The effect of bulk‑fill composites: Activa and Smart Dentin Replacement on cuspal deflection in endodontically treated teeth with different access cavity designs

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Abstract

Aim: The aim was to evaluate the effect of bulk‑fill composites – Activa and Smart Dentin Replacement (SDR) on cuspal deflection in endodontically treated teeth with different access cavity designs.

Materials and Methods: Forty-two maxillary first premolar teeth were randomly divided into three experimental groups based on different access designs as Group I – conservative endodontic cavities (CECs), Group II – traditional endodontic cavities, and Group III – CECs with diverging walls and two subgroups, based on the different access cavity restorations subgroup A-Activa and subgroup B-SDR with \( n = 7 \) per group. Root canal treatment was completed under the dental operating microscope. Cuspal deflection was assessed by measuring the distance between the glass beads using an optical microscope and micrometer immediately after a Root canal treatment and final measurements after access restorations. Data were statistically analyzed and tabulated.

Results: Results showed that the access cavity restored with Activa showed the highest cuspal deflection than SDR in all the groups \( (P < 0.05) \). Conservative access designs showed the least cuspal deflection among other groups.

Conclusion: CEC designs showed lesser cuspal deflection than traditional endodontic cavity designs. SDR can be considered as a choice of material for access restorations.

Keywords: Activa; conservative endodontic cavity; conservative endodontic cavity with diverging walls; cuspal deflection; Smart Dentin Replacement; traditional endodontic cavity

INTRODUCTION

Endodontically treated teeth (ETT) are at a higher risk of biomechanical failure than vital teeth. The factors posing the highest risk of fracture include loss of dental tissue; preparation of an endodontic access cavity to disinfect the root canal; volume and time of contact of disinfectant

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a direct restoration using resin composite due to its high bond strength to the dental substrate.\(^3\),\(^4\)

Polymerization shrinkage remains one of the disadvantages that may breakdown the adhesion at the tooth–restoration interface, generally leading to microleakage, cuspal deflection, and recurrent caries.\(^3\) Cuspal deflection of 4–45 \(\mu\)m has been reported with resin composites, which varies according to the measurement method, tooth type, and cavity size.\(^6\)

Cuspal deflection may cause cracks in the enamel and/or tooth fracture. They have explained important biomechanical factors which plays an important role in cuspal deflection. First is geometrical factors such as cavity dimensions in terms of cavity size, cavity wall thickness after preparation and restorative material properties in terms of polymerization shrinkage, elastic modulus, flow, and hygroscopic expansion of resin composite. Clinical factors involve placement technique and direct or indirect restoration using stress-absorbing liners and light-curing protocol.\(^4\)

Bulk-fill composites (BFCs) have been introduced to reduce the time taken for placement and also increase the fracture resistance of ETT.\(^8\) These materials can be placed in bulk layers up to 4–5 mm due to its enhanced translucency and low-polymerization shrinkage stress.

Smart Dentin Replacemen (SDR) (SureFil SDR Flow+, Dentsply) is a bulk-fill flowable, fluoride-containing, radiopaque, visible light-cured resin composite used as an access restoration and dentin substitute in Class I and II restorations.

Recently introduced Bioactive Bulk-fill Restorative Activa\(^\text{TM}\) (Pulpdent, USA) has patented bioactive ionic rubberized resin and bioactive ionomer glass which mimics the physical and chemical properties of natural teeth by combining the strength, esthetics, and physical properties of composites and is more bioactive than glass ionomers.\(^6\)

However, very few studies have been done on the effect of these restorative materials on cuspal deflection in ETT. Hence, the aim was to evaluate the effect of BFCs – Activa and SDR on cuspal deflection in ETT with different access cavity designs. The null hypothesis was that there would not be any difference in the effect of BFCs – Activa and SDR on the cuspal deflection of ETT with different access cavity designs.

**MATERIALS AND METHODS**

**Sample selection**

After ethical approval (KIDS/IEC/02-2021/32), 42 human maxillary first premolar teeth extracted for orthodontic purposes and free from caries, cracks, or defects were selected for this study. The teeth had crown dimensions of 6.0–7.5 mm in the mesiodistal (MD) and 6.0–8.0 mm in the buccolingual (BL) direction. The teeth were stored in 0.5% thymol and buffered saline at 4°C before use. A glass bead of 1 mm diameter was fixed to each cusp as a reference point for intercuspal distance measurements.

Teeth were randomly divided into three experimental groups based on different access designs \(n = 7\) in each group and two subgroups based on the different access cavity restorations – Activa \(n = 7\) and SDR \(n = 7\).

- Group I-CECs
- Group II-traditional endodontic cavities (TECs)
- Group III-CECs with diverging walls (CECDW).

**Root canal preparation**

Endodontic access was gained according to different access cavity designs [Table 1] under the dental operating microscope. Cleaning and shaping till F2 were done using ProTaper NiTi Rotary System (Dentsply Mailleffer), and the single-cone obturation technique was carried out using AH Plus sealer (Dentsply; De Trey, Konstanz, Germany).

**Description of the characteristics of experimental groups**\(^7\)

Group I (CEC) → BL extension smaller than half of the distance between the main groove and cusp tips:
- MD extension smaller than half of the distance between the central portion of the central groove and proximal crests
- No divergent walls to the occlusal plane.

Group II (TEC) → BL extension to half of the distance between the main groove and cusp tips:
- MD extension to half of the distance between the central portion of the main groove and the proximal crests
- Divergent walls to the occlusal plane.

**Table 1: Distributions and differences in mean cuspal deflection among conservative endodontic cavities, traditional endodontic cavities, and conservative endodontic cavities with diverging walls in different restorative groups using paired \(t\)-test**

| Group      | Access designs | \(n\) | Mean  | SD     | \(F\) | \(P\) |
|------------|----------------|------|-------|--------|-------|-------|
| Activa     | CEC            | 7    | 6137.14 | 480.823 | 0.616 | 0.551 |
|            | initial        | 7    | 5922.86 | 625.292 |       |       |
|            | CEC            | 7    | 5781.43 | 686.159 |       |       |
| Activa     | final          | 7    | 6125.43 | 480.357 | 0.643 | 0.537 |
|            | CEC            | 7    | 5882.86 | 627.838 |       |       |
|            | TEC            | 7    | 5766.14 | 686.592 |       |       |
| SDR        | initial        | 7    | 5922.43 | 401.897 | 0.014 | 0.986 |
|            | CEC            | 7    | 5934.29 | 392.932 |       |       |
|            | TEC            | 7    | 5915.43 | 578.121 |       |       |
| SDR        | final          | 7    | 5914.00 | 401.500 | 0.015 | 0.986 |
|            | CEC            | 7    | 5951.57 | 579.101 |       |       |

Initial: Before restoration, Final: After restoration. SDR: Smart Dentin Replacement, CEC: Conservative endodontic cavities, CECDW: CEC with diverging walls, TEC: Traditional endodontic cavities, SD: Standard deviation
Group III (CECDW) → BL extension smaller than half of the distance between the main groove and cusp tips:
- MD extension smaller than half of the distance between the central portion of the central groove and proximal crests
- Divergent walls to the occlusal plane.

**Restorative procedures**

After obturation, the teeth were restored with BFCs as per the manufacturer’s instructions:
1. **Group 1 (ACTIVA):** The teeth were etched with 37% phosphoric acid for 15 s and then rinsed for 1 min and blot dried; 3M Single-Bond Universal Adhesive was placed and light-cured for 10 s. The access cavity was bulk filled with Activa™ composite (Pulpdent, USA) using an automated syringe. It was then allowed to self-cure for 2 min, followed by light cure for 20 s using a light-emitting diode light-curing unit set at 1200 mW/cm²
2. **Group 2 (SDR):** Etching and bonding were carried out in the same fashion, followed by cavity was bulk filled with SDR till 1 mm below the occlusal surface over which it is filled with a conventional composite (Tetric N-Ceram, Ivoclar Vivadent).

**Cuspal deflection measurement**

The distance between the glass beads was measured with an optical microscope and noted as the “initial distance” immediately after endodontic procedures, and final measurements were done after restorative procedures, and the data were recorded.

**Sample measurement**

Optical microscope (LCM 30t Clinical Trinocular Microscope, Droplet Equipments, India) and Micrometer (Series 510, Bombay Tools Centre [Bombay] Pvt. Ltd.) were used for the measurements. The tooth was fixed to the microscope stage, and the two cuspal indices were aligned with the eyepiece crosshair. The intercuspal distance of each tooth was measured utilizing the indices. The distance between reference points was measured at 5 min after completion of the restoration. The same operator performed all measurements.

**Statistical analysis**

The mean cuspal deflection for each group was calculated using one-way ANOVA which was applied for the analysis of significant differences between the groups, followed by paired t-test keeping significance level at $P < 0.05$.

**RESULTS**

One-way ANOVA revealed that the different restorative groups significantly influenced the mean values of cuspal deflection ($P = 0.001$). The restorations with Activa showed the highest cuspal deflection. The SDR group showed lower mean values for cuspal deflection. The descriptive statistical analysis and results of the paired t-test are shown in Table 1.

Table 2 represents a comparison of mean intercuspal distance among both restorations with different access designs using the ANOVA test. The mean cuspal deflection was highest in groups restored with Activa and was lowest in groups restored with SDR.

**DISCUSSION**

One of the most important causes of fractures in ETT is the loss of tooth structure. The preparation of the endodontic access cavity following TEC principles was reported as the second largest cause of loss of tooth structure.[3,9] CEcs are proposed to reduce the size of TECs which could enhance the fracture resistance of ETT without affecting the quality of the mechanical preparation.[3,10,11] The success and survival rate of ETT depends on both endodontic therapy and postendodontic restoration placed. The best technique and material according to the functional demands also play a significant role in clinical success.[7] Direct adhesive restorations have the ability to withstand masticatory stresses facilitating reinforcement of the weakened tooth structure, resulting in increased fracture resistance.[7]

Shrinkage stress was not measured directly (because stress cannot be measured directly), but cuspal deflection was used as an indication of stresses within the restored...
Cuspal deflection occurs as a result of the volumetric stress of resin composites on tooth structure which could facilitate tooth fracture under occlusal load.\(^{[15]}\)

Extracted teeth have been used in cuspal deflection measurement in various studies because they eliminated the problem of the compliance of the testing system and supporting structures.\(^{[16]}\) Due to their uniformity in size and shape, maxillary first premolar teeth were used in this study.\(^{[17]}\)

In the present study, for measuring cuspal deflection using an optical microscope and micrometer, glass beads were used as reference points as the same methodology was followed in other published studies.\(^{[5,15]}\) although other more sensitive methods such as Linear Variable Differential Transformer (LVDT) and Direct Current differential transducer (DCDT) are also suggested to detect cuspal deflection.\(^{[18]}\) The distance between glass beads was measured at 5 min after completion of the restoration, based on findings by Suliman et al. that the highest percentage of cuspal deflection occurs during the first 5 min.\(^{[8]}\)

BFCs show higher depth of cure and minimal polymerization stress than conventional composites. Hence, BFCs were chosen in our study.

In all the experimental groups, Activa showed the highest cuspal deflection. The SDR showed significantly lower cuspal flexure, in accordance with the study reported by Vinagre et al.\(^{[19]}\) The results of intergroup analysis showed that Group II exhibited the highest cuspal deflection and Group I showed the least. The values were statistically significant (\(P = 0.001\)) [Table 2]. This is due to the variation in the dimensions of the access cavity prepared which could influence the polymerization stress exhibited on the tooth. Therefore, the null hypothesis was rejected.

The SDR’s stress-relieving flowability and enhanced translucency that promotes light transmittance and better polymerization kinetic up to 4 mm could be an additional factor for exhibiting lower cuspal deflection.\(^{[20]}\)

Alshali et al.\(^{[21]}\) reported that the BFCs (SDR and Venus Bulk Fill) shrinkage was generally comparable to those of the conventional composites. However, in other studies,\(^{[22,23]}\) it was reported that SDR showed 60%-70% less polymerization shrinkage stress than that of the conventional resin composites. Marovic et al.\(^{[23]}\) and Kim et al.\(^{[24]}\) reported that shrinkage stress induced by SDR was significantly lower than other BFCs.

SDR contains modified urethane Dimethacrylate (UDMA)-monomer with incorporated photoactive groups which is claimed to function as polymerization modulator; this allows the monomers to link more flexibly during the formation of the polymer network, which in turn helps in a higher degree of conversion and network density.\(^{[20]}\)

Activa (Pulpdent, USA) exhibits dual-cure property and greater curing depth. In the present study as per the manufacturer’s guidelines, 2 min delayed photoactivation was done similar to the study done by Hughes et al.\(^{[12]}\) In his study, they concluded that delayed photoactivation could reduce cuspal flexure without compromising mechanical properties. But still, compared with other BFCs, Activa showed statistically significant more cuspal flexure.

The present study demonstrates that the degree of tooth removal influences the cuspal flexure from volumetric shrinkage of resin composites, which may cause failure during composite curing or act as a preloading, facilitating tooth fracture under occlusal loads.\(^{[25]}\)

CEC designs are recommended to preserve as much as tooth structure possible to facilitate the fracture resistance of the tooth and replacing traditional access designs.

Since this is the first study to evaluate Activa with SDR on cuspal deflection on ETT. Further research is warranted to

### Table 2: Comparison of mean intercuspal distance values (initial and final) among Activa and Smart Dentin Replacement with different access designs using ANOVA test

| Group | Design | Material | Time | Mean   | n  | SD    | Mean difference | T     | Df  | P    |
|-------|--------|----------|------|--------|----|-------|-----------------|-------|-----|------|
| 1     | CEC    | Activa   | Initial | 6137.14 | 7  | 480.823 | 11.714          | 11.795 | 6   | 0.001 |
|       | CEC    | SDR      | Initial | 5922.43 | 7  | 401.897 | 7.000           | 16.039 | 6   | 0.001 |
|       | CEC    | SDR      | Final  | 5915.43 | 7  | 401.500 |                 |       |     |      |
| 2     | TEC    | Activa   | Initial | 5922.86 | 7  | 625.292 | 40.000          | 32.922 | 6   | 0.001 |
|       | TEC    | SDR      | Initial | 5882.86 | 7  | 627.838 | 20.286          | 9.453  | 6   | 0.001 |
|       | TEC    | SDR      | Final  | 5914.00 | 7  | 393.646 |                 |       |     |      |
| 3     | CECDW  | Activa   | Initial | 5781.43 | 7  | 686.159 | 15.286          | 16.192 | 6   | 0.001 |
|       | CECDW  | SDR      | Initial | 5766.14 | 7  | 686.592 | 11.286          | 7.649  | 6   | 0.001 |
|       | CECDW  | SDR      | Final  | 5951.57 | 7  | 579.101 |                 |       |     |      |

Initial: Before restoration, Final: After restoration. SDR: Smart Dentin Replacement, CEC: Conservative endodontic cavities, CECDW: CEC with diverging walls, TEC: Traditional endodontic cavities, SD: Standard deviation.
clearly establish the behavior of composite restorations under occlusal loading and its influence on marginal sealing and tooth resistance to fracture.

CONCLUSION

The type of access cavity design and placement of composite influences the clinical outcome of ETT. The amount of dental tissue plays a pivotal role in enhancing the fracture resistance of ETT. CEC designs showed lesser cuspal deflection than TEC designs. Clinically, it is important to preserve the stress-bearing areas in ETT to maximize resistance and minimize fracture susceptibility in teeth without full-coverage indirect restorations. Thus, SDR can be considered a choice of material for access restoration.

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Conflicts of interest
There are no conflicts of interest.

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