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Research Article

A CP- OCT STUDY ON ADAPTATION OF ANTIMICROBIAL NANOFILLED COMPOSITE RESTORATIONS

Ghada H. Naguib[1], Eslam H. Attieh[2], Saeed Alamoudi[2], Ammar Sanyoor[2], Turki A. Bakhsh[1] and Mohamed T. Hamed[3]

[1] Department of Restorative Dentistry, Faculty of Dentistry, King Abdulaziz University, Jeddah, KSA
[2]Faculty of Dentistry, King Abdulaziz University, Jeddah, KSA
[3]Department of Oral & Maxillofacial Rehabilitation, Faculty of Dentistry, King Abdulaziz University, Jeddah, KSA

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ABSTRACT

One of the substantial determinants of restorations survival is their surface adaptation to cavity walls and floor. The objective of this study is to appraise the coalition of flowable composite enhanced with antimicrobial MgO nanoparticles under OCT, and to compare it with non filled flowable composite restorations adopting cross-polarization optical coherence tomography (CP-OCT).
Methods: Thirty sound central incisor teeth were used in which class five was prepared and randomly distributed into three groups: G-1control, G-3, and G-5 a mixture of 0.3% and 0.5% Magnesium oxide nanoparticles and flowable composite respectedly.
Clear l SE Bond 2 adhesive was used for bonding all the groups (SE; Kuraray Noritake Dental Inc, Japan). Microgaps adaptation of composite were determined by CP-OCT.
Reults: Data were analyzed by Mann–Whitney showed no significant difference in flowable composite adaptation between the three groups ($p < 0.05$) CP-OCT is a safe and predictable method that gives a perception of composite performance .
There was no statistical difference in the adaptation of Flowable composite with and without the addition of MgO nanoparticles.
Conclusion: It is beneficial to incorporate the antimicrobial MgO nanoparticles to flowable composite in order to benefit of its antimicrobial properties, as it does not affect the internal adaptation of the composite restoration.

INTRODUCTION

Posterior resin composite with their improved mechanical and esthetic properties has attracted dentists and patients globally. Meanwhile polymerization shrinkage is still a major problem for resin restorations that affect the proper adaptation of the restoration walls and floor impairing the composite durability (18). Lack of proper adaptation open the doors to the ingress of oral fluids leading to harmful effects to the oral structure such as marginal discoloration and secondary caries. (26,27) Attempts have been made to eliminate the micro leakage including the introduction of different types of adhesive systems and varying placement techniques but the elimination of micro leakage proves not possible. Which lead to the introduction of a new group of composite named nano-filled composite that uses nanoparticles to fill the gap between the fillers particles in resin composite minimizing the space between them, producing highly filled resin with smoother surface and improved physical properties. (11,21)

Corresponding author:* **Ghada H. Naguib
Department of Restorative Dentistry, Faculty of Dentistry, King Abdulaziz University, Jeddah, KSA

The incorporation of nanoparticles to composite restorations is one of the recent applications of nanotechnology in dentistry. The addition of metal oxide nanoparticles such as nano zinc oxide (NZnO) particles to resin composite,showed an antibacterialeffect against streptococcus mutans with low microleakage(16, 23).

Magnesium oxide (MgO) nanoparticles is a vital mineral with competence in strong inhibition against resistant bacterial strains(10, 22).The use of MgO nanoparticles has been applied to many materials for different purposes such as catalysis, refractory materials, relief of heartburn, sore stomach and for bone regeneration. Also in recent years, MgO nanoparticles have shown promising results in tumor treatment. (10) Studies attributed the antimicrobial activity of MgO nanoparticles to lipid peroxidation in bacteria as a result of production of reactive oxygen species. They also showed a correlation between the small size of the particles and the increase of antimicrobial effect of it due to the increase of the surface area of action (17) However, MgO nanoparticles has not been used in dentistry, which made it a beneficial addition to infer their antibacterial property to the composite restorations and reduce microleakage. (6, 9)

Several invasive techniques were used to check the fitting of the restoration to the cavity walls and floor such as: optical microscope, scanning electron microscope (SEM), micro computed tomography (micro-CT), or transmission electron microscope (TEM) and replica technique.

In the last decade, a non-invasive method was used to check the internal tooth structure at a very precise measure.(8)The Optical Coherence Tomography (OCT) is an auspicious technique that permits dentists to have a perception of the dental work with preservation of the tooth configuration.(2, 5, 8,20)Its concept of development is based on projecting light n a subject and obtaining information by analyzing the reflected light.

Lately, dental studies and clinical practices have been using OCT without having to section and slice into the material. This technique has proven to be very useful in hands on clinical practice to visualize and detect caries and demineralization, occlusal, interproximaly and secondarily beneath an existing restoration through a hand-held probe suitable to be used on patients. Previous studies showed the ability for OCT to detect and measure clearly the voids and failure in adaptation of material to the tooth surface.(3,4,7,8,12,14, 19,)

Thus, the objective of this study is to appraise the adaptation of the flowable composite restorations with and without the incorporation of antimicrobial MgO nanoparticles under OCT.
We assessed the inference of no difference in marginal integrity for the tested composite restorations in micro gap formation.

MATERIALS AND METHODS

Materials

The following materials were used: flowable composite (Tetric-N flow, Ivoclar/Vivadent, Liechtenstein), adhesive (Clearfil SE bond 2, Kuraray Noritake Dental, Japan) and microwave synthesized MgO nanowires (particle size 40nm diameter and 100nm length) (1) were used. The MgO nanofillers were weighed using a balance accurate to 0.0001g (BEL Engineering , Monza, Italy) and were added to the flowable composite in the ratio of 0.3% and 0.5% by weight (wt).

Experimental Design and sample Preparation

An Ethical approval was obtained from King AbdulAziz University Faculty of Dentistry (KAUFD) for the research.
Class-V cavities (3 mm x 1.5 mm) were prepared by a diamond wheel shaped bur(ISO #068/064, Shofu, Japan) on the buccal and lingual surfaces of teeth with cavity margins on enamel.

All prepared cavities were bonded with adhesive (Clearfil SE bond 2, Kuraray Noritake Dental) according the manufacturer recommendation. Then, the specimens were haphazardly split into three groups (n=10); G- Ctrl: Control, G-3and G-5. In G-Ctrl, cavities were restored with non filled flowable composite. In G-3, a mixture of 0.3% Magnesium oxide nanoparticles and flowable composite was used to restore the cavities, while 0.5 % concentration of MgO nanoparticles was used in G-5 group. All restorations were filled and light cured LED (~1200mW/cm2) according to the manufacturer's directions. Subsequently, all groups were reserved in water at 37°C for one day.

Cross-Polarization OCT (CP-OCT)

A portable OCT (CP-OCT; IVS-300; Santec, Japan) was used to develop the restored cavities non-invasively. It utilizes a scanning diode laser of 30kHz scan rates and a wavelength range of 100 nm.

Tomographic Imaging

After 24h of water storage, restorations were evaluated under CP-OCT to detect any changes in signal intensities along the pulpal floor. Teeth were mounted on a micrometer stand With buccal or lingual surface being oriented perpendicular to the projected light source from the scanning probe, while cavity floor being parallel to the micrometer stage base and subjected to tomographic scanning (B-scan) at every 250 μm.

CP-OCT Image interpretation

From our earlier studies we interpreted bright pixels as interfacial microgaps. OCT data analysis was obtained according to the literature (3,4) On every B-scan image the floor adaptation and gaps were calculated using a modified image analysis software (ImageJ 1.5 m9, National institutes of health, USA) (4). The modified version converts the OCT raw date into an image, analyzed into black and white pixels that allowed determination of the microgaps. The adaptation criterion was calculated as follows: Adaptation % = [(floor length – microgap length)/ floor length]× 100.

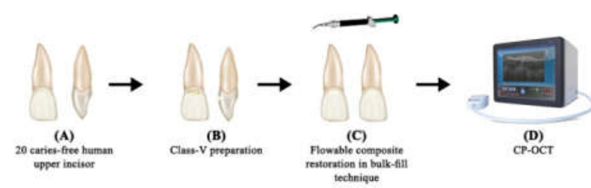

Fig 1 Simplified analogy of the specimen preparation, restoration, and CP-OCT imaging

Statistics

Kruskall-Wallis and MannWhitney tests were used to analyze floor gap percentage among the groups. The software used was Statistical Package for Social Science (SPSS for Windows, Version 23, SPSS, USA) with the significance of $p<0.05$.

RESULTS

Statistical analysis showed no significant difference among the control and the 0.3% and 0.5% MgO nanofilled composite in cavity floor adaptation ($p < 0.05$). (Table1, Figure 4)

Representative CP-OCT images obtained from composite restorations with or without MgO nanofillers are shown in Fig.2,3,4. Images with better adaptation showed no bright spots at the cavity floor. This was defined as remarkable adaptation rate.

Others showed continuous or scattered bright-clustered pixels in some specimens, as shown in Fig. 2 and 3. These bright clusters corresponded to gaps under the resin restorations (4). Values of the gap at the floor are shown in Table 1 and Fig 5.

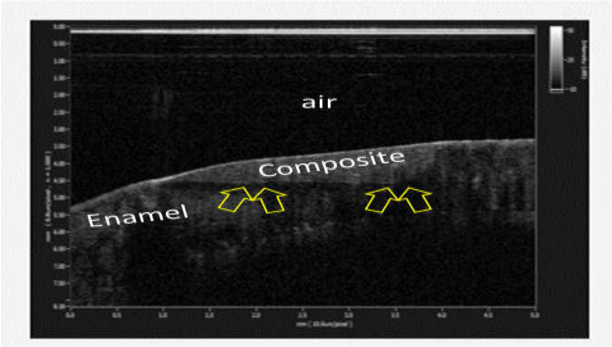

Fig 2 Representative OCT image that shows adequate adaptation between the composite and enamel (Hollow arrows).

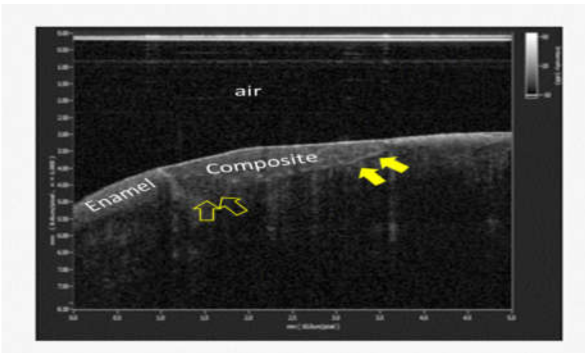

Fig 3 Representative OCT image of Group 2 with 0.3% MgO that shows adequate adaptation between the composite and enamel at one side no high signal intensity (Dark pixels) can be seen at the interface indicated by Hollow arrows, and loss of interfacial seal at the other side as it showed high signal intensity (White clusters of pixels) that is indicated by the solid arrows.

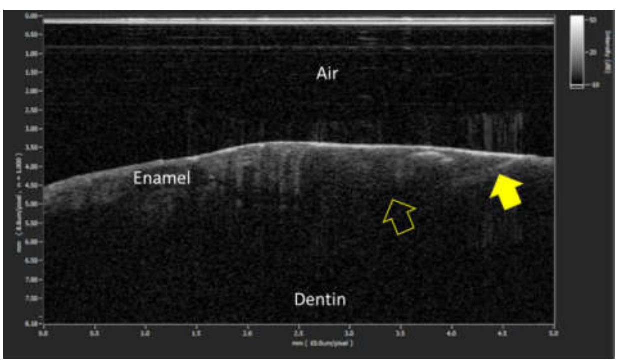

Fig 4 Representative OCT image of Group 3 with 0.5% MgOthat shows adequate adaptation between the composite and enamel at one side no high signal intensity (Dark pixels) can be seen at the interface indicated by Hollow arrows, and loss of interfacial seal at the other side as it showed high signal intensity (White clusters of pixels) that is indicated by the solid arrows.

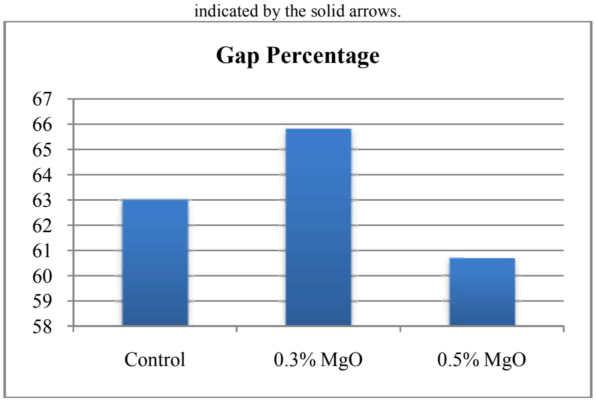

Fig 5 Bar chart representing the gap percentage showing no significant Difference Between the groups $p<0.05$

Table 1 Summary of the gap percentage of the groups (mean +/- Standard Deviation)

	Control	0.3% MgO	0.5% MgO
Gap Percentage (Mean +/- SD)	63 (+/- 3.15)	65.82 (+/- 3,29)	60.7 (+/- 3.03)

DISCUSSION

CP-OCT is a non-invasive diagnostic tool that gives images of high resolution nearly like histologic pictures with a safe broadband light source (12, 20). Lately, medical and dental fields got the chance to benefit of OCT use. It outlines images of materials in the patient body while protecting the body from ionizing radiation (19). Microleakage in enamel or dentin is one of the great concerns in bonded restorations. Researchers (26) reported that the there was no significant difference in microleakage at occlusal and gingival margins. While others (15) did not show significant differences in microleakage of glass-ionomer cement at enamel in primary teeth.

Addition of MgO nanoparticles has been utilized in the medical field such as in relief of heartburn, sore stomach, bone regeneration and tumor treatment. Also, previous work with MgO nanoparticles has shown some advantages such as antimicrobial effect and stability under harsh conditions.

While in the present study the gap percentage decreased in the group of composite filled with 0.5% MgO nanoparticles , the results showed that marginal adaptation of nanofilled flowable composite restorations were not significantly different than the unfilled ones.

The results stated an interesting finding and that regardless of the incorporated MgO fillers percentage, the cavity adaptation remained the same. This means it can bond chemically along with other silica fillers of the composite to the underlying adhesive.

These results are also in accordance with the fact that bonding to enamel is more effective due to its high mineral content. Also, Clearfil SE bond 2 self-etch adhesive contains MDP monomer that has a binding affinity to Ca in enamel. In addition, from the results it can be speculated that MDP has no interference in bonding with the included MgO fillers.

CONCLUSION

Within the limitations of this study, it is recommended to incorporate the antimicrobial MgO nanoparticles to flowable composite in order to benefit of its antimicrobial properties, as it does not affect the internal adaptation of composite restoration.

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