Original Article

Effect of Smart Dentin Replacement, Biodentine, and Its Combination for Dentin Replacement as Alternatives to Full-crown Coverage for Endodontically Treated Molars: An *In Vitro* Study

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Abstract

Aim: The aim of this *in vitro* study was to assess newer dentin replacement restorative materials that could substitute full-crown coverage restoration. **Materials and Methods:** Twenty freshly extracted maxillary and mandibular molars were selected for this *in vitro* study and were randomly divided into four groups of five teeth each. All the teeth in the experimental groups (Groups 2–4) were subjected to access cavity preparation, mimicking class 1 deep dentinal caries without involving marginal ridges, and with approximately 1.5 mm of tooth structure remaining throughout its circumference. Group 1: sound molar teeth, which will serve as a control group. Group 2: endodontically treated molars restored with smart dentin replacement (SDR) as post-endodontic restoration. Group 3: endodontically treated molars restored with Biodentine as post-endodontic restoration. Group 4: endodontically treated molars restored with the combination of SDR and Biodentine as the post-endodontic restoration. Fracture resistance of all the teeth was then evaluated using a universal testing machine. **Statistical Analysis:** The results of this *in vitro* study were calculated statistically using one-way analysis of variance and *post hoc* tests such as Tukey's, Scheffe's, Bonferroni, and Holm tests for intragroup comparison. **Results:** Statistically significant results were observed among all groups, except Group 2 (SDR) and Group 4 (combination of SDR and Biodentine). The highest and lowest values were noted with Groups 2 and 3, respectively, ($P = 0.05$). **Conclusion:** SDR alone or the combination of SDR with Biodentine can be considered as a substitute for full-crown coverage restoration for endodontically treated molars.

Keywords: *Biodentine, smart dentin replacement, Alternative to Full Crown Coverage*

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Introduction

Fracture resistance of endodontically treated teeth is less when compared with natural teeth. As in root canal–treated teeth, there will be dehydration and loss of dentin after the procedure.[1] Hence, restoring the teeth to gain strength is important to protect against fracture. Hence, post-endodontic restoration plays an important role in the success of root canal–treated teeth.[2]

The post-endodontic restoration of root canal–treated teeth is a major concern, which is considered extensively, and is questionable in dentistry. Different speculation remains about clinical procedures and materials to

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restore once fractures occur due to eccentric forces acting on endodontically treated teeth.[3]

Clinicians suggest full-crown coverage after the endodontic procedure. However, restoring a root canal–treated tooth to its original anatomy may provide good strength and fracture resistance without placement of full-crown coverage restoration, which could provide potential and economic benefits to the patients.[4]

Post-endodontic restoration is a common procedure in a dental practice. Though comprehensive research has been carried out on this matter, it has been difficult to say what type of clinical restorative procedure gives us considerable success.[3]

Whether full-crown coverage restorations, notably in molars, are indeed mandatory or not after endodontic treatment has been a matter of controversy for some time now. Although full-crown coverage restoration has been advised as a means to strengthen a tooth after endodontic treatment, tooth fractures have been inescapable despite the full-crown coverage placement.[5]

Hence, this *in vitro* study was conducted to evaluate whether newer dentin replacement restorative materials would be considered as an alternative to full-crown coverage restoration. This study compared the fracture resistance of endodontically treated molars restored with two different dentin replacement restorative materials and their combination as restorative materials.

Figure 1: Marking of margins before access cavity preparation, relieving 1.5 mm of tooth structure around the circumference of the tooth without involving marginal ridges

Materials and Methods

Sample size for this *in vitro* study was calculated using G*Power software, version 3.0.1 (Franz Faul Universitat, Kiel, Germany) and was estimated to be 20 (five in each group), which would yield 80% power to detect significant differences, with an effect size of 0.5567 and significance level at 0.05.

Twenty sound maxillary and mandibular molars, which were freshly extracted for periodontal reasons, were collected for this *in vitro* study. To rule out any deformity, the teeth were inspected under a dental operating microscope (LABOMED, Berlin, Germany) at ×12.8 magnification, and only sound teeth without any fracture lines or cracks and caries were included for this *in vitro* study.

The teeth were stored in physiological saline until the commencement of the study. For achieving standardization and to lessen the diversity in size and shape of the teeth on the results, the teeth were chosen based on their mesiodistal (10.5 ± 1 mm) and buccolingual (9.5 ± 1 mm) dimensions and were randomly assigned into four groups of five teeth each.

In Group 1, the teeth were sound teeth where no treatment was performed, and they represented control group. All the teeth in the experimental groups (Groups 2–4) were subjected to access cavity preparation, mimicking class 1 deep dentinal caries without involving marginal ridges and with approximately 1.5 mm of tooth structure remaining around the circumference as shown in Figure 1.

Figure 2: Tooth after access cavity preparation, note that marginal ridges are unharmed

Except in control group, all the teeth in experimental group (2-4) were commenced for root canal treatment and were enlarged till F1 Protaper Rotary file [Figure 2], followed by obturation with corresponding gutta percha using AH plus sealer [Figure 3].

In Group 2, endodontically treated molars after obturation were etched using 37% phosphoric acid (3M ESPE, Maplewood, USA), and bonding agent was applied (Adper, 3M ESPE) and cured using Bluephase curing unit (Ivoclar Vivadent) according to the manufacturer's instruction. A 4-mm increment-wise smart dentin replacement (SDR) (Dentsply Sirona, Belmont, Australia) was placed against the entire inner circumference of the remaining weakened tooth structure and was cured using Bluephase curing unit (Ivoclar Vivadent, Liechtenstein, Europe).

In Group 3, endodontically treated molars after obturation were restored with Biodentine (Septodont Healthcare, St. Maur-des-Fossés, France) as post-endodontic restoration material.

Figure 3: IOPAR of the tooth after completing obturation and post endodontic restoration

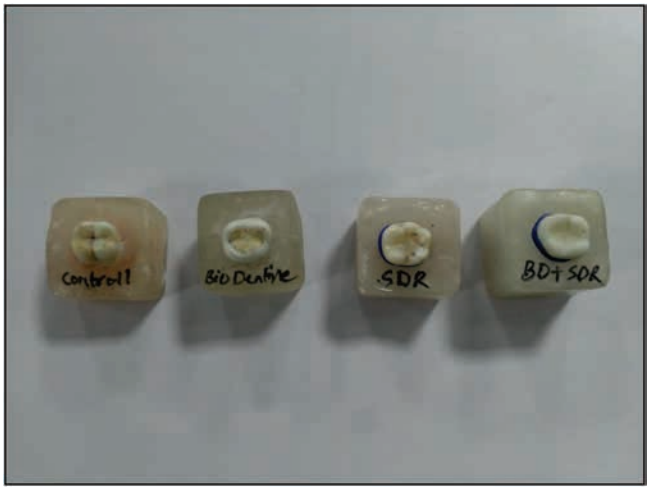

Figure 4: Control and other experimental groups after completed post endodontic restoration

In Group 4, after obturation in the endodontically treated molars, the teeth were restored with the application of 2 mm of Biodentine (Septodont Healthcare) layer, and were left to mature for 24 h, after which the same manner of etching and bonding was performed as that of Group 2 and the other half of the access cavity was restored with SDR (Dentsply Sirona) and cured using Bluephase curing unit (Ivoclar Vivadent).

Each tooth was then covered with a thin layer of polyvinyl siloxane impression material (EXAFLEX, GC America, Alisp, IL) to simulate periodontal ligament and was encapsulated in a block of self-curing acrylic resin (Tempron, GC India, Hyderabad) with the long axis of the tooth perpendicular to the base of the block as shown in Figure 4. Until subjected to a fracture resistance test by a universal testing machine (UTM, Instron India, Chennai at Indian Institute of Science [IISC], Bengaluru, India), all the teeth were stored in an incubator at 37°C and 100% humidity.

Static fracture resistance testing was completed using a UTM. A 5-mm diameter round tip stainless steel metal rod was fixed parallel to the long axis of the tooth and was focalized on the center of the tooth until the bar just touched the occlusal surface as shown in Figure 5. Compressive loading of the teeth was operated at a crosshead speed of 1 mm/min, and the force necessary to fracture each tooth was recorded in Newton (N).

The results of this *in vitro* study were assessed statistically with Statistical Package for Social Sciences (SPSS) software, Bangalore, India, version 20.0 (IBM, SPSS Statistics, IBM released 2011), using one-way analysis of variance and applying *post hoc* tests such as Tukey's, Scheffe's, Bonferroni, and Holm tests for intragroup comparison. *P* values obtained were computed and compared with the statistical significance at the level of 0.05.

Results

The mean of the fracture resistance values and also the standard deviation and standard error for each of the groups are presented in Table 1.

Figure 5: Evaluation of fracture toughness using UTM

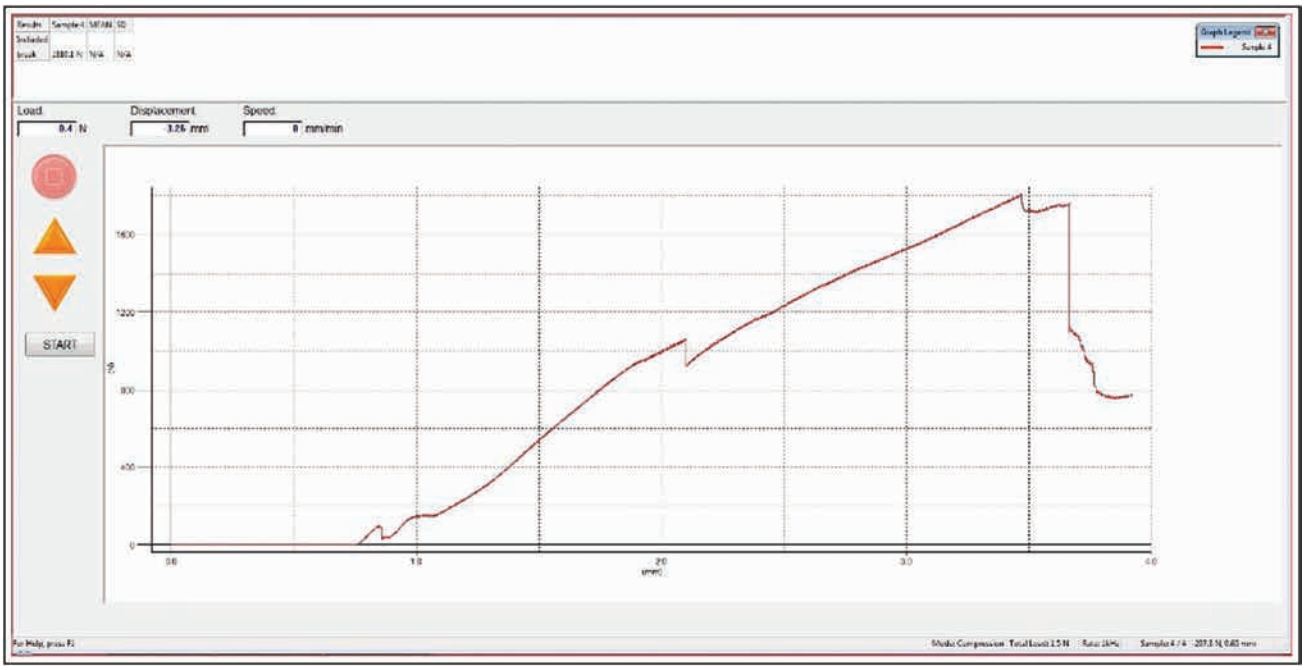

Figure 6: Graphical representation of fracture resistance of control group

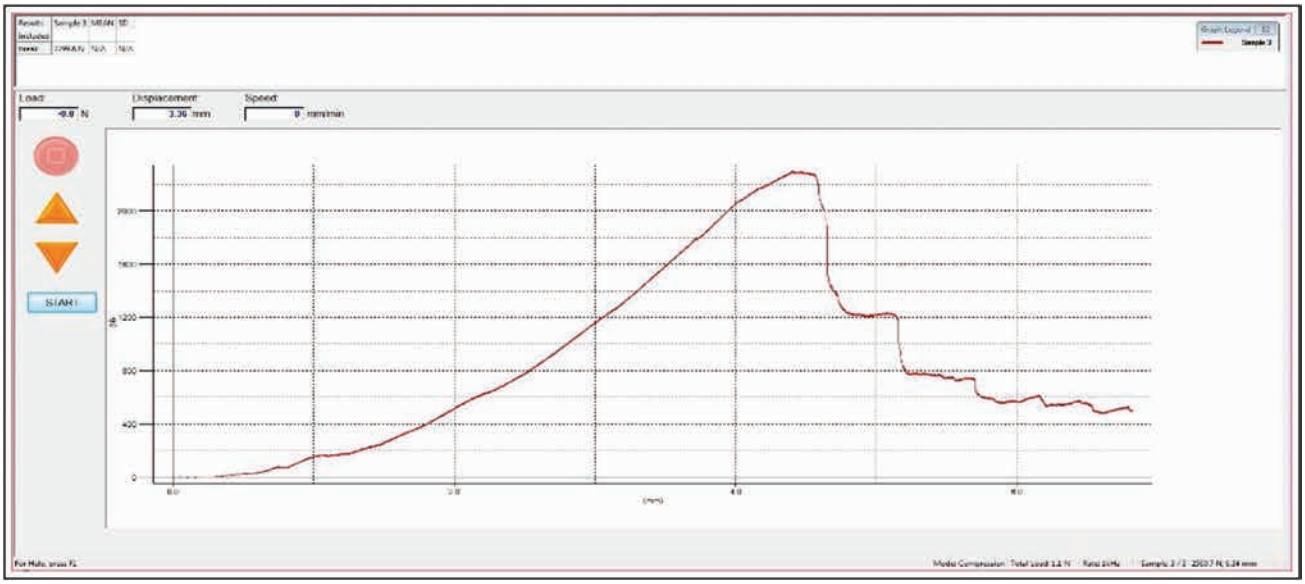

Figure 7: Graphical representation of fracture strength of SDR group

Table 1: Mean and standard deviation values for fracture strength (Mpa)

	Control (Group 1)	Smart dentin replacement (Group 2)	Biodentine (Group 3)	Smart dentin replacement and Biodentine (Group 4)
Mean	2170.8	1872.1	1088	1737.5
Standard deviation	117.774	46.887	200.2	86.2
Standard error	52.67	20.96	89.5	38.5

Tests: Analysis of variance, $P < 0.01$ nonsignificant, SD=Standard deviation

In Group 1 (control), the mean fracture resistance value was observed as 2170.8 N [Figure 6], which was the highest when compared to all the other experimental groups.

In Group 2 (SDR), the mean fracture resistance value was observed as 1872.1 N [Figure 7], which was the highest when compared to all other experimental groups except the control group.

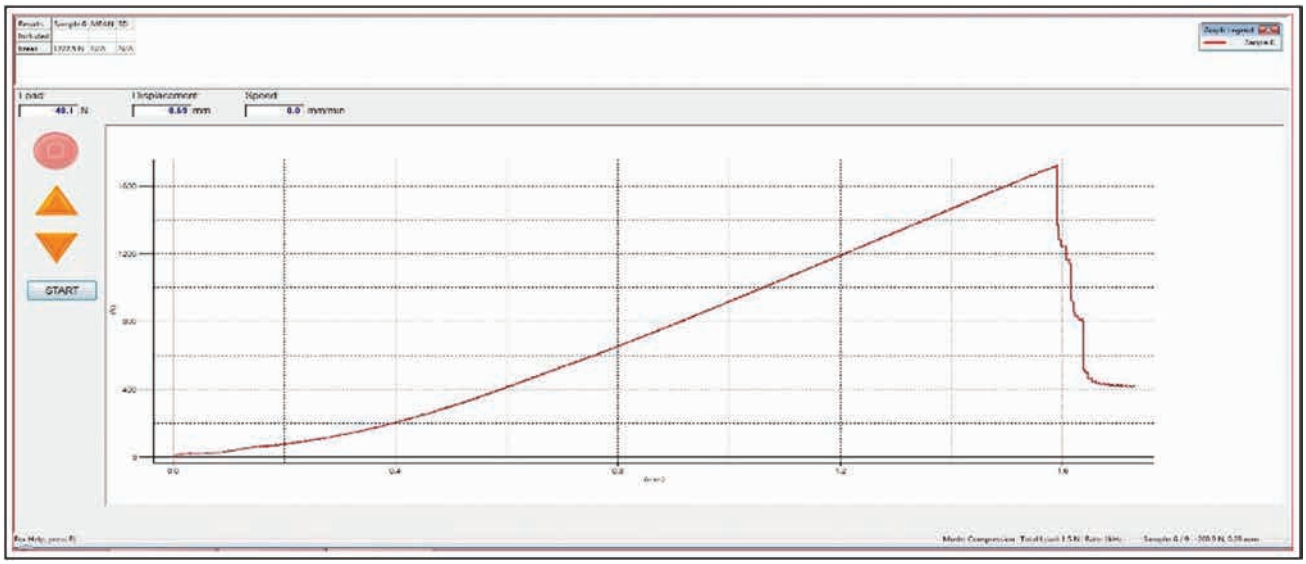

Figure 8: Graphical representation of fracture strength of biodentine group

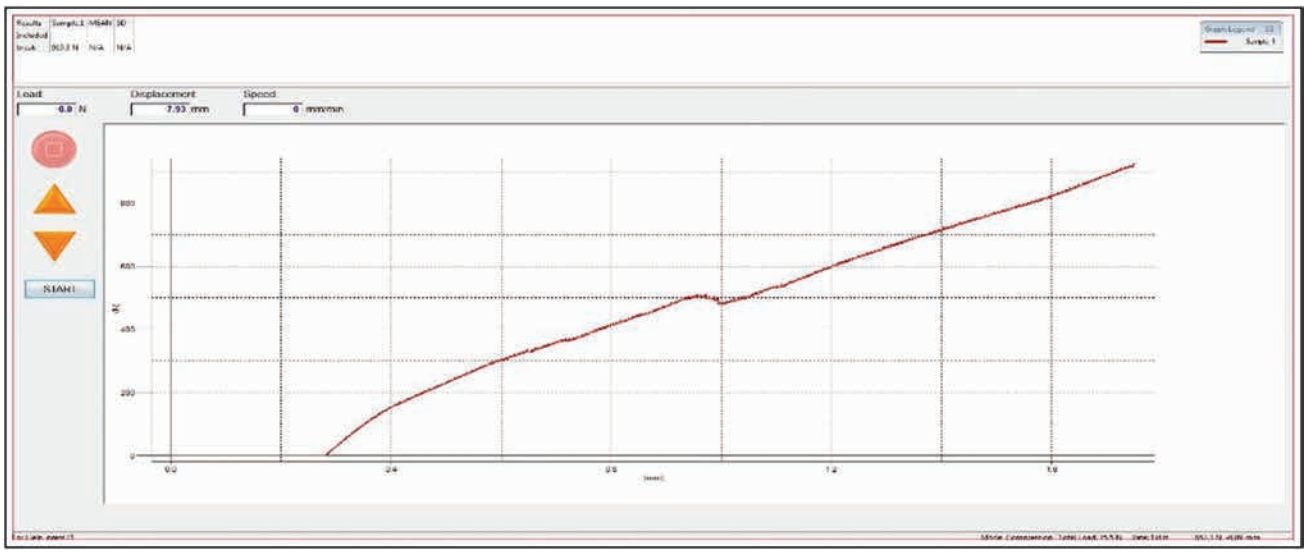

Figure 9: Gaphical representation of fracture strength of SDR and biodentine combination group

In Group 3 (Biodentine), the mean fracture resistance value was observed as 1088 N [Figure 8], which was the least when compared to all other experimental groups and control group.

In Group 4 (the combination of SDR and Biodentine), the mean fracture resistance value was observed as 1737.5 N [Figure 9], which was lesser than Group 1 (control) and Group 2 (SDR). No statistical significance was found between Groups 2 (SDR) and 4 (combination of SDR and Biodentine), which was verified using *post hoc* tests such as Tukey's, Scheffe's, and Bonferroni tests, where the *P* value was observed to be less than 0.1 as presented in Table 2.

Discussion

Successful restoration of endodontically treated teeth principally depends on the remaining circumferential dentin around the access cavity.[6] A correlation exists for the reduction in fracture resistance between occlusal cavity preparation in proportion to the extent of the preparation in restorative dentistry.[7] Similarly, an identical concept was later adopted in endodontics, wherein a correlation was proved between cuspal deflection and endodontic access cavity size.[8] In later years, Clark and Khademi[9] showed a modified endodontic cavity with minimal tooth structure removal, which proposed to improve the fracture resistance of endodontically treated teeth.

Table 2: Intragroup comparison of fracture strength

Treatment pair	Tukey's test (*P* value)	Scheffe's test (*P* value)	Bonferroni test (*P* value)	Holm test (*P* value)	Inference
A vs. B	0.0086	0.015	0.01	0.003	$P < 0.01$ significant
A vs. C	0.001	0.0001	0.0001	0.0001	$P < 0.01$ significant
A vs. D	0.001	0.0006	0.0003	0.0001	$P < 0.01$ significant
B vs. C	0.001	0.0001	0.0001	0.0001	$P < 0.01$ significant
B vs. D	0.362	0.440	0.666	0.111	$P > 0.01$ in significant
C vs. D	0.001	0.0001	0.0001	0.0001	$P < 0.01$ significant

$P < 0.01$- significant, scheffe's test, Tukey's test, Bonferroni and holm test

This *in vitro* study was designed to evaluate the fracture toughness of endodontically treated teeth mimicking the loss of dentin structure due to class 1 deep dentinal caries. Considering the tooth's function and position in the arch, maxillary and mandibular molars were selected for this *in vitro* study.[10]

The remaining encompassing dentin provides a sound base for tooth restoration, the structural strength of which will depend on the quality and integrity of its anatomic form, which is lacking in the case of endodontically treated teeth.[11] Also, the greater decrement in tooth stiffness results due to the loss of marginal ridges during further tooth preparation.[12]

In this *in vitro* study, the toughness of the teeth was reduced considerably after access cavity preparation as shown in previous studies.[6,12] Therefore, increasing the strength and the toughness of the access cavity with a post-endodontic restoration becomes necessary. Therefore, selecting an appropriate post-endodontic dentin replacement restorative material is necessary for the success of endodontic treatment.

Recent advances in dentin replacement restorative materials mainly include SDR, a bulk-fill composite, and Biodentine, a tricalcium silicate–based cement. SDR is a fluoride-containing component and radiopaque restorative material, which shows a compressive strength of 242 MPa and less microleakage when restored. Similarly, Biodentine, which is known as dentin in a capsule, is a biocompatible and bioactive dentin substitute with a compressive strength of 213 MPa and less microleakage when restored under a layer of composite.[13,14] Both these materials have a compressive strength closer to human dentin.

SDR had been developed, especially for dentin replacement, and cured increments up to 4 mm depth. The polymerization shrinkage had been reduced by 50% or more compared to conventional resin composites. It was based on the chemistry of universal composite with the main difference in the modulator that incorporated in the urethane-based dimethacrylate. An *in vitro* study by Atalay *et al.*[15] evaluated the fracture strength restored with bulk-fill, fiber-reinforced, and conventional resin composite, and found out that bulk-fill showed the highest fracture strength. Similarly, in this study, Group 2 (SDR) showed fracture toughness, which was very close to the control group (sound teeth).

Biodentine, which is referred to as a dentin substitute, is considered as one of the post-endodontic restorative materials. It has a setting time of 12 min, which helps its users in immediate crown restoration. The properties of this restorative material, such as elastic modulus, compressive strength, and microhardness, are incredibly similar to that of natural dentin. It has a good bacterial tight seal with the margins of the tooth structure.[16] In an *in vitro* study conducted by Koubi *et al.*,[17] Biodentine was used as a posterior restoration, which proved satisfactory surface properties such as good marginal adaptation until six months, and later was covered by a surface layer of composite. The low mechanical properties are due to the presence of aluminate components, which make the restoration fragile. Also, the excess water will create porosity, significantly decreasing the mechanical resistance; like in this study, Group 3 (Biodentine) showed low fracture resistance as compared to other experimental groups.

The endodontically treated teeth in Group 4 were restored with SDR and Biodentine. According to Nekoofar *et al.*,[18] the micro-shear bond strength of resin to matured Biodentine, at a set time of 12 min, presented higher micro-shear bond strength. Also, it was concluded that if a prolonged waiting time can be achieved after mixing Biodentine, greater shear bond strength values can be expected.[18]

There was a significant decrease in bond strength between resin and aged Biodentine as the hydration process of calcium silicate cement undergoes several stages, and the resulting cement in its initial setting stages is poorly crystallized and highly porous. Bonding agent application and the polymerization shrinkage of resin composite may stress the porous, unmatured

Biodentine cement at this early setting stage to adversely affect the bond strength.

According to Koubi *et al.*,[17] Biodentine was a weaker restorative cement in its initial setting phase and the application of resin composite as the final restoration over Biodentine was best postponed for more than two weeks to allow intrinsic maturation to withstand contraction forces from resin composites. The mean fracture resistance values of this combination group were slightly less than that of control and marginally lesser than the Group 2 (SDR), although statistically no significant difference was found.

These newer and advanced restorative materials with unique techniques facilitate the dental practitioner to face existing problems from a different perspective, and thereby achieve an innovative solution. Although there is lacking evidence to support or negate the reliability of conventional fillings over full-crown coverage for the restoration of endodontically treated teeth, clinicians should decide on their clinical expertise as well as the economic status of the patient. The most important factor regarding the choice of restorative material depends immensely on the amount of remaining tooth structure, which may largely influence the long-term survival of the root-filled tooth and its economic factor.[19]

Conclusion

Within the limitation of this *in vitro* study, it can be concluded that when the remaining tooth structure is approximately 1.5 mm around the access cavity, post-endodontic restoration using SDR has shown better fracture resistance than the Biodentine and SDR and Biodentine combination.

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Nil.

Conflicts Of Interest

There are no conflicts of interest.

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