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The Effect of Resin-modified Glass Ionomer Containing Bacterial Cellulose Nanocrystal as a Base on the Fracture Resistance of Class II Restorations

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Abstract

Background: Resin-modified glass ionomer cements (RMGICs) are commonly used as base materials in restorative dentistry due to their fluoride release and chemical bonding properties. Incorporating bacterial cellulose nanocrystals (BCNCs) into RMGIC may improve its mechanical properties, especially fracture resistance (FR), which is critical in Class II restorations. This study aimed to evaluate the effect of BCNC-reinforced RMGIC on the fracture resistance and fracture patterns mesio-occluso-distal (MOD) cavities restored premolars using the sandwich technique.

Material and Methods: Sixty sound human maxillary premolars were randomly divided into five groups (n = 12) based on the restoration protocol: Group I) intact teeth (positive control); Group II) MOD cavities left unrestored (negative control); Group III) MOD cavities restored with short-fiber reinforced composite (SFRC) only; Group IV) MOD cavities restored with conventional RMGIC + SFRC; Group V) MOD cavities restored with 1% BCNC-reinforced RMGIC + SFRC. The restorations in groups III to V were finally covered with 1 mm of nanohybride composite. All specimens underwent thermocycling. Fracture resistance was tested using a universal testing machine, and fracture patterns were classified as restorable or unrestorable based on the CEJ level. Data were analyzed using one-way ANOVA and Tukey's post-hoc test ($P < 0.05$).

Results: The negative control group (Group II) exhibited significantly lower fracture resistance compared to all other groups ($P < 0.001$). Group V (BCNC-modified RMGIC+SFRC) showed the highest fracture resistance, but no significant differences were found among Groups I (intact teeth), III (SFRC only), IV (RMGIC+SFRC), and V ($P > 0.05$). Group II had predominantly unrestorable fractures, while other groups showed a higher proportion of restorable fractures.

Conclusions: The incorporation of BCNC into RMGIC as a base in Class II restorations improved fracture resistance and resulted in more favorable fracture patterns, suggesting its potential as a reinforcing agent in restorative dentistry.

Key words: Bacterial cellulose nanocrystals; Fracture resistance; Glass ionomer cement; Sandwich technique; Short-fiber reinforced composite.

riables such as occlusal dynamics, salivary enzymes, and patient-specific factors could influence long-term outcomes.

Nonetheless, the data suggest that incorporating BCNCs into RMGIC, followed by a fiber-reinforced composite overlay, provides a promising restorative strategy for structurally compromised premolars. This layered biomimetic approach addresses critical restorative goals, such as resistance to fracture, stress modulation, marginal integrity, and potential caries inhibition, making it highly relevant for clinical translation in high-stress posterior restorations [29,30].

This study has several limitations, including its in-vitro design, the potential influence of variations in tooth morphology and cavity preparation and the absence of advanced interfacial characterization techniques such as FTIR or XRD to verify the homogeneous dispersion of BCNC within the RMGIC matrix. Future work should include clinical trials, and advanced analytical methods to confirm and extend the present findings.

Conclusions

The results of this study demonstrated that the addition of bacterial cellulose nanocrystals (BCNC) to resin-modified glass ionomer cement (RMGIC), combined with short fiber-reinforced composite (SFRC) in the open sandwich technique, offers promising benefits for enhancing fracture resistance in Class II MOD cavities in premolars. BCNC reinforcement may contribute to improved mechanical performance and stress distribution within the tooth-restoration system. Therefore, this study provides a foundation for advancing biomimetic restorative techniques to enhance both mechanical and clinical outcomes.

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Institutional Review Board Statement

The study protocol was reviewed and approved by the Research Ethics Committee of Shiraz University, approval with the code of IR.SUMS.DENTL.REC.1403.044.

Data Availability Statement

The data used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

Conceptualization was made by M.M., study design was planned by M.S., the software was performed by M.K.; validation was done by M.M. formal analysis was executed by M.M. and M.S.; investigation was performed by M.M., M.M. and M.K.; resources were collected by M.M.; data acquisition was done M.K.; original draft preparation was written by M.M., M.S. and M.K.; review and editing was done by

M.M., M.S.; visualization was performed by M.M. All authors read and approved the final manuscript.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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