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EVALUATION OF SHRINKAGE AND POLYMERIZATION SHRINKAGE STRESS IN RESIN COMPOSITES REINFORCED BY NANOFIBERS – INTEGRATIVE LITERATURE REVIEW

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Abstract: Even though it is considered a key factor in the clinical failure of the restoration, the **shrinkage** and polymerization **shrinkage** stress associated with resin composites reinforced by nanofibers have been little explored. Thus, the present study aimed to carry out an integrative literature review to evaluate the **shrinkage** and polymerization stress in resin composites reinforced by experimental nanofibers and available in the dental market, allowing support for decision-making in clinical practice. The MEDLINE-PubMed, Embase, Web of Science, Scopus, VHL (LILACS, BBO and IBECS), Cochrane, LIVIVO databases were used, without limitations regarding language and year of publication. The inclusion criteria used for the selection of articles were: in vitro studies, with no language restriction, published in the selected databases, with texts available in full and on the subject in studies. It was possible to analyze through this integrative literature review that more studies are needed to evaluate the polymerization shrinkage of resin composites reinforced by nanofibers and the effect of shrinkage stress. In general, the properties change according to the orientation of the fibers, and the short fibers seem to promote a lower rate of polymerization shrinkage.
Keywords: Polymerization shrinkage. Nanofibers. Composite resins.

INTRODUCTION

Since the advent of resin composites, increasing improvements have been taking place for the development of more resistant composite materials, in order to achieve greater success in restorations, especially in areas of high masticatory effort (Correa et al. 2012; Nascimento et al. 2013). In posterior teeth, fracture of restorations and polymerization stress have been considered as major causes related to restoration failures over time (Demarco et al. 2017). The volumetric contraction of resin composites induces **shrinkage** stress at the material/cavity wall interface, generating the formation of interfacial gaps and enabling the circulation of dentine fluids. The result can lead to degradation of the adhesive interface, increasing the susceptibility of caries development adjacent to the restorative material (Ferracane, 2008; Garoushi et al. 2013; Mantri and Mantri, 2013), postoperative sensitivity, development of cracks in the surrounding walls, and marginal staining of the restoration.

Although the polymerization stress is dependent on several factors, the composition of the restorative material plays a key role in relation to the magnitude and kinetics of shrinkage (Mantri and Mantri, 2013). Therefore, new composites have been developed, improving the mechanical properties of restorative materials and minimizing the polymerization **shrinkage** stress (Santin et al. 2021; Mantri and Mantri, 2013).

Nanofiber-reinforced composite resins have been introduced in the dental market and experimental resins have been developed, demonstrating significant improvement in physical-mechanical properties (Vidotti et al. 2015; Salek et al. 2018; Velo et al. 2019; Obeid et al. 2022). The increase in matrix strength and toughness of nanofiber-reinforced composites is mainly due to the reduced diameter and alignment of the nanofibers when compared to inorganic fillers. Under masticatory stress, if a microfracture is initiated in the resin matrix, the nanofibers function as a "bulk", supporting the applied load and dispersing the tension, which keeps the nanofiber intact (Lassila et al. 2005; Chen et al. 2011; Sharma et al. 2019; Velo et al. 2019).

Even though it is considered a key factor in the clinical failure of the restoration, the

shrinkage and **shrinkage** stress associated with resin composites reinforced by nanofibers have been little exploredIt was demonstrated that a commercial resin reinforced by nanofibers presented similar shrinkage stress to the conventional resin, suggesting that there is no advantage in the use of composite resins reinforced by nanofibers compared to traditional hybrid resins (Yancey et al., 2019). The possibility of the formation of internal gaps, as well as postoperative sensitivity, justify the need for elucidation of the shrinkage and polymerization stress of nanofiber reinforced resin composites.

Thus, the present study aimed to carry out an integrative literature review to evaluate the contraction and polymerization stress in composite resins reinforced by experimental nanofibers and available in the dental market, allowing support for decision-making in clinical practice. Through the researched literature, the scientific question was: "Do composite resins reinforced by nanofibers present less **shrinkage** and polymerization **shrinkage** stress than traditional resin composites? "

METHODOLOGY

The present research method summarized the analysis of published studies in order to provide general conclusions on the subject. The elaboration of this integrative review took place considering the six necessary steps (Mendes et al. 2008): (1) Selection of the study hypothesis; (2) Inclusion and exclusion criteria for articles; (3) Definition of information to be extracted from selected studies; (4) Evaluation of included studies; (5) Interpretation of results and (6) Synthesis and presentation of the review.

The MEDLINE-PubMed, Embase, Web of Science, Scopus, VHL (LILACS, BBO and IBECS) databases were used, without limitations regarding language and year of publication. The descriptors used for the article were: ("resin composite", "composite resins", "composite", "composites" first studied separately and then joined by the Boolean AND operator, alternating with the OR operator, including the terms: "fiber", "fibers", "nanofiber", "nanofibers", "dental", "material", "materials", "Glycidyl bisphenol A methacrylate", "Bis GMA", "shrinkage", "polymerization shrinkage stress". The inclusion criteria used for the selection of articles were: *in vitro* studies, with no language restriction, published in selected databases, with texts available in full and on the subject in studies.

The strategies used to survey the articles were adapted for each database, according to the main theme of the research, taking into account the inclusion criteria and the guiding question. Initially, a total of 3214 articles were found and, after considering the inclusion criteria and research question, 8 articles were included.

The analysis of the articles was independently conducted by 2 researchers. After careful analysis of the studies, the synthesis was performed exposing the main results obtained and interpreted.

RESULTS AND DISCUSSION

The present work aimed to carry out an integrative literature review to evaluate the **shrinkage** and polymerization **shrinkage** stress in resin composites reinforced by experimental nanofibers and available in the dental market, allowing support for decision-making in clinical practice. In the field of dental materials, technical-scientific advances occur quickly and the amount of information together with the limited time of professionals has driven the development of strategies that provide concise paths to research results. (Mendes et al. 2008).

The integrative review is a method that

allows readers to get to know the main researchers on the subject, offers a scientific basis and describes the current state of the art, facilitating choices for clinical practice and even boosting new research in the area. (Roman and Friedlander, 1998; Mendes et al. 2008). Table 1 describes the main results related to the included studies.

In general, it was observed that the interaction between the resin matrix and the fillers significantly influences the polymerization shrinkage of the resin composites. As the interface between the resinous matrix and the inorganic filler increases, less contraction is expected (Kleverlaan and Feilzer, 2005; Visvanathan et al. 2007). In the study by Amiri et al. (2021), it was observed that the polymerization shrinkage of a resin reinforced by nanofibers that were previously treated on the surface, decreased the polymerization shrinkage by 37%, due to a good adhesion interface that occurs between the nanofibers and the organic matrix of the resin.

Studies in general suggest that resin composites reinforced with short nanofibers within the organic matrix promote a lower rate of contraction or polymerization stress compared to particulate filler composites (Garoushi et al. 2008; Yancey et al. 2019; Borges et al. 2019; Tsujimoto et al. 2016; Bocalon et al. 2016). Compared to commercial composites, GC's EverX Posterior fiber reinforced resin has a lower shrinkage rate (0.17%) compared to other short fiber reinforced composites (Alert – SYNCA), bulk fill composite resin and glass/ conventional pottery. The properties vary according to the orientation of the fibers in anisotropic materials and, therefore, the shrinkage changes depending on the orientation (Garoushi et al. 2013).

In conclusion, it was possible to analyze through this integrative literature review that more studies are needed to evaluate the polymerization shrinkage of resin composites reinforced by nanofibers and the effect of shrinkage stress. In general, the properties change according to the orientation of the fibers, and the short fibers seem to promote a lower rate of polymerization shrinkage.

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Reference	Resin composite	Results of volumetric polymerization shrinkage (CPV - %) and linear polymerization shrinkage (CPL - %)
Amiri et al., 2021	Experimental	Polymerization shrinkage significantly decreases by 37% for nanofiber reinforced composite compared to pure resin
Borges et al. 2019	Experimental	The smallest shrinkage of volumetric polymerization was observed at the concentration of 20% with no difference for 10% of nylon-6 nanofibers with carbon nanotubes
Yancey et al. 2019	NovaPro Fill, Nanova (nanofiber-reinforced hybrid composite); (2) Filtek Z250, 3M ESPE; (3) Esthet-X HD, Dentsply	NovaPro Fill showed volumetric polymerization shrinkage similar to Esthet-X HD, but greater than Filtek Z250
Bocalon et al. 2016	Experimental	The incorporation of 6% long fibers decreased the volumetric polymerization shrinkage
Tsujimoto et al. 2016	EverX Later; TetricEvoCeram Bulk Fill; SureFil SDR Flow; Z100 Restorative; Tetric EvoCeram; Clearfil AP-X	EverX Posterior showed improvements in volumetric polymerization shrinkage over Z100 Restorative, Tetric EvoCeram and Clearfil AP-X
Wang et al. 2016	Experimental	SiO2 nanofibers improved the behavior of Bis-GMA/ TEGDMA, decreasing volumetric polymerization shrinkage
Garoushi et al. 2013	EverX Later; TetricEvoCeram Bulk Fill; Voco X-tra base; SDR; Venus Bulk Fill; SonicFill; Filtek Bulk Fill; Filtek Superme; Filtek Z250; alert	EverX Posterior showed less volumetric polymerization shrinkage compared to conventional resins and bulk fill
Garoushi et al. 2008	Experimental	The experimental resin with short glass fibers showed less volumetric polymerization shrinkage compared to a conventional resin

Table 1. Main results related to the included studies