ORIGINAL RESEARCH

Evaluation of Microleakage Using Dye-penetration Method in Three Different Composite Resin Core Build-up Materials: An *In Vitro* Study

Mrinmoy Chakraborty[1], Amitu Singh[2], Suneel V Vadavadagi[3], Amrita Kumari[4], Ravi S Prasad[5], Abhishek Anand[6]

Abstract

Aim: Aim of the current research is to establish and assess the microleakage in bulk-fill composite, nanohybrid ormocer-based resins, and nanofilled composite resin core build-up materials employing the dye-penetration technique.

Materials and methods: Sixty human mandibular first premolar teeth with a solitary root canal without dental caries were chosen for this research. Each specimen was subjected to decoronation of 2 mm from the cementoenamel junction (CEJ), following which the root canal treatment procedure was rendered complete. A space for the post was made for all the 60 samples. Following positioning of the post, specimens were allocated into one of the following three investigational groups (20 specimens in every group) on the basis of the core build-up materials used as group I: bulk-fill composites, group II: nanohybrid ormocer-based resins, and group III: nanofilled resin composites. Direct composite was used for core build-up and subjected to light-curing. Following this, the specimens were immersed in 1% methylene blue solution for 24 hours interval. Each section was evaluated for dye diffusion employing a stereomicroscope with software at a magnifying power of 40× and surface contact between dentin and base of the material was evaluated under scanning electron microscope.

Results: Nanohybrid ormocer-based composites exhibited the least microleakage at 1.12 ± 0.14, in pursuit by nanofilled composite resins at 1.79 ± 0.09, and finally the bulk-fill composites at 2.85 ± 0.11, amid the investigational groups studied. A statistically significant difference amid the three dissimilar cores buildup substances was found upon analysis of variance.

Conclusion: Despite the study limitations, this research came to a conclusion that each of the three investigated core build-up substances exhibited microleakage. However, amid the three, nanohybrid ormocer-based composites depicted the lowest amount of microleakage in pursuit by the nanofilled resins and the bulk-fill composites.

Clinical significance: Core build-up is an important requirement as the remaining tooth substance following root canal treatment reduces and needs reinforcement with core build-up to sustain the tooth structure and provide resistance. A vital mandate for enduring efficiency of the restoration in the mouth is high-quality adhesive bond of these agents to cavity walls with diminished microleakage.

Keywords: Composite resin, Core build-up materials, Dye-penetration, Microleakage.

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Introduction

Tooth structure that is absent may be replaced by a restorative technique called core build-up prior to preparation of the crown. However, the tensile/compressive strength of agents used in core build-up is highly significant as the core essentially restores a huge portion of the tooth structure and must be capable of resisting the forces of mastication from all directions for several years.[1] Such features of these substances are essential as the core build-up should provide support as well as protection for the remaining tooth while providing appropriate retentive and resistance outline for the ultimate restoration. The triumph of the ultimate restoration depends on the undamaged tooth structure plus encouraging performance of the fundamental core.[2]

It is a challenge for a majority of dentists to choose the apt restorative agent despite numerous being available, particularly for a tooth that has undergone root canal treatment that offers low resistance to forces of occlusion owing to absent tooth structure. An evaluation of residual dentin in the crown has to be meticulously performed prior to choosing post and core or a direct core build-up treatment.[3]

Few frequently employed core build-up substances include amalgam, composite, and glass ionomer cement. Bonilla et al. have concluded that composite resins exhibit superior mechanical traits over amalgam due to two chief causes—micromechanical bonding/monoblock consequence of composite resin to the teeth as well as dual-cure technique of composite curing.[4]

Additionally, it has been demonstrated that root canal therapy and large restorations coupled with great masticatory forces plus contacts made on lateral excursion cause greater vulnerability to

[1,4,5]Department of Conservative Dentistry and Endodontics, Vananchal Dental College and Hospital, Garhwa, Jharkhand, India

[2,6]Department of Pedodontics, Vananchal Dental College and Hospital, Garhwa, Jharkhand, India

[3]Department of Prosthodontics, SJM Dental College and Hospital, Chitradurga, Karnataka, India

Corresponding Author: Suneel V Vadavadagi, Department of Prosthodontics, SJM Dental College and Hospital, Chitradurga, Karnataka, India, Phone: +91 9845804642, e-mail: Sunilvvv123@gmail.com

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fracture in the esthetic areas. Thus, a good restorative technique must provide for esthetics as well as tooth structure conservation/strengthening to protect them from fractures.[5]

The tooth/restoration edge should be rendered capable of resisting dimensional alterations in order to avoid leakage/probable worsening of the adhesive restorative material. The dentin penetrating capacity while using adhesive bound restorative materials relies on adhesive sealant property, restoration-adhesive binding, and polymerization shrinkage of resins of the dentin tubule wall that can cause inappropriate seal at the dentin. If the forces produced within the restoration/at the edges during shrinkage of rein polymers surpass the bond strength gap creation, microleakage can result at the tooth-restoration edge. Microleakage refers to the flow of liquids, microorganisms, molecules/ions, or air amid the restoration and the cavity preparation wall.[6] Microleakage investigations of core build-up composite materials exist only in a limited number of products and to our knowledge never in direct comparison including bulk-fill composites, nanohybrid ormocer-based resins, and nanofilled resin composites. Thus, the current research was performed to appraise the microleakage by means of dye-penetration technique in three different composite resin core build-up materials.

Materials and Methods

The current *in vitro* research was performed in the Department of Prosthodontics, SJM Dental College and Hospital, Chitradurga, India. Sixty human mandibular first premolar teeth with a solitary root canal without dental caries that were recently extracted in course of orthodontic treatment and having alike anatomic traits were chosen for this research and subjected to storage in normal saline until their utilization for this research following a 24-hour immersion in Chloramine T-solution. Recently extracted premolars, solitary root canal, and absence of root resorption constituted the inclusion criteria. Exclusion criteria consisted of teeth with dental caries, restorations, external cracking/deficiency, calcified canals, and presence of external/internal resorption.

Samples Preparation

Each specimen was subjected to decoronation 2 mm from the cementoenamel junction (CEJ). A 10-K-file was employed to evaluate the radicular canal patency that was tucked back by a millimeter to determine the working length (WL). All samples were subjected to mounting within an acrylic resin block. Number 15 and 20 ISO size K-files (Dentsply Maillefer) were used to instrument the sample premolars up till the WL that had been ascertained previously in course of creating a glide pathway. Universal rotary instruments were used for chemomechanical tooth preparation employing a torque-restricted motor (X-smart, Dentsply Maillefer) until the F3 master apical file.

Irrigation of the radicular canals between the change of instruments was accomplished by 2 mL of 5.25% NaOCl. To remove the smear layer, irrigation with 10 mL of 5.25% NaOCl pursued by 10 mL of 17% EDTA and 10 mL of 5.25% NaOCl afterward was executed. The resino-seal sealant was carried by a lentulo spiral within the radicular canal. Traditional F3 gutta-percha cones coated with the sealer were placed up till the WL inside the radicular canal.

Preparation of Post Space

The gutta-percha was removed from cervical third of the radicular canal using a peeso reamer. A space for the post was made for all the 60 samples. Post spaces, thus created, had a standardized size of 1.5 mm diameter to a length of 9 mm inside the root plus 2 mm above the root resulting in a whole post length of 11 mm. Consistency was attained with a rubber stopper positioned at 11 mm measurement lengthwise of the peeso reamer. Debris was removed by irrigating the canal. Following canal space preparation, the resin luting cement mixing was done in accordance with the standard procedure followed by application to the post space plus the post. The fiber posts were placed under consistent digital pressure for ten seconds followed by wiping off the surplus.

Core Build-up Procedure

Following the positioning of the post, specimens were allocated into one of the following three investigational groups (20 specimens in every group) on the basis of the core build-up materials used as:

- Group I: Bulk-fill composites (Tetric EvoCeram Bulk Fill, Ivoclar Vivadent AG, Liechtenstein)
- Group II: Nanohybrid ormocer-based composites (Admira Fusion; Voco, Cuxhaven, Germany)
- Group III: Nanofilled resin composite resin [Filtek Supreme XTE, 3M ESPE, St Paul, Minnesota, The United States of America (USA)]

Direct composite was used for core build-up and subjected to light-curing. A pre-made matrix was employed to prepare a core height of 4 mm. Vacuum adapter system was used to adjust the matrix over the core.

Dye-penetration Procedure and Microleakage Measurement

Specimens were subjected to thermocycling between 5 and 55°C (±2°C) for 500 cycles. Thirty seconds was the dwell time followed by 10 seconds transfer time. The specimens were stored in distilled water and placed in an incubator at 24 hours for 37°C. After the thermocycling step, every surface with the exception of the restoration and a millimeter from the edges was subjected to coating using two layers of nail varnish. Following this, the specimens were immersed in 1% methylene blue solution for 24 hours interval to allow dye flow into probable unoccupied spaces along the tooth structure and restorative material. Following the dye exposure, the specimens were washed and rinsed with distilled water, followed by sectioning longitudinally throughout the middle of the restorations buccolingually employing a diamond disk at a slow-speed handpiece. Each section was evaluated for dye diffusion employing a stereomicroscope (Wild Heerbrugg) with software (Leica application suit) at a magnifying power of 40×. And surface contact between dentin and base of the material was evaluated under scanning electron microscope (Carl Zeiss EVO 40) with a magnification of 100x (Fig. 1). Dye diffusion at the core/tooth boundary was subjected to scoring for the occlusal as well as the gingival borders as per the following criteria by Popoff et al.[7]

- Score 0—Absence of dye penetration
- Score 1—Dye penetration <1 of 2 of the cavity depth
- Score 2—Dye penetration >1 of 2 of the cavity depth
- Score 3—Dye penetration dispersal the length of the axial wall
- Score 4—Dye penetration against the pulpal wall.

Statistical Analysis

Statistical Package for the Social Sciences software version 19 for Windows (SPSS Inc., Chicago, Illinois, United States) was used to analyze the data statistically. Standard deviation and mean were used to express the results. The statistical tests, analysis of variance (ANOVA) and Tukey's *post hoc* tests, were used subsequently to

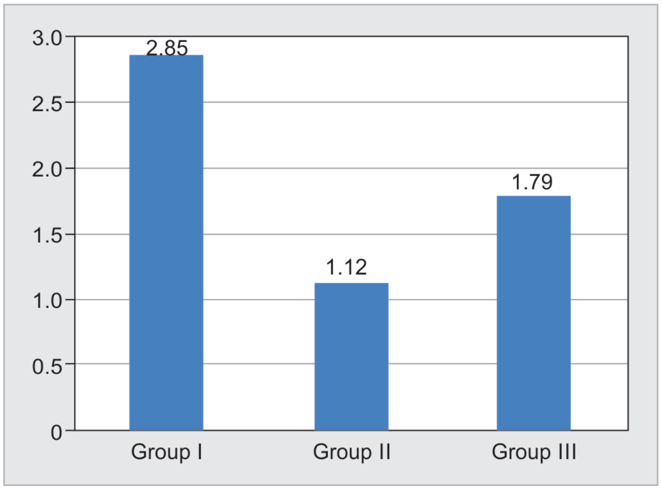

Fig. 1: SEM image (100×) of surface contact between dentin with post and base of the nanohybrid ormocer-based resins

Table 1: Comparison of mean microleakage of three different core build-up materials

Experimental groups	*Mean ± SD*	*F value*	*p value*	*Significance*
Group I—bulk-fill composite resin	2.85 ± 0.11	25.162	0.001	HS
Group II—nanohybrid ormocer-based composite resin	1.12 ± 0.14			
Group III—nanofilled resin composites	1.79 ± 0.09			

$p < 0.05$; HS, highly significant

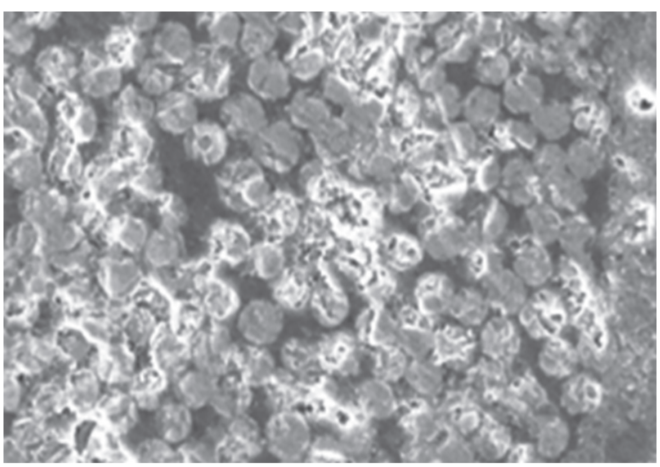

Fig. 2: Mean microleakage scores of three core build-up materials

ascertain the statistically significant differences amid every group. Statistical significance was set at a p value <0.05.

Results

Table 1 and Figure 2 show the mean microleakage scores of the three different core build-up substances. Nanohybrid ormocer-based composites exhibited the least microleakage at 1.12 ± 0.14, in pursuit by nanofilled composite resins at 1.79 ± 0.09, and finally the bulk-fill composites at 2.85 ± 0.11, amid the investigational groups studied. A statistically significant difference amid the three different core build-up substances was found upon ANOVA.

Table 2: Multiple core build-up materials comparison using Tukey HSD

Experimental groups	*Compared with*	*Mean difference (I–J)*	*Significance*
Group I	Group II	1.73*	0.001
	Group III	1.06*	0.001
Group II	Group I	−1.73*	0.001
	Group III	−0.67	0.192
Group III	Group I	−1.06*	0.001
	Group II	0.67	0.192

*Significant, p <0.05

Multiple comparative assessments amid the core build-up substances are delineated by Table 2. Group I vs group II and group I vs group III core build-up showed statistically significant differences at a p value <0.05, as noted in the table. Group II vs group III showed no statistically significant differences at a p value >0.05.

The surface contact between dentin with post and base of the material was evaluated under scanning electron microscope. The microgaps at post–core interface of the group with post and core restoration materials can be explained by the incomplete post–core integration between prefabricated post and core materials during the procedure.

Discussion

Root canal–treated teeth filled using metal-free/physiochemical uniform agents having mechanical characteristics not unlike dentin is a key goal of successful dental management. Rebuilding root canal–treated teeth with precustomized fiber posts and core structures have wide acceptance as a management strategy that offers enhanced functionality and esthetics.[8]

Clinically unidentifiable permeation of microorganisms, liquids, chemicals, molecules/ions amid the walls of the cavity, and the restoration is known as microleakage. Investigators/dentists can envisage the functionality of restorations in the oral atmosphere by quantifying the amount of microleakage.[9]

Composites exhibit contraction on polymerization leading to microleakage. Elevated binding power, linking the restoration with dentinal surface can oppose the polymerization contraction of the filling and consequent microbreach development at the tooth-filling edge. Reduced adaptation of the filling to the walls and edges of the cavity plus, the technique by which the restoration is introduced into the prepared cavity, may influence the sealant features of the restoration.[10]

Amid the three core build-up agents that were investigated in the current research, nanohybrid ormocer composites exhibited the lowest microleakage in pursuit by the nanofilled resins and bulk-fill composites. Ormocer-based composites comprise ceramic polysiloxane that possesses small shrinkage. Sidechains capable of polymerization are supplementary to the polysiloxane chains that ormocer has and which act in response to curing as well as while developing a setting medium. The presence of such organic molecules elucidates the lesser polymerization contracture and diminished microleakage. This result is similar to the study conducted by Kalra and Singh et al.[11] suggest that further inclusion of filler particles lessens volumetric shrinkage from 2 to 8% without fillers to 1–3% when fillers are integrated. Similarly, Moszner et al.[12] and Erdilek et al.[13] state that ormocer exhibits lesser water solubility as it comprises prepolymerized particles along with less monomer elution.

In this research, bulk-fill composites showed the highest microleakage as compared to the other investigational groups. This result is similar to Giachetti et al's.[14] study, which states that bulk introduction of composites causes deprived polymerization toward the apical parts of a restoration. The same results from failure of the light from light-curing unit to enter these areas. Burgess and Cakir et al.[15] have documented that bulk-fill resin composite resins are a resourceful set of dental resins that were initiated for easy placing of direct composite fillings. Clinical advice states that composite resins have a larger curing depth, may be introduced in 4-mm thick increments, and can achieve suitable polymerization.

Another study by Czasch and Ilie et al.[16] elucidates that the stress-reducing resin technique was intended to reduce the stress from polymerization shrinkage and permit bulk positioning of the composite. In a clinical setting, this eliminates the prerequisite for placement in increments along with the curing, thereby decreasing the requirement for material handling and time necessary in course of insertion, thus enhancing patient obedience.

In accordance with Roggendorf et al.,[17] a single clinician did every core build-up procedure to decrease operator inaccuracy and achieve standardization. In the current study, the specimens were subjected to storage in distilled water at 37˚C for 24 hours following 500 phases of thermocycling amid 5 and 55°C at dwell period of 30 seconds. Composites are subjected to a variety of changes in the mouth, and thus to appraise microleakage, techniques to replicate these characteristics are obligatory. Geerts et al.[18] likewise feel that the sole *in vitro* process to simulate thermal stresses in the dentition is thermocycling. Thermocycling, as per Helvatjoglu-Antoniades et al.,[19] creates inclusion of extreme hot/cold situations in the mouth and delineates the association of linear coefficient of thermal expansion among tooth structures as well as restorative agents. According to Souza et al.,[20] thermocycling combines both hydrolytic/thermal deprivation that replicates the oral temperatures from unexpected fluctuations.

The limitations of this research include that it was performed in *in vitro* circumstances and used natural extracted teeth for core build-up, and thermocycling was used as part of test protocol. *In vitro* research is pivotal for preliminary evaluation of a dental substance. Yet, only clinical research can account for every possible variable that change among individual patients. Few of these factors subject to variation are forces of mastication, food varieties, oral temperature/humidity, as well as existence of salivary enzymes in addition to bacterial products. A lot of novel restorations are developing swiftly, everyone with enhanced characteristics and hopeful consequences for superior performance. As a result, additional research is needed to estimate the accurate clinical merit of these resources to authenticate their *in vitro* recognized outcomes.

Conclusion

Despite the study limitations, this research came to a conclusion that each of the three investigated core build-up substances exhibited microleakage. However, amid the three, nanohybrid ormocer-based composites depicted the lowest amount of microleakage in pursuit by nanofilled resins and the bulk-fill composites.

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