vadini M, D'Amario M, Caputi S. Fracture resistance and deflection of pulpless anterior teeth restored with composite or porcelain veneers. *J Endod*. 2010;**36**(1):153-6.
50. Santos MAF dos. Resistência à fratura de dentes tratados endodonticamente, reforçados com pinos intra-radiculares diretos. 2010;149-149.
51. Destro A de SS, Uemura ES, Yamamoto ETC. Avaliação de diferentes compósitos na resistência à fratura de núcleos de preenchimento. *Pesqui Bras Em Odontopediatria E Clínica Integrada*. 2010;**10**(2):177-81.
52. Cecchin D, Farina AP, Guerreiro CAM, Carlini-Júnior B. Fracture resistance of roots prosthetically restored with intra-radicular posts of different lengths. *J Oral Rehabil*. 2010;**37**(2):116-22.
53. Toman M, Toksavul S, Sarikanat M, Nergiz I, Schmage P. Fracture resistance of endodontically treated teeth: effect of tooth coloured post material and surface conditioning. *Eur J Prosthodont Restor Dent*. 2010;**18**(1):23-30.
54. Chuang SF, Yaman P, Herrero A, Dennison JB, Chang CH. Influence of post material and length on endodontically treated incisors: an *in vitro* and finite element study. *J Prosthet Dent*. 2010;**104**(6):379-88.
55. Silva GR da, Santos-Filho PC de F, Simamoto-Júnior PC, Martins LRM, Mota AS da, Soares CJ. Effect of post type and restorative techniques on the strain and fracture resistance of flared incisor roots. *Braz Dent J*. 2011;**22**(3):230-7.
56. Dejak B, Mlotkowski A. Finite element analysis of strength and adhesion of cast posts compared to glass fiber-reinforced composite resin posts in anterior teeth. *J Prosthet Dent*. 2011;**105**(2):115-26.
57. Li Q, Yan P, Chen Z. Fracture resistance and failure patterns of open apex root teeth with different posts after endodontic treatment. J Huazhong Univ Sci Technol Med Sci Hua Zhong Ke Ji Xue Xue Bao Yi Xue Ying Wen Ban Huazhong Keji Daxue Xuebao Yixue Yingdewen Ban. 2011;**31**(2):271.
58. Aghdaee NA, Darban JG, Mohajeri A. Fracture strength in restored teeth before and after load cycling: an *in vitro* study. *J Calif Dent Assoc*. 2011;**39**(5):300-7.
59. Solomon CS, Osman YI. *In vitro* comparison of endodontic posts in structurally compromised roots of maxillary incisors. *SADJ J South Afr Dent Assoc Tydskr Van Suid-Afr Tandheelkd Ver*. 2011;**66**(5):220-3.
60. Li Q, Xu B, Wang Y, Cai Y. Effects of auxiliary fiber posts on endodontically treated teeth with flared canals. *Oper Dent*. 2011;**36**(4):380-9.
61. Zicari F, Van Meerbeek B, Debels E, Lesaffre E, Naert I. An up to 3-year controlled clinical trial comparing the outcome of glass fiber posts and composite cores with gold alloy-based posts and cores for the restoration of endodontically treated teeth. *Int J Prosthodont*. 2011;**24**(4):363-72.
62. Zogheib LV, Saavedra G de SFA, Cardoso PE, Valera MC, Araújo MAM de. Resistance to compression of weakened roots subjected to different root reconstruction protocols. *J Appl Oral Sci Rev FOB*. 2011;**19**(6):648-54.
63. Queiroz VS de, Pizi ECG, Soares CJ, Macedo VC, Martins LRM. Fracture resistance of composite resin cores with or without prefabricated posts over different substrates. *Gen Dent*. 2011;**59**(5):e214-218.
64. Alsamadani KH, Abdaziz ESM, Gad ES. Influence of different restorative techniques on the strength of endodontically treated weakened roots. *Int J Dent*. 2012;2012.
65. Costa RG, De Morais ECC, Campos EA, Michel MD, Gonzaga CC, Correr GM. Customized fiber glass posts. Fatigue and fracture resistance. *Am J Dent*. 2012;**25**(1):35-8.
66. Flores DSH, Aldrete AL, Contreras AG, Morales MH. A comparative study of teeth restored using different prefabricated root-canal post and castpost-and-core systems based on *in vitro* evaluation. *Rev Asoc Dent Mex*. 2012;**69**(6):271-6.
67. Rosa R, Hwas A, Melo D, Valandro LF, Kaizer O. Fracture strength of endodontically treated teeth restored with different strategies after mechanical cycling. *Gen Dent*. 2012;**60**(2):e62-68.
68. Fragou T, Tortopidis D, Kontonasaki E, Evangelinaki E, Ioannidis K, Petridis H, *et al*. The effect of ferrule on the fracture mode of endodontically treated canines restored with fibre posts and metal-ceramic or all-ceramic crowns. *J Dent*. 2012;**40**(4):276-85.
69. Watanabe MU, Anchieta RB, Rocha EP, Kina S, Almeida EO de, Freitas ACJ, *et al*. Influence of crown ferrule heights and dowel material selection on the mechanical behavior of root-filled teeth: a finite element analysis. *J Prosthodont Off J Am Coll Prosthodont*. 2012;**21**(4):304-11.
70. Castro CG, Santana FR, Roscoe MG, Simamoto PCJ, Santos-Filho PCF, Soares CJ. Fracture resistance and mode of failure of various types of root filled teeth. *Int Endod J*. 2012;**45**(9):840-7.
71. Valdivia ADCM, Raposo LHA, Simamoto-Júnior PC, Novais VR, Soares CJ. The effect of fiber post presence and restorative technique on the biomechanical behavior of endodontically treated maxillary incisors: an *in vitro* study. *J Prosthet Dent*. 2012;**108**(3):147-57.
72. Wandscher VF, others. Análise de sobrevida e resistência à fratura de raízes fragilizadas restauradas com diferentes pinos intrarradiculares. 2012;
73. Borelli B, Sorrentino R, Zarone F, Ferrari M. Effect of the length of glass fiber posts on the fracture resistance of restored maxillary central incisors. *Am J Dent*. 2012;**25**(2):79-83.
74. Ambica K, Mahendran K, Talwar S, Verma M, Padmini G, Periasamy R. Comparative evaluation of fracture resistance under static and fatigue loading of endodontically treated teeth restored with carbon fiber posts, glass fiber posts, and an experimental dentin post system: an *in vitro* study. *J Endod*. 2013;**39**(1):96-100.
75. Balkaya MC, Birdal IS. Effect of resin-based materials on fracture resistance of endodontically treated thin-walled teeth. *J Prosthet Dent*. 2013;**109**(5):296-303.

ejprd.org - Published by Dennis Barber Journals.

76. Evangelinaki E, Tortopidis D, Kontonasaki E, Fragou T, Gogos C, Koidis P. Effect of a crown ferrule on the fracture strength of endodontically treated canines restored with fiber posts and metal-ceramic or all-ceramic crowns. *Int J Prosthodont.* 2013;**26**(4):384-7.

77. Kumar BS, Spoorti P, Reddy J, Bhandi S, Gopal SS, Ittigi J. Evaluation of fracture resistance of reattached vertical fragments bonded with fiber-reinforced composites: an *in vitro* study. *J Contemp Dent Pract.* 1 2013;**14**(4):573-7.

78. Sagsen B, Zortuk M, Ertas H, Er O, Demirbuga S, Arslan H. *In vitro* fracture resistance of endodontically treated roots filled with a bonded filling material or different types of posts. *J Endod.* 2013;**39**(11):1435-7.

79. Franco EB, Lins do Valle A, Pompéia Fraga de Almeida AL, Rubo JH, Pereira JR. Fracture resistance of endodontically treated teeth restored with glass fiber posts of different lengths. *J Prosthet Dent.* 2014;**111**(1):30-4.

80. Santos-Filho PCF, Veríssimo C, Soares PV, Saltarelo RC, Soares CJ, Marcondes Martins LR. Influence of ferrule, post system, and length on biomechanical behavior of endodontically treated anterior teeth. *J Endod.* 2014;**40**(1):119-23.

81. Abdulrazzak SS, Sulaiman E, Atiya BK, Jamaludin M. Effect of ferrule height and glass fibre post length on fracture resistance and failure mode of endodontically treated teeth. *Aust Endod J J Aust Soc Endodontology Inc.* 2014;**40**(2):81-6.

82. Amin RA, Mandour MH, Abd El-Ghany OS. Fracture strength and nanoleakage of weakened roots reconstructed using relined glass fiber-reinforced dowels combined with a novel prefabricated core system. *J Prosthodont Off J Am Coll Prosthodont.* 2014;**23**(6):484-94.

83. Tey KC, Lui JL. The effect of glass fiber-reinforced epoxy resin dowel diameter on the fracture resistance of endodontically treated teeth. *J Prosthodont Off J Am Coll Prosthodont.* 2014;**23**(7):572-81.

84. Pereira JR, do Valle AL, Shiratori FK, Ghizoni JS, Bonfante EA. The effect of post material on the characteristic strength of fatigued endodontically treated teeth. *J Prosthet Dent.* 2014;**112**(5):1225-30.

85. Zhou W mei, Huang G wei. [Fracture resistance of thin-walled teeth restored with different post and core materials]. Shanghai Kou Qiang Yi Xue Shanghai *J Stomatol.* 2014;**23**(3):312-6.

86. Celik K, Belli S. The effect of different restoration techniques on fracture strength of teeth with flared roots. *J Adhes Sci Technol.* 2015;**29**(1):12-23.

87. Clovis LDMMN, Paulo AF, Jose M, Silvia SS, Rodrigo LP, Sábio S. Evaluation of linear-elastic fracture toughness of the teeth restored with different post and core systems. *J Dent Oral Hyg.* 2015;**7**(8):125-9.

88. Gencel Z, Ersu B, Senyilmaz DP, others. Influence of one-piece (monoblock) fibreglass post design on the fracture resistance of extensively damaged teeth: an *ex vivo* study. *Br J Med Med Res.* 2015;**8**(1):22-9.

89. Vachhani KA, Asnani MM. «Evaluation of fracture strength of teeth restored with different types of posts luted with different luting cements»: an *in vitro* study. *Niger J Clin Pract.* 2015;**18**(3):411-5.

90. Maroulakos G, Nagy WW, Kontogiorgos ED. Fracture resistance of compromised endodontically treated teeth restored with bonded post and cores: An *in vitro* study. *J Prosthet Dent.* 2015;**114**(3):390-7.

91. Kurthukoti AJ, Paul J, Gandhi K, Rao DBJ. Fracture resistance of endodontically treated permanent anterior teeth restored with three different esthetic post systems: An *in vitro* study. *J Indian Soc Pedod Prev Dent.* 2015;**33**(4):296-301.

92. Abduljawad M, Samran A, Kadour J, Al-Afandi M, Ghazal M, Kern M. Effect of fiber posts on the fracture resistance of endodontically treated anterior teeth with cervical cavities: An *in vitro* study. *J Prosthet Dent.* 2016;**116**(1):80-4.

93. Fontana PE, others. A influência da espessura da férula na resistência à fratura de dentes restaurados com diferentes pinos intrarradiculares. 2017;

94. Kaushalya P. A comparative evaluation of fracture resistance and retention of three different fiber reinforced posts in endodontically treated teeth with oval-shaped canals: An *in vitro* study [PhD Thesis]. *Adhiparasakthi Dental College and Hospital, Melmaruvathur*; 2017.

95. Spina DRF, others. Retentores customizados em CAD/CAM utilizando diferentes materiais estéticos: avaliação da resistência à fratura e de união. 2017;

96. Maksimovskaya LN, Krutov VA, Kuprin PV, Kuprina MA. [Direct restoration of the tooth crown using various core build-up materials]. *Stomatologiia* (Sofiia). 2017;**96**(1):33-9.

97. Aggarwal A. Comparative Evaluation of fracture resistance of endodontically treated teeth restored with two different post systems cemented with two resin cements-an *in vitro* study [PhD Thesis]. *Rajiv Gandhi University of Health Sciences (India)*; 2017.

98. Sungur DD, Ersu B, Tezvergil-Mutluy A, Canay S. The fracture resistance of composite core materials reinforced by varying fiber orientations. *Int J Prosthodont.* 2017;**30**(1):25-6.

99. Abduljawad M, Samran A, Kadour J, Karzoun W, Kern M. Effect of fiber posts on the fracture resistance of maxillary central incisors with Class III restorations: An *in vitro* study. *J Prosthet Dent.* 2017;**118**(1):55-60.

100. Magne P, Lazari PC, Carvalho MA, Johnson T, Del Bel Cury AA. Ferrule-effect dominates over use of a fiber post when restoring endodontically treated incisors: An *in vitro* Study. *Oper Dent.* 2017;**42**(4):396-406.

101. Haralur SB, Al Ahmari MA, AlQarni SA, Althobati MK. The effect of intraradicular multiple fiber and cast posts on the fracture resistance of endodontically treated teeth with wide root canals. *BioMed Res Int.* 2018;**2018**:1671498.

102. Santos Pantaleón D, Morrow BR, Cagna DR, Pameijer CH, Garcia-Godoy F. Influence of remaining coronal tooth structure on fracture resistance and failure mode of restored endodontically treated maxillary incisors. *J Prosthet Dent.* 2018;**119**(3):390-6.

103. Khiavi HA, Habibzadeh S, Safaeian S, Eftekhar M. Fracture Strength of Endodontically treated Maxillary Central Incisors restored with Nickel Chromium and Nonprecious Gold Alloy Casting Post and Cores. *J Contemp Dent Pract.* 2018;**19**(5):560-7.

104. Lazari PC, de Carvalho MA, Del Bel Cury AA, Magne P. Survival of extensively damaged endodontically treated incisors restored with different types of posts-and-core foundation restoration material. *J Prosthet Dent.* 2018;**119**(5):769-76.

105. Medrano Céspedes B. Evaluación de la resistencia a la fractura de órganos dentarios con postes de fibra de vidrio anatomizados vs no anatomizados [PhD Thesis]. *Universidad Autónoma de Nuevo León*; 2019.

106. Pinto CL, Bhering CLB, de Oliveira GR, Maroli A, Reginato VF, Caldas RA, *et al.* The influence of post system design and material on the biomechanical behavior of teeth with little remaining coronal structure. *J Prosthodont Off J Am Coll Prosthodont.* 2019;**28**(1):e350-6.

107. Santos T da SA. Resistência à fratura de dentes fragilizados utilizando reforço intra-radicular com pino de fibra de vidro: *Rebilda Post e Rebilda Post GT.* 2019;

108. von Stein-Lausnitz M, Bruhnke M, Rosentritt M, Sterzenbach G, Bitter K, Frankenberger R, *et al.* Direct restoration of endodontically treated maxillary central incisors: post or no post at all? *Clin Oral Investig.* 2019;**23**(1):381-9.

109. Santos Pantaleón D, Valenzuela FM, Morrow BR, Pameijer CH, García-Godoy F. Effect of ferrule location with varying heights on fracture resistance and failure mode of restored endodontically treated maxillary incisors. *J Prosthodont Off J Am Coll Prosthodont.* 2019;**28**(6):677-83.

110. Cimpean SI, Pop-Ciutrila IS, Buduru S, Pavel LL, Florea DF, Delean AG, *et al.* Assessing fracture resistance of non vital teeth using two different composite systems: short-fibre-reinforced composite and glass fibre post with microfilled hybrid composite. *Mater Plast Vol Issue Ages.* :286-96.

111.Alshahrani AS, Alamri HB, Nadrah FM, Almotire MK, Alateeq AY, Alshiddi IF, *et al*. Fracture resistance of endodontically treated teeth restored with fiber posts luted with composite core materials. *J Contemp Dent Pract*. 2020;**21**(4):383-9.

112.Sarkis-Onofre R, Amaral Pinheiro H, Poletto-Neto V, Bergoli CD, Cenci MS, Pereira-Cenci T. Randomized controlled trial comparing glass fiber posts and cast metal posts. *J Dent*. 2020;**96**:103334.

113.Xie W, Yang S, Hai Q, Wang J. Effect of ferrule thickness on fracture resistance of endodontically treated incisors restored with fiber post and metal crown. *Int J Prosthodont*. 2020;**33**(3):321-7.

114.Lassila L, Oksanen V, Fráter M, Vallittu PK, Garoushi S. The influence of resin composite with high fiber aspect ratio on fracture resistance of severely damaged bovine incisors. *Dent Mater J*. 2020;**39**(3):381-8.

115.Tavano KTA, Botelho AM, Douglas-de-Oliveira DW, Avila AF, Huebner R. Resistance to fracture of intraradicular posts made of biological materials. *BMC Oral Health*. 2020;**20**(1):300.

116.Sugano K, Komada W, Okada D, Miura H. Evaluation of composite resin core with prefabricated polyetheretherketone post on fracture resistance in the case of flared root canals. *Dent Mater J*. 2020;**39**(6):924-32.

117.Santos Pantaleón D, Valenzuela FM, Morrow BR, Pameijer CH, García-Godoy F. Effect of cervical lesions on fracture resistance and failure mode of maxillary central incisors restored with fiber posts and complete crowns. *Oper Dent*. 2021;**46**(6):669-79.

118.Resende TH. Avaliação de alternativas restauradoras com compósito para incisivos tratados endodonticamente sem efeito férula.

119.Chirila M, Dimitriu B, Bartok RI, Amza O, Serban AM, Suciu I. Fracture resistance of endodontically treated teeth restored with resin post reinforced with glass fiber. *J Med Life*. 2021;**14**(1):81-5.

120.Eid R, Tribst JPM, Juloski J, Özcan M, Salameh Z. Effect of material types on the fracture resistance of maxillary central incisors restored with CAD/CAM post and cores. *Int J Comput Dent*. 2021;**24**(1):41-51.

121.Spicciarelli V, Marruganti C, Fedele I, Martignoni M, Ounsi H, Ferrari M, *et al*. Influence of remaining tooth substance and post-endodontic restoration on fracture strength of endodontically treated maxillary incisors. *Dent Mater J*. 2021;**40**(3):697-703.

122.Fráter M, Sáry T, Néma V, Braunitzer G, Vallittu P, Lassila L, *et al*. Fatigue failure load of immature anterior teeth: influence of different fiber post-core systems. *Odontology*. 2021;**109**(1):222-30.

123.Özarslan M, Büyükkaplan UŞ, Özarslan MM. Comparison of the fracture strength of endodontically treated teeth restored with polyether ether ketone, zirconia and glass-fibre post-core systems. *Int J Clin Pract*. 2021;**75**(9):e14440.

124.Comba A, Baldi A, Saratti CM, Rocca GT, Torres CRG, Pereira GKR, *et al*. Could different direct restoration techniques affect interfacial gap and fracture resistance of endodontically treated anterior teeth? *Clin Oral Investig*. 2021;**25**(10):5967-75.

125.Bergamo ET, Lopes AC, Campos TM, Amorim PH, Costa F, Jalkh EBB, *et al*. Probability of survival and failure mode of endodontically treated incisors without ferrule restored with CAD/CAM fiber-reinforced composite (FRC) post-cores. *J Mech Behav Biomed Mater*. 2022;**136**:105519.

126.Rabelo TL, da Gama Antunes AN, Pardini DS, de Castro Albuquerque R, André CB, Oliveira HHA, *et al*. Intraradicular fiberglass posts: comparison among different techniques for restoring flared roots. *Res Soc Dev*. 2022;**11**(6):e21111628948-e21111628948.

127.Oliveira CR de M, Reis ÉGJ, Tanomaru-Filho M, Reis JMDSN. Fracture strength of teeth with coronal destruction after core build-up restoration with bulk fill materials. *J Esthet Restor Dent*. 2022;**34**(3):541-9.

128.Popescu AD, Popa DL, Nicola AG, Dascălu IT, Petcu C, Tircă T, *et al*. Post placement and restoration of endodontically treated canines: a finite element analysis study. *Int J Environ Res Public Health*. 2022;**19**(15):8928.

129.Ranjkesh B, Haddadi Y, Krogsgaard CA, Schurmann A, Bahrami G. Fracture resistance of endodontically treated maxillary incisors restored with single or bundled glass fiber-reinforced composite resin posts. *J Clin Exp Dent*. 2022;**14**(4):e329.

130.Santos T da SA, Abu Hasna A, Abreu RT, Tribst JPM, de Andrade GS, Borges ALS, *et al*. Fracture resistance and stress distribution of weakened teeth reinforced with a bundled glass fiber-reinforced resin post. *Clin Oral Investig*. 2022;**26**(2):1725-35.

131.Garcia-Contreras R, Serrano-Morales O, Scougall-Vilchis RJ, Arzate-Sosa G, Granados PAC, Garcia-Contreras R, *et al*. Fracture resistance of endodontically restored teeth with two system root post. *Int J Odontostomat*. 2022;**16**(1):100-5.

132.Kawasaki T, Sato T, Hisanaga R, Nomoto S, Yotsuya M, Yoshinari M, *et al*. Influence of one-wall remaining coronal tooth with resin abutment and fiber post on static and dynamic fracture resistance. *Dent Mater J*. 2022;**41**(2):241-8.

133.Oliveira GR, Machry RV, Cadore-Rodrigues AC, Sarkis-Onofre R, Valandro LF, Bacchi A, *et al*. Fatigue properties of weakened and non-weakened roots restored with CAD-CAM Milled fiber post, prefabricated fiber post, or cast metal post. *Oper Dent*. 2022;**47**(6):658-69.

134.Moura FB de. Avaliação da resistência à fratura de dentes com fragilização simulada utilizando sistemas de pinos de fibra de vidro. 2023;

135.Sharma S, Makkar M, Luthra R, Arora S, Pathania P, Das G, *et al*. Fracture load assessment of digitally fabricated post and prefabricated fibre post in endodontically treated teeth. *Technol Health Care Off J Eur Soc Eng Med*. 2023;**31**(2):447-58.

