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OPTIMIZING COMPOSITE RESIN DEPTH TO MAXIMIZE FRACTURE RESISTANCE OF TREATED TOOTH

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Abstract:
Lifespan of restorations in stress-bearing posterior cavities relies on various factors, including the materials, the dentist, and the patient. According to the dental literature, annual failure rates of posterior composite resin inlays and onlays range from 0% to 10%, demonstrating that indirect posterior restorations are a long-lasting option for the rehabilitation of major defects. The literature was searched in the most well-known databases, Medline and Embase, for all pertinent research published up to the middle of 2022. Within the constraints of this in vitro study, the results demonstrated that the use of composite resin overlays represents a conservative approach to endodontically treated tooth rehabilitation. All composite resin overlays had fracture strengths greater than the expected bite forces. The introduction of glass fibers boosted fracture resistance and had a beneficial influence on failure mode and thus re-restorability in the event of fracture.

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INTRODUCTION:

The duty of repairing the tooth after root canal therapy falls to dental practitioners. Endodontically treated tooth restoration has been extensively researched and debated in the dentistry literature [1,2]. Endodontically treated teeth pose a difficulty to dental practitioners after access cavity preparation, shaping treatment, and obturation phases because of tooth structure loss, altered physical characteristics, dehydration, and decreased neurosensory feedback mechanism [3]. Nonetheless, holistic rehabilitation, which includes esthetic, functional, and structural components, is crucial to achieving a successful restorative outcome [4].

The use of a post and core, upon which a complete crown is cemented, is a typical approach of restoring endodontically treated teeth [5,]. The post is a restorative material that is put in the canal root to aid in the retention of the restoration and to protect the tooth by dispersing or distributing stresses along the tooth [6]. Endodontic posts are available in pre-formed or custom forms, metallic and non-metallic, esthetic and non-esthetic [7]. The usage of fiber-reinforced composite posts among the many types of endodontic posts has increased due to their attractive physical qualities, such as high tensile strength and strong fatigue resistance. These types of posts can reduce the likelihood of root fracture and have much greater survival rates [8,9].

Because of their excellent physical features, including as high tensile strength and fatigue resistance, fiber reinforced composite (FRC) posts have greatly boosted the restoration of endodontically treated teeth. Also, their modulus of elasticity is comparable to that of dentin. Composite core build-up material is frequently utilized in conjunction with FRC post to reconstruct the coronal portion of the teeth and to achieve retention and resistance shape for the crown [10]. The clinical examination of the FRC post and core restoration revealed a high success rate with a reduction in root fracture failure. The most prevalent material failures of these restorations are post debonding, crown debonding, or post fracture, which are usually associated with core failure, particularly in teeth with few coronal walls [11].

A composite core build-up material is frequently utilized in conjunction with a fiber-reinforced composite post to reconstruct the coronal section of the teeth in order to achieve a retention and resistance shape for the preparation [12]. Restorative composites are typically utilized as core build-up materials, allowing for preparation after curing [13]. Nonetheless, it is crucial to highlight that several commercially available resin composites are specifically engineered for core build-up. These materials are designed with more filler kinds and increased content to provide greater strength and ease of manipulation [14].

DISCUSSION:

Resin composite is a preferred core build-up material to employ with FRC posts due to its hardness and fracture toughness similarity to tooth structure, allowing the preparation to be performed after curing. Restorative composites can be used as core build-up material on a regular basis [15]. There are several resin composites available now that are specifically developed for core build-up with more fillers for higher strength and ease of manipulation. These materials differ in terms of filler amount and type, viscosity, curing mode, and build-up technique, among other things, and their physical properties have been studied in a variety of ways [16,17]. When it comes to viscosity, high viscosity composite core materials are handled incrementally to ensure complete polymerization and optimal strength. Low viscosity core build-up composites are often made in an automix syringe to avoid contamination from air. These materials can also be utilized to simultaneously cement the FRC post and core material. These are dual-curing composites that allow polymerization in the root canal and are suitable for use with fiber posts when light curing may not be completely accomplished. Clinicians have discovered that low viscosity core materials are easier to prepare with a diamond cutting device than high viscosity materials. As a result, while the low viscosity composite core may be easier to handle, its strength may suffer. Rüttermann et al. [16] studied the physical parameters of direct core materials and discovered that high viscosity composites (Clearfil and MultiCore HB) have higher flexural strength than flowable composites (Rabilda SC). Several investigations, however, have found that low viscosity composite core materials have stronger bond strengths to FRC posts than hybrid composites [16]. Naumann et al. [18] found no statistically significant difference in failure risk between high viscosity composite (Clearfil Core), low viscosity composite (LuxaCore Dual), and self-adhesive cement (RelyX Unicem) for core build-up after long term storage, thermocycled, and mechanically loaded. This could imply that the strength of the core material alone has no bearing on the strength of endodontically treated teeth repaired with FRC post. Kim and Lee [19] evaluated the usage of various posts and cementation processes and discovered that changing the post or core had no effect on fracture strength and failure patterns. However, because some core materials were employed as both cement and core material, a variety of factors influenced the study's findings.

Several types of all ceramic materials with great compressive strength have recently been discovered, and improved adhesive processes have allowed their application in the fabrication of all ceramic restorations. Sintered, milled, penetrated, pressed, or cast ceramics [19]. Ceramic inlay restorations have excellent long-term retention, color matching, and anatomic shape stability. Because there is little marginal degradation, they are not prone to marginal discolouration or secondary caries. Patients rarely have postoperative sensitivity when the ceramic inlay is placed [18,19].

Teeth also grow more brittle with age, making them more prone to breaking and fracturing, particularly if the tooth has been damaged by restorative procedures. The effect of masticatory pressures on restored and unrestored teeth varies. Masticatory stresses seldom fracture sound teeth, however cusp fracture can occur in teeth with cavity preparation and restorations. Cavity preparations degrade the remaining tooth structure dramatically. Direct and indirect intracoronal adhesive restorations can help to restore fracture resistance in teeth that have been compromised by extensive cavity preparation [20]. As a result, adhesive restorations can help to strengthen teeth that have been weakened by cavity preparation. When the influence of cavity design is considered, the onlay design is more effective in protecting the tooth structures than the inlay design. [21] Resin cement used for adhesive restorative cementation is elastic and deforms under tension, allowing it to absorb more stress. As a result, the success of ceramic inlays is entirely contingent on the development of an uncompromised adhesive tooth ceramic interface [22].

The fracture resistance of teeth treated with direct and indirect composite resin and indirect ceramic restorations was tested by Dalpino et al. [23]. They discovered that bonded indirect ceramic restorations require a higher fracture load than direct and indirect composite resin restorations. A bonded indirect ceramic restoration is an excellent choice for repairing teeth weakened by extensive cavity preparation [23]. However, the benefit of posterior composites is that they may be placed in a single session, whereas ceramic inlays normally require two consultations with the dentist due to the time required for manufacture in the laboratory.

Yamanel et al. [21] used three-dimensional (3-D) finite-element analysis to evaluate the effects of restorative materials and cavity design on stress distribution on tooth structures and restorative materials. In their work, they used two different nano filled composites and two different all ceramic materials. The enamel and dentin components of a permanent molar tooth were modeled. 3-D inlay and onlay cavity designs were constructed; the findings of this study revealed that more stress was transferred to the tooth structures when materials with low elastic moduli were used. As a result, the all ceramic inlay and onlay materials evaluated imparted less stress to the tooth structures than the nanofilled composites [21].

The fracture pattern of all groups was identical in terms of mode of failure. The oblique application of force on the occlusal surface of the simulated crown may cause the post to flex labially [24]. Since the lingual dentin is under tension, this causes a compressive stress on the labial dentin. The fulcrum was placed near the acrylic block's upper border, resembling the labial alveolar bone crest. Tensile stresses may cause the post-cement-root dentin contact to fail adhesively. The post may then become loose within the root canal and function as a wedge. Loads greater than the tensile strength of dentin resulted in oblique cervical root fracture from the cervico-lingual to the labio-apical direction [25]. This finding is consistent with a three-dimensional finite element analysis in which stress concentration in the post region was observed at the interface between the lingual side of the fiber post and the resin core, and maximum stress in the remaining radicular dentin was observed on the inner side of the proximal wall at the cervical level. The observed fracture pattern revealed that stress concentrations were larger in the coronal third of the dentin than at the apex. Additionally, large stress concentrations developed in the cervical area of the metal crown edge and the brittle dentin between a rigid and less rigid section. Due to the distinct method of failure, the installation of all-ceramic or porcelain fused to metal crowns may have different results than the entire metal crown used in this study [26].

The length of the ferrule and the amount of residual coronal dentin are critical factors in the outcome of endodontically treated teeth. The lack of a coronal wall may increase the likelihood of restoration failure [27]. The success of endodontically treated restorations is affected by a variety of material qualities. According to the previous study, the performance of the core materials was dependent on their formulation as well as their proper curing process [27]. Because there are so many restorative solutions on the market today, physicians should examine not only the ease of use, but also the appropriate qualities to achieve more successful restorations. As a result, it is critical to choose the appropriate composite core material to employ with the FRC post, especially when the tooth has moderate to severe coronal structural loss [27].

When the remaining tooth structure is restricted, the strength of the composite core build-up is an important aspect in achieving a long-lasting repair [24]. As stress was applied to the core material, a stronger material was required to withstand fracture load [23]. Additionally, fracture resistance amongst composite resins may be related to material qualities such as bonding ability to post and dentin, strength, polymerization mode, and rigidity [25].

The majority of resin composites are made up of an organic matrix, a bisphenol A-glycidyl methacrylate (Bis-GMA) compound, and filler particles. Some composites with a higher filler percentage, on the other hand, are employed for core build-up [23,24]. The enhanced fracture strength obtained utilizing core-build up materials in this investigation could be due to their filler content [19]. The flexural modulus increased when the filler content was increased. Additionally, a rise in the modulus of the core materials resulted in an increase in fracture resistance [26]. This could explain the findings of this investigation, as a recent paper shown that the flexural modulus, which reflected the endurance and strength of the repair, could indicate the stiffness of a core material within an elastic range. In this regard, a core build-up material with the same dentin substrate modulus as the root and post could be used to provide the optimal distribution of masticatory forces to the root and post [27].

Apart from the influence of fillers on pulpless tooth fracture resistance, the bonding ability of composite materials is critical in the strength-promotion noted in this meta-analysis. Incompatibility between materials was avoided since the bonding agent was applied prior to core build-up according to the manufacturer's recommendations [28]. Another possible explanation for the increased strength is that the core material, when employed with poor consistency, gained greater integration with the post due to the reduction of air bubbles and voids inside the core-post interface or the core [29]. In this way, doctors should keep in mind that the performance of core materials is dependent on their composition. Selecting a proper composite material to utilize with the post could result in a more successful endodontically treated restoration. As a result of the findings in this publication, dentists should employ core composite build-up materials if the tooth has coronal loss. According to the methodological quality assessment, all of the included articles were evaluated as having a medium risk of bias, indicating that the quality of the evidence for the analyzed outcome might be high. In this regard, it should be noted that the sample size calculation and operator blinding parameters were not provided in the majority of the articles reviewed, and failure to define these aspects could increase the likelihood of performance and detection of bias.

Several undiscovered aspects could have influenced the current report's findings. The presence of nanofillers in the polymeric composite resin or the restoration type may have an effect on mechanical properties and fracture strength; thus, future research may include these factors [30,31]. Additionally, resin composites specifically developed for core build-up are made with an increase in fillers for increased strength and ease of manipulation, which may potentially influence the results [32].

CONCLUSION:

The advancement of fiber-reinforced composite resin technology has broadened the scope of composite resin materials' applications. Glass fibers have shown an impressive capacity to sustain tensile stress and prevent crack development in composite resin materials. The use of FRC may help to prevent unwanted subgingival fracture and may improve the failure mode of composite resin restorations as well as reparability in the case of a fracture. The in vitro evidence for the composite core build-up materials utilized in the literature to achieve excellent fracture resistance in pulpless teeth was examined. It should be noted that the primary cause of endodontically treated tooth failure is connected to materials such as crown debonding, post-debonding, or root fracture. It is vital to note that the core material, especially when utilized with post, is a critical component of overall effectiveness in the restoration of endodontically treated teeth. As a result, it appears that increasing the fracture resistance of pulpless teeth is critical to the long-term clinical success of restorative treatment.

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