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A NEW APPROACH TO RESTORATIVE DENTISTRY USING PEPTIDE-ENHANCED DENTAL CEMENTS FOR STRONGER BONDS

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ABSTRACT
Dental materials make drastic impacts on the success rate and durability of all the restorative procedures. More recently, the development of dental cements containing bioactive peptides has been considered as a prospect for increasing the adhesive properties to dentin and enamel. This paper examines the synthesis and functionalization of dental cements with incorporation of peptides, and its performance characteristics such as mechanical properties, biocompatibility and adhesion as compared to the conventional cements. Studies done in a test tube have postulated that using peptides in cement increases bond strength and predictive of increasing the durability of restorations.

Introduction
It is clear that dental cements are critical materials in restorative dentistry with their use being confined to acting as the bonding agents which hold crowns, bridges, inlays, and onlays on the hard tissues of teeth, particularly the dentin and the enamel (1)(2). These restorations fade in effectiveness and durability depending upon the bond strength between the cement and the tooth structure (3). But the oral environment poses some challenges in terms of its acidity, temperature and abrasive forces that constantly act on the material, which may, therefore, cause a gradual deterioration of the bond and significantly affect the durability of dental restorations (4)(5).
Research developments on self-setting biologically active dental cements, that are capable of bonding to tissues to facilitate tissue repair and healing, represent an area of great potential in dental materials science (6). Bioactive peptides are short sequences of amino acids that have been observed to make contact with dental tissues and they exhibit bactericidal effects on tissues while at the same

time increasing adhesion and tissue regeneration(7)(8). Incorporation of these peptides into dental cements may improve their bond strength and resistance to wear thereby providing more durable restorative dental products for use under the extreme conditions within the oral cavity (9).
This study hypothesizes that dental cements incorporating bioactive peptides will demonstrate superior adhesive strength compared to traditional cements, ultimately leading to more effective and sustainable dental restorations.

Objective
The primary objective of this study is to evaluate the bond strength, biocompatibility, and mechanical properties of peptide-reinforced dental cements in comparison with conventional cements.

Materials and Methods
Materials
In this work, the bioactive peptides applied were prepared via solid-phase peptide synthesis (SPPS). Among these peptides, preference was given to adhesive and those with affinity to the mineralized tooth tissue (10). Three concentrations of peptides (1%, 5%, and 10%) were evaluated in resin based dental cement systems. Resin based cement without peptides was used as the control (11).
The specimens used in the present study are human molar teeth in 0. Nine percent saline solution used for bonding tests were also prepared. The teeth were conditioned with 37% phosphoric acid for 15 seconds for the purpose of opening the dentin and enamel prisms. It is important to note that after etching the surfaces following bonding agent were applied and then cement (12).

Methods
1. Peptide Synthesis and Cement Preparation: Peptides were synthesized via SPPS and purified using HPLC. The peptides were incorporated into resin-based cements at concentrations of 1%, 5%, and 10%. The cements were applied to prepared tooth surfaces and cured for 20 seconds using an LED curing light.
2. Bond Strength Testing: The bond strength of the cements to dentin and enamel was measured using a universal testing machine (Instron, USA). The shear bond strength was tested at a crosshead speed of 1 mm/min until failure. Bond strength was recorded in megapascals (MPa) .
3. Biocompatibility Testing: Human gingival fibroblasts (HGFs) were exposed to the cement formulations for 72 hours. Cell viability and proliferation were assessed using the MTT assays.
4. Mechanical Properties: The compressive strength and modulus of elasticity of the peptide-enhanced cements were evaluated using standardized tests.

Results
Bond Strength
It was observed that bond strength of all groups of peptide-enhanced cements were enhanced compared to the control group at all peptide concentrations. The surface with the highest bond strength was obtained with the peptides containing 5% peptide concentration and achieved a bond strength of 30. 5 ± 1. 14 MPa for dentin, an increase in the DBA of 0. 2 ± 2. 0 MPa for dentin. These values are a considerable improvement, that is 33% increase in enamel bond strength, and 28% in dentin bond strength compared to the control group which 22. 9 ± 2. 72 MPa for dentin; the pressure of 3 MPa dehydrated enamel without causing it to buckle while the pressure of 18. 9 ± 1. 7 MPa for dentin. Notably, the increase in bond strength was also observed in the 10% peptide concentration group; bond strength of 26. 1 ± 2. 5 MPa for enamel and 21. 0 ± 1. 6 MPa for dentin; however, it is still not significantly different from that of 5% group and implied that there is an optimum level of peptides after which there will be no increase in bonding

Mechanical Properties

It is worth to note that the mechanical properties of the dental cements were enhanced by the addition of peptides without compromising the mechanical characteristics of the cement. Results for the 5% peptide CM was 240 ± 10 MPa slightly higher than the control group of 225 ± 14 MPa for the compressive strength. Furthermore, the modulus of elasticity were comparable in all the groups, which proved that incorporation of peptides did not have any negative impact on the mechanical properties of dental cement.

Biocompatibility

Significantly, based on the MTT assay, none of the tested peptide-enhanced cements exhibited cytotoxicity to cells wherein the cell viability was more than 95% on all the groups. MTT assay also did not show any sign of cell toxicity after 72 hours of treatment reinforcing its safety in clinical setting with use of these peptide-infused formulations.

Discussion

This led to the conclusion this work, revealing that the incorporation of the bioactive peptides in dental cements increases the bond strength in the dentin and enamel specially at the 5% concentration. This can be explained by the fact that the peptides can inculcate into the etched tooth surfaces, thus demonstrating better chemical adhesion with the tooth substrate (8). These results are in consonance with other works that have noted the adhesive effectiveness of bioactive peptides in dental uses(14)(15).

Touching on this, the mechanical properties of the peptide-enhanced cements were similar to the conventional cement thus implying that peptides do not adversely affects the structural stability of the material(16). This is an important aspect because the mechanical properties of dental cements are vital in as far as the durability of any restorations is considered (17).

In addition, cytotoxicity of the modified cements was assessed for biocompatibility, revealing no toxicity to cells (18). This supports potential for the clinical use of these cements in restorative dentistry as demonstrated by the author.

The absence of further enhancement of bond strength at 10% peptide concentration indicated that there is optimum peptide level beyond which it could not bring any improvement(19). Further studies should look into the initial degradation behaviour of peptide incorporated cements under cyclic loading and their ability to prevent biofilm formation (20).

Conclusion

Peptide-enhanced dental cements represent a promising innovation in restorative dentistry, offering improved bond strength to dentin and enamel without compromising mechanical properties or biocompatibility. The highest bond strength was achieved with a 5% peptide concentration, suggesting an optimal balance between peptide content and bonding performance. These findings pave the way for further development of bioactive dental materials that can enhance the longevity and effectiveness of restorations.

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