SEVEN publicações acadêmicas

Considerations on the "no-post" philosophy in endodontically treated teeth: A Literature Review

Crossref doi
https://doi.org/10.56238/interdiinovationscrese-051

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ABSTRACT
The restoration of endodontically treated teeth with great loss of tooth structure is a real challenge for dentistry, since it requires the use of materials capable of extending the coronal support and preventing the propagation of fractures. Recently, a change in the use of intraradicular retainers has emerged, creating a new "no post" concept, based on the use of glass fiber reinforced resin composites. The aim of this review is to explore in the literature whether the material, represented by EverX Posterior (GC), presents any advantage of use in comparison with other materials already described for the restoration of endodontically treated teeth. The search was conducted in the main databases, PubMed, Scopus and Web of Science, resulting in 163 articles. After exclusion of duplicates and full-text reading, 14 in vitro articles and 1 clinical article were included in the final analysis version. With regard to the data found, the new biomaterial showed higher fracture resistance in posterior teeth in most of the studies evaluated, except in comparison with indirect restorations, especially the endocrown type. In comparison with direct restorations, EverX Posterior, in a "bilayer", worked as a reinforcement for force distribution and with improved properties in the presence of retentive grooves. For the intraradicular retainers, the new biomaterial also guaranteed an improved mechanical behavior, similar to the comparison made for polyethylene and glass fibers. Thus, further clinical studies should be carried out to confirm the considerations about this philosophy.

Keywords: Composite resins, EverX Posterior, Non-vital tooth, Permanent dental restoration.

1 INTRODUCTION

The completion of a restorative procedure on a tooth undergoing endodontic treatment (DTE) is given by the recovery of its anatomy and function, whether it is made directly through the use of composites directly or indirectly through the cementation of ceramic elements (Bijelic-Donova, Keulemans, Vallittu, & Lassila, 2020).Therefore, the amount of tooth remnant is not always sufficient to support any of the options described above, considering the loss of cusps and ridges as a consequence of the carious process, endodontic access cavities (Fuss, Lustig, & Tamse, 1999) and trauma resulting from the reduction of proprioception after endodontics (Garlapati, Krithikadatta, &

Natanasabapathy, 2017). In these cases, it is necessary to use materials capable of expanding coronary support and preventing the propagation of fractures (Garlapati et al., 2017).

As materials traditionally described in the literature (Figueiredo, Martins-Filho, & Faria-E-Silva, 2015), intraradicular retainers are widely used in daily clinical practice, in anterior and posterior teeth, as elements that can offer the desired coronary support in DTE. Among them are cast or prefabricated metal cores, which no longer have advantages in terms of the longevity of the dental element and have fallen into disuse (Gaintantzopoulou, Farmakis, & Eliades, 2018). Fiber-reinforced pins, on the other hand, continue to be widely used due to their aesthetic and mechanical characteristics, such as the lower risk of catastrophic failure considering their modulus of elasticity (20 GPa) similar to dental dentin (≈ 18.6 GPa) (Gaintantzopoulou et al., 2018). However, recently, some studies have been published with a change of concept about the use of retainers, since, although easy to use, there is a relatively high number of technical failures in the preparation of the conduit, choice of retainer material and cementation protocol, leading to losses in the restoration and, in more drastic cases, trepanation and loss of the tooth element (Garlapati et al., 2017;Mena-Álvares, Agustín-Panadero, & Zubizarreta-Macho, 2020). Also in view of their limitations of adhesion to dentin and disadvantages of use, minimally invasive techniques of DTE restorations become an advantageous advance in Dentistry (Cimpean et al., 2020).

With the development of adhesive systems and new fiber-reinforced resin composite materials (CRRF), new studies have been released on a "no post" philosophy (Garlapati et al., 2017). These materials are presented as possible substitutes for the use of retainers and other composite resins, since they act as reinforcement and replacement of dentin, increasing fracture resistance and flexural modulus (Kassis et al., 2020; Kaur et al., 2021). This technique, also called "wallpapering technique", is a valuable tool for increasing the longevity of the restoration of structurally compromised vital and non-vital teeth, through the protection of the cavity walls with reinforcement fibers, favoring the prognosis of rehabilitation (Delipere, Alleman, & Rudo, 2017). Thus, in non-vital teeth, the amount of remaining tooth element takes on a new importance in the treatment, given the existence of a fiber with biomimetic properties that can be placed as a filling nucleus before the final restoration (Rocca et al., 2015; Scotti et al., 2020).

There are several CRRF of various diameters, lengths, and fiber orientations developed in the dental market (Rocca et al., 2015), and the Posterior EverX (GC) (EVXP), although not yet available in Brazil, has emerged as a restorative base option (Garlapati et al., 2017). The material is composed of a resin matrix, 25% randomly oriented glass fibers (E-Glass), and inorganic particle fillers (Tanner, Tolvanen, Garoushi, & Säilynoja, 2018; Keuleman, Garoushi, & Lassila, 2017; Garoushi, Gargoum, Vallittu, & Lassila, 2018). The resin matrix is formed of bisphenol-A-diglycidyl-dimethacrylate (bis-GMA), triethylene glycol dimethacrylate, and polymethylmethacrylate, forming a matrix called semiinterpenetrating polymer network (semi-IPN), which provides improved binding properties for increased polymer matrix toughness (Keulemans et al. 2017; Garoushi et al., 2018). According to the manufacturer, their volumetric contraction is significantly lower (0.17%) compared to other materials and, therefore, they enable polymerization in large increments (Tanner et al., 2018; Baraba et al., 2021), in addition to having fibers with a high capacity to reinforce restorations avoiding fractures, which is one of the main causes of post-endodontic restoration failures (Garlapati et al., 2017).

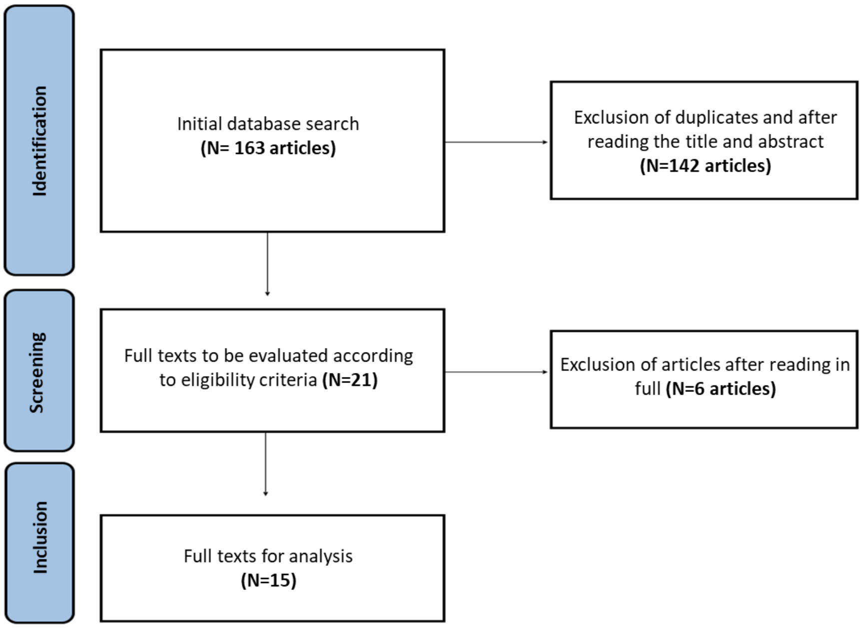
The aim of this study was to conduct a literature review to expose the "no post" philosophy through the use of the fiber-reinforced resin composite, EverX Posterior (GC), in the restoration of endodontically treated teeth. In addition to exploring in the scientific literature if the same material presents any advantage of use compared to the other restorative materials and techniques already described in scientific articles.

2 METHODOLOGY

The following descriptors and their combinations in English were used to search for the articles: "composite resins", "EverX Posterior", "nonvital tooth", "permanent dental restoration" and "Post and core technique", indexed in DeCS/Mesh. The databases Pubmed, Scopus, Web of Science, as well as the gray literature, represented by Google Schoolar and Pro-Quest, were used. The inclusion criteria defined for the selection of articles were: articles in English and indexed in the aforementioned databases in the last 10 years, in vitro and clinical studies, articles that fully portrayed a comparison between the use of fiber-reinforced composites, particularly EverX Posterior (GC), and other forms of restoration of endodontically treated teeth. The research was expanded as necessary by searching the references of the selected articles and the main journals with publications in the area, and the results provided were also included as part of the study.

The number of articles selected at the time of identification in the databases, followed by their screening and final inclusion according to the eligibility criteria of the study are schematized in the following diagram (Flowchart 1).**LOWCHART**

1 - Criteria for identification, screening and inclusion of studies in the literature review following the PRISMA format.



Source: PRISMA format (http://prisma-statement.org).

In this flowchart, it is possible to observe the number of articles evaluated, excluded and selected for final analysis.

3 RESULTS AND DISCUSSION

The main results corresponding to the 15 articles selected by the research eligibility criteria are described in Table 1 and Figure 1 below.

Table 1: Summary of the main data of the articles selected for the study (continued).

Author and year of publication	Study design	Location	Materials Compared	Results
Baraba et al. (2021)	Ex vivo	Molars	Composite Resin (G–ænial Posterior, GC) Fiber-reinforced composite (EverX Posterior, GC)	There was no statistically significant difference between the two materials and the control (p = 0.4617).
Bijelic-Donova et al. (2020)	In vitro	Mesio-occluso-distal (MOD) cavities of 3rd mandibular molars	Composite Resin (GC Posterior) Fiber Reinforced Composite (EverX Posterior, GC)	The inclusion of the Posterior EverX influenced the type of fracture, resulting in the majority of repairable fractures (67–75%).
Cimpean et al. (2020)	In vitro	Premolar MOD	Fiberglass Pin (Reforpost, Angelus) Fiber-reinforced composite (EverX Posterior,GC)	EverX Posterior showed higher fracture resistance values, being more resistant than those reinforced with fiberglass pins.

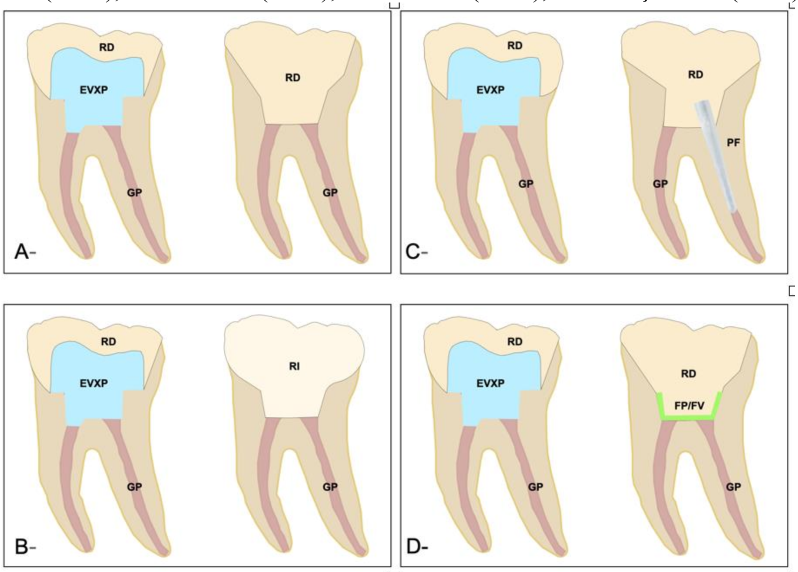
Frankenberger et al. (2021)	In vitro	MOD, Partial and Total Crowns of Mandibular Molars	Composite resin (Tetric EvoCeram BulkFill); Fiber-reinforced composite (EverX Posterior) Indirect Restoration EMAX CAD Indirect Restoration Celtra Duo Indirect Restoration Indirect Zirconia Restoration Indirect Metallic Restoration (Ketac Cem).	There was no statistical difference in fracture strength between the Tetric EvoCeram and EverX Posterior groups. All indirect restorations showed promising performance after the fatigue test.
Gaintantzopoulou et al. (2018)	In vitro	Tongue cusps of maxillary 1st premolars	Fiberglass Pin (Glassix) Fiber-reinforced composite (EverX Posterior) + restoration	There was no statistically significant difference between the groups in the mean values of fracture load, but the Posterior EverX significantly modified the failure mode.
Garlapati et al (2017)	In vitro	MOD of 1st molars	Hybrid resin (Te-Econom Plus, Ivoclar) Polyethylene fibre Fibre reinforced composite (EverX Posterior,GC).	The highest fracture resistance value was found in the Posterior EverX group.
Kassis et al. (2021)	In vitro	MOD, inlays, Onlays and endocrowns of 3rd Mandibular Molars	Composite resin (G–ænial posterior, GC) Fluid Resin (G-anial Universal Flow, GC) Fiber-reinforced composite (EverX Posterior, GC) Indirect Restoration (CERASMART)®	Endocrown indirect restorations have higher fracture resistance than other groups, being significantly lower for inlays, intermediate for onlays with Posterior EverX followed by onlays with G-aenial Universal Flo.
Kaur et al. (2021)	In vitro	Upper premolars MOD	Composite Resin (FILTEK P60) Bulk-fill resin (TETRIC-N-CERAM BULK FILL) Dual core resin (LUXACORE Z DUAL) Fiber-reinforced composite (EverX Posterior, GC)	The Posterior EverX showed increased mean fracture resistance compared to the other groups.
Mena-Alvarez et al. (2020)	In vitro pilot study	MOD of 1st Maxillary Premolars	Fiberglass Pin Elastic Fiber Pin (Gradia Core, GC) Fiber-reinforced composite (Everx X Posterior, GC) Composite Resin(Gradia Core, GC)	The highest fracture strength value was found in the fiberglass pin and EverX Posterior group and the lowest value in the insulated fiberglass pin.
Ozsevik et al. (2015)	In vitro	Mandibular molars	Composite resin (G–ænial posterior, GC); Polyethylene Fiber (Ribbond; Seattle, WA, USA) Fiber-reinforced composite (Posterior EverX, GC)	Posterior EverX showed higher fracture resistance compared to the other groups.
Rocca et al. (2015)	In vitro	Overlay on molars	Composite resin (G–ænial posterior, GC); Fiberglass ((EverStick NET, GC) Fiber-reinforced composite (EverX Posterior, GC) Indirect Restoration (Lava Ultimate, 3M ESPE)	No significant differences were found between the groups ($p>0.05$) and the use of EverX Posterior to reinforce the "core" against vertical fractures under static loads seems useless when the thickness of the CAD/CAM composite resin restoration is high.
Scotti et al. (2020)	In vitro	Upper premolars MOD	Fiber-reinforced composite (EverX Posterior GC) Composite Resin (Filtek Supreme XTE) Fiberglass (EverStick NET, GC) Fluid Resin	No differences in fracture strength were found between Filtek Supreme XTE and EverX Posterior; In addition, the fiberglass insertion did not significantly improve fracture strength in either case.

			(G-anial Universal Flow, GC) Composite Resin (FSXTE, 3M)	
Tanner et al. (2018)	Clinical Trial	Molars and premolars	Fiber-reinforced composite (EverX Posterior, GC)	The overall survival rate of 36 EverX Posterior restorations was 97.2% at a 2.5-year follow-up.
Tekce et al. (2017)	In vitro	MOD of 1st Mandibular Molars	Polyethylene Fiber (Ribbond; Seattle, WA, USA) Composite Resin (G Aenial Posterior, GC) Composite Resin (G Aenial Flo, GC) Fiber-reinforced composite (EverX Posterior, GC)	The polyethylene fiber-reinforced composite groups showed fracture strength results similar to EverX Posterior.
Yasa et al. (2016)	In vitro	MOD1st molars	Nano-hybrid composite resin (Filtek Z550) Bulk-fill flow resin (Filtek Bulk Fill) Fiber-reinforced composite (EverX Posterior,GC).	Posterior EverX with retentive cavities showed significantly higher fracture strength values compared to the other test groups ($p < 0.05$).

Source: Prepared by the author.

In this table, readers can observe the main results obtained in the selected articles, as well as the materials used in each one.

FIGURE 1: Schematic illustration of dental restoration models found in the articles. A - EVXP versus direct (RD) restorations found in Baraba et al. (2021), Bijelic-Donova et al. (2020), Frankenberger et al. (2021), Garlapati et al. (2017), Kaur et al. (2021), Mena-Alvarez et al. (2020), Ozsevik, Yildirim, Aydin, Culha, and Surmelioglu, (2015), Scotti et al. (2020), and Yasa et al. (2015). B - EVXP versus indirect restorations (IR) found in Frankenberger et al. (2021); Kassis et al. (2021) and Rocca et al. (2015) C-EVXP versus glass fiber pin (PF) found in Cimpean et al., (2020), Mena-Alvares et al. (2020), and Gaintantzopoulou et al. (2018); D- EVXP versus polyethylene (FP) or glass (FV) fiber found in Garlapati et al. (2017), Oszevik et al. (2015), Rocca et al. (2015), Scotti et al. (2020), and Tekçe et al. (2017). GP= gutta percha.



Source: prepared by the author.

The figure illustrated above facilitates the understanding of the comparisons made in the selected scientific articles.

3.1 COMPARISON OF POSTERIOR EVERX *VS.* DIRECT RESTORATIONS IN NON-VITAL TEETH

Direct restorations using conventional composite resin (RC) have been used for decades by restorative dentistry on vital and non-vital teeth. However, depending on the amount of remaining dental tissue and added to the limitations of the technique, such as polymerization contraction, failures may occur, leading to the propagation of fractures, for example (Frankenberger et al., 2021; Yasa et al., 2016). In non-vital teeth, the characteristics of the pulp chamber floor contribute to an even more challenging adhesion surface for restoration, considering the presence of open dentin tubules and the action of irrigants, such as sodium hypochlorite, altering the organic and mineral content of the dentin (Kijsamanmith, Timpawat, Harnirattisai, & Messer, 2002; Baraba et al., 2021). Described in the literature as a "bilayer restoration", the use of CRRF emerges as a basic option for restorations with this extensive loss of dental tissue (Behr, Rosentritt, Latzel, & Handel, 2003); Bijelic-Donova et al., 2020).

3.1.1 Influence of restorative material on bond strength to microtensile in non-vital teeth

To prove the differences in dentin composition and test the materials described above, Baraba et al. (2021) compared CRRF with particulate CR, evaluating their microtensile bond strength to coronary dentin and pulp chamber floor in non-vital molars. The test was performed by applying a tensile load at a speed of 0.5 mm/min until the fracture. The results showed different strengths between EVXP (22.91 ± 14.66 MPa in the coronary dentin and 14.00 ± 5.83 MPa in the floor dentin) and CR (24.44 ± 13.72 MPa in the coronary dentin and 12.10 ± 8.89 MPa in the dentin of the pulp chamber floor), but stated that the values were not influenced by the type of composite used for the construction. Therefore, the two options were equally favorable for the restoration of vital and non-vital teeth. As this was an in vitro study, the authors clarified that further studies would be needed and that the use of a self-etching adhesive could explain the low bond strength obtained in the dentin of the pulp chamber floor in both cases (Lohbauer, Nikolaenko, Petschelt, & Frankenberger, 2008).

3.1.2 Influence of restorative material on masticatory fracture strength in non-vital teeth

Parallel to this analysis, a series of studies (Frankenberger et al., 2020; Bijelic-Donova et al., 2020; Kaur et al., 2021; Garlapati et al., 2017; Yasa et al., 2016, Ozsevik et al., 2016; Mena-Alvarez et al., 2020) evaluated the masticatory fracture resistance of compromised teeth directly restored with CR in the presence and absence of CRRF as a reinforcement baseline. One of these studies was that of Frankenberger et al. (2021), who also evaluated the marginal behavior in mesio-occluso-distal (MOD) cavities of non-vital molars, restored with RC BulkFill and universal adhesive system and others with CRRF as lining. The tests were performed by applying a force of 100 N and, similar to the previous study, there was no difference between both materials regarding fracture strength ($p>0.05$), but the teeth restored by EVXP as a "bilayer" presented more margins free of failures, i.e., less gap formation at the restoration-enamel interface. Therefore, although with favorable reports, the new biomaterials behaved with similarity in vitro to the biomaterials already used (Carvalho, Lazari, Gresnigt, Del Bel Cury, & Magne, 2018).

Yasa et al. (2016) studied the efficiency of restorative materials in 3 mm thick MOD cavities, in the presence and absence of retention grooves in the buccal and lingual walls of mandibular molars. Significantly, the presence of retentive grooves of 1.5 mm long x 1.5 mm wide and 2/3 of the height of the cavity wall influenced the analysis ($p<0.05$), according to the considerations of Kassis et al. (2021). The authors concluded that EVXP with retentive cavities presented higher fracture strength values compared to the other groups, represented by nano-hybrid RC and BulkFill Flow RC as base. Bijelic-Donova et al. (2020), comparing samples of third molars with oblique reinforcement increments of 2 mm, submitted to mastication tests (1.5Hz) with a load of 85 N and in static load tests, also found advantages in the biomaterial. In this study, the majority (75%) of the restorations with direct CR alone, i.e., without CRRF, fractured unfavorably below the cementoenamel junction (JCE), in vital and non-vital teeth, while the reinforcement of EVXP was beneficial in terms of fracture mode, both for vital teeth (75% of restorable fractures) and for non-vital teeth (66.7% of restorable fractures). with fractures above the JCE.

Recently, Kaur et al. (2021) produced a study on maxillary premolars and, similarly to the authors above, also reported greater resistance in the groups restored with EVXP (909.2 N) as the filling core, compared to BulkFill CR (564N), particulate CR, and Dual-cure CR (592N) ($p<0.0001$), when subjected to a vertical load along the tooth axis at a speed of 1mm/min. For these authors (Kaur et al., 2021; Eapen, Amirtharaj, Sanjeev, & Mahalaxmi, 2017; Kumar & Sarthak, 2018), the increase in average strength can be explained by the support provided with the short fiber substructure of this resin composite, which receive the stresses and function as crack buffers. Mena-Alvarez et al., (2020), in load tests of 80N and 0.5mm/s, on the same dental elements, also found greater resistance for the EVXP group (3040N) compared to the conventional CR (2560N). In congruence, but in mandibular molars, Garlapati et al. (2017) found higher results for the group with EVXP (1994.8N), compared to only hybrid CR (1418.3N). The lower strength of the straight composites can be explained due to their polymerization contraction, resulting in marginal breaks, while the higher strength of the CRRF can be explained by its short glass fibers that, at the appropriate length, can function as a reinforcement for force distribution (Garlapati et al., 2017; Garoushi et al., 2007; Vallittu, Lassila, & Lappalainen, 1994)

Confirming the studies mentioned above, Ozsevik et al. (2015) also found favorable results for EVXP, with higher values (2550.7N) and very similar to intact molar teeth, compared to DR (1489.5N). Although it has been reported as an advantageous material based on the in vitro studies, only one clinical pilot study has been performed (Tanner et al., 2018) in posterior teeth with a follow-up of 2.5 years. In this study, by means of photographic and radiographic records of the treatment, of 36 restorations with EVXP material, the overall survival rate was 97.2% and the success rate of performing the restoration without failure was 88.9%, indicating with caution, as this is a non-randomized pilot study, that direct CRRF restorations in the "bilayer" technique present a good clinical performance in the short-period evaluation.

Only one article performed a complementary methodology to the analyses (Scotti et al., 2020) using microcomputed tomography to assess the presence of a gap between the restoration and the tooth element before and after the chewing simulation. A major advantage of EVXP found was the significant reduction of gaps when incorporated with glass fibers, since DRs cause a greater polymerization contraction when used alone and, as a consequence of the decrease in volume, the formation of gaps for stress relief occurs, causing microinfiltration (Gordan, Shen, Riley, & Mjör, 2006). However, it is important to emphasize that, regarding the strength of the material, no statistical difference was found ($p>0.05$).

3.2 COMPARISON OF POSTERIOR EVERX VERSUS INDIRECT RESTORATIONS IN NON-VITAL TEETH

Endodontically treated teeth are already considered elements of low resistance and resilience, considering the substantial loss of tooth structure (Kassis et al., 2021). For this reason, lab-made partial or full crowns are typically one of the treatment options chosen by dentists (Alshiddi & Aljinbaz, 2016). Another approach that has emerged as a treatment option for these large cavities is CRRF, as a substitute for dentin and which require further clinical investigations (Garoushi et al., 2018).

Frankenberger et al. (2021) studied the fracture strength behavior of CRRF, represented by EVXP, compared to indirect restorations (IR), represented by partial (endocrows) and total crowns of lithium disilicate, zirconia, and molten gold, cemented by various materials. Comparing only the IR, partial and total crowns of any of the evaluated materials did not obtain significant differences in relation to the evaluated strength ($p>0.05$). On the other hand, in comparison with the group restored with EVXP, the partial coverage (endocrown) was more effective in both marginal behavior and fracture. On the other hand, the zirconia and cast gold crowns were the ones with the highest resistance value among all the materials evaluated, being superior even to healthy teeth ($p<0.05$). Thus, the authors claimed that IR presents a more promising performance, in relation to the test performed, as rehabilitation material.

Confirming the result mentioned above, Kassis et al. (2021) also performed a comparison between EVXP and IR of the endocrowns type made in the CAD/CAM system. These authors claimed in their results that fracture strength was higher in endocrowns (p=0.021) compared to the material in question, since this type of rehabilitation uses the pulp chamber to increase stability through adhesive cementation (Altier, Erol, Yildirim, & Dalkilic, 2018). However, a slight difference in relation to the previous study was found, stating that the highest fracture resistance was obtained in healthy teeth, followed by IR. Thus, it is observed that endocrown, in this literature review, presented an advantage over the tested material and can be an interesting treatment option, since it requires a less invasive preparation than the use of intraradicular retainers, reducing clinical steps of conduit preparation, cementation of retainers and construction of filling nuclei (Rocca et al., 2015; Pashley et al., 2011).

Regarding the IR of hybrid resins, the results also showed lower values in the glass-reinforced biomaterial. Rocca et al. (2015) reported a resistance of 2429N in EVXP compared to 2817N in the hybrid RC made in CAD/CAM, in the overlay preparation configuration, applied an axial occlusal load (49N) at a speed of 1 mm/min. In the evaluation of fracture mode, however, all groups evaluated fractured catastrophically, below the JCE, suggesting that the use of CRRF in large cavities as the "core" of thick resin restorations is useless in strength. Kassis et al. (2021) also pointed out that cavity design can influence the strength of the material when performing tests on MOD cavities (inlays) and also on onlays restored with hybrid RC made in CAD/CAM. Their results showed that resistance was higher in healthy teeth, followed by onlays with CR, intermediate for onlays with EVXP and lower for MOD cavities, both with CRRF and RC. Thus, CRRF presented a lower condition than indirect hybrid CR as a base material for restorations, perhaps due to the need for retentive grooves to avoid cusp fracture (Atalay et al., 2016).

3.3 POSTERIOR EVERX COMPARISON VS. INTRARADICULAR RETAINERS IN NON-VITAL TEETH

The use of intraradicular retainers, especially glass fiber (PF) pins, is widely recommended in the literature in order to provide greater retention for restorative materials, considering their modulus of elasticity more similar to dentin. (Saker & Özcan, 2015; Nothdurft et al., 2018, Mena-Alavarez et al., 2020). However, new materials with different properties have been tested to ensure a better prognosis in the treatment of non-vital teeth subject to endodontics (Mortazavi et al., 2012; Mena-Alvarez et al., 2020).

Mena-Alvarez et al. (2020), in MOD cavities of maxillary premolars, compared the fracture strength of glass and elastic PF with EVXP, in an isolated and combined manner. Considering the technique adopted, the preparation of the conduit was performed by leaving the apical sealing of 4 mm of gutta-percha in the canal. The resistances found, in ascending order, were 2420N for the group with only PF glass, 3040N for only EVXP, 3510N for the group with only elastic PF, 3520N for elastic PF with EVXP and 3620N for PF glass with EVXP. Considering the control group (3290N), the presence of glass-reinforced composites inside the channel and as a filling core improved the biomechanical behavior, increasing the fracture resistance of the specimens.

Other studies have also considered EVXP as the treatment of best choice (Cimpean et al., 2020; Gaintantzopoulou et al., 2018). Cimpean et al. (2020) reinforced that the new biomaterial represents being a good substitute for dentin in large cavities, such as MOD cavities, compared to glass PFs. In their analysis, the use of CRRF as a "bilayer" with a microparticulate CR increased the fracture strength (1159.42N) twice as much as the value obtained only with the use of the intraradicular retainer (522.35N). Obviously, the use of these materials increases coronary reinforcement compared to those teeth in the absence of it, but they remain the weakest link in adhesion (Cimpean et al., 2020). EVXP, on the other hand, contains multidirectional E glass fibers, preventing the propagation of cracks in the restoration, in addition to having a diameter of 16 µm and a length between 1 and 2 mm, which alter the fracture mode and increase its resistance (Garoush et al., 2017; Abouelleil et al., 2015).

Gaintantzopoulou et al. (2018) verified the effect of restorations on lingual cusps of premolars subjected to the load cycle. The authors did not find statistically significant differences (p=0.273) in fracture load between the groups, being 860N for glass PF and 1059N for EVXP, in a 4-mm layer and covered by particulate CR. But, interestingly, 60% of the samples with the first material fractured catastrophically in the roots and 40% fractured in a mixed way, in the cusp and restoration region. Differently from this result, the new material did not present any root fractures, only coronal fractures at JCE (p=0.004).

3.4 COMPARISON OF POSTERIOR EVERX VS. POLYETHYLENE OR GLASS REINFORCING FIBER IN NON-VITAL TEETH

Teeth subjected to endodontic treatments are fracture-prone and, according to the scientific literature already published on the subject (Garlapati et al., 2017, Eskitaşcioğlu, Belli, & Kalkan, 2002; Belli, Erdemir, Ozcopur, & Eskitascioglu, 2005), one form of prevention is the use of CRRF. Other materials used are polyethylene (FP) and glass (PV) fibers, which have higher fracture strength and flexural modulus (Belli, Erdemir, & Yildirim, 2006; VALLITTU, 1998; Garlapati et al., 2017). They also have the property of absorbing and distributing the occlusal force generated for the dental element, as they function as a "monoblock" positioned between the direct or indirect restorative material and the dentin (Garlapati et al., 2017; Ayna, Celenk, Atakul, & Uysal, 2009).

Garlapati et al. (2017) conducted a study with the aim of highlighting the differences between these two materials. The study evaluated the fracture toughness of MOD cavities restored with EVXP compared to VFs, in a technique also called "wallpapering technique" (Valizadeh, Ranjbar Omrani, Deliperi, & Sadeghi Mahounak, 2020). The authors claimed that, by means of the force applied at a speed of 0.5 mm/min, the DTE restored with EVXP (1994.8N) showed superior resistance to the other group analyzed (1716.7N). They also stated that PVs have longitudinal orientation, ensuring their shear strength (Kalburge, Yakub, Kalburge, Hiremath, & Chandurkar, 2013), while CRRF has fibers with random orientation, important for their mechanical properties, such as polymerization contraction (Garlapati et al., 2017). In another corresponding study (Ozsevik et al., 2015), the glass-reinforced resin biomaterial also showed higher strength compared to the other fibers. Ozsevik et al. (2015) demonstrated resistance of 2550.7N for EVXP versus 1958.3N for PF. In addition, they highlighted the difference in the clinical stage, since the new biomaterial is easier to apply in the smaller dental cavity, or even in molars, as in the test carried out in the study.

An evaluation with fiber overlap was found in 2 in-vitro studies (Rocca et al., 2015; Scotti et al., 2020). In them, the samples were divided into isolated conditions, i.e., some restored with CRRF as a reinforcement base and others with VF, and also in an overlapping condition, with VF immersed in the biomaterial. In the study by Scotti et al. (2020), the VFs have a dimension of 10 mm x 3 mm inserted in the MOD cavity, followed by the 2 mm EVXP and the micro-hybrid CR cover. The results showed resistances of 465.36N for EVXP alone, 499.79N for PV alone, and 515.96N for EVXP with VF, respectively, indicating that the use of CRRF with VF presented positive results as a treatment option ($p<0.05$). However, in the evaluation of the fracture mode, the presence of the fiber was unable to alter its propagation, which, in all groups evaluated, occurred above the JCE. According to the still scarce literature on the subject, many factors can influence the reinforcement function, such as the shape and direction, the fiber-resin ratio, and the bond strength between them, and more research is needed to define the best protocol to be used (Scotti et al., 2020; Belli, Cobankara, Eraslan, Eskitascioglu, & Karbhari, 2006).

In the study by Rocca et al. (2017), 3 layers of a PV network of 0.06 mm thickness and 6 mm x 6 mm width and length ratio were inserted into the cavity of the overlay type above the 2 mm EVXP and then the hybrid CR made in the CAD/CAM system. The resistance values were: 2128.125 N and 2429.25 N for the isolated PV and EVXP conditions, respectively, and 2577.25 N for the superposition. Although the values differed between the groups, there was no statistical difference ($p>0.05$) between them and all of them presented catastrophic failure, so the incorporation of fibers in non-vital teeth did not trigger any gain to increase the load capacity or improve the failure mode. Another form of evaluation described by Tekçe et al. (2017) was to investigate the effect of the direct and indirect fiber polymerization method on fracture strength. The type of polymerization of the fiber under the 4 mm BulkFill composite did not alter the fracture strength results, which remained similar ($p> 0.05$) with 2142.9N for EVXP, 2254.1 and 2228.6N for PV polymerized directly and indirectly, respectively. The polymerization requirement is an important point for material analysis, since the ideal mechanical properties of composites are closely related to their complete polymerization (Ferracane & Greener, 1986)

3.5 LIMITATIONS OF THE STUDY

This literature review presents its limitations, mainly because it compares inhomogeneous studies regarding the tooth analyzed, the size of the cavity prepared for restoration, the preparation of specimens and the restoration protocol, with adhesive systems and choice of different composite resins. It also addresses a large number of in vitro studies, in which tooth samples are subjected to a heterogeneity of tests for aging by thermal cycling and compressive loads in various forces and directions, therefore presenting some limitations in terms of simulation of intraoral clinical conditions.

4 FINAL CONSIDERATIONS

It is concluded that the use of CRRF, especially the Posterior EverX (GC), presents a good performance in in vitro studies as a form of restoration of endodontically treated teeth. The analyzed material showed higher fracture strength in most of the studies selected in this literature review, compared to direct restorations, intraradicular retainers, and polyethylene and glass reinforcement fibers. However, indirect restorations, especially of the endocrown type, showed a more promising behavior in the articles evaluated, compared to the new biomaterial. Further clinical studies should be carried out to substantiate the considerations about the "no post" philosophy described.

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