THE NEW ARMENIAN MEDICAL JOURNAL
Volume20 (2026), Issue 2, p. 23-29

DOI: https://doi.org/10.56936/18290825-2026.20v.2-23

IN-VITRO EVALUATION OF NANOPARTICLE-REINFORCED ORTHODONTIC ADHESIVES FOR ENHANCED SHEAR BOND STRENGTH AND ANTIMICROBIAL ACTIVITY

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Received 2.12.2025; Accepted for printing 14.05.2026

Abstract

Introduction: *White spot lesions and bracket bond failures remain common complications of fixed orthodontic therapy. Conventional orthodontic adhesives lack sustained antimicrobial activity, allowing biofilm formation by Streptococcus mutans. Incorporation of antimicrobial nanoparticles into adhesive systems may enhance biological performance without compromising mechanical properties.*

Material and Methods: *Eighty extracted human premolars were randomly allocated into four groups (n = 20): Group I (control adhesive), Group II (1% titanium dioxide nanoparticles), Group III (1% silver nanoparticles), and Group IV (hybrid: 0.5% TiO_2 + 0.5% Ag nanoparticles). Shear bond strength was evaluated using a universal testing machine, while antimicrobial efficacy against Streptococcus mutans was assessed using a colony-forming unit assay. Adhesive remnant index scores were recorded to determine failure patterns.*

Results: *Mean shear bond strength values were 21.45 ± 2.31 MPa (control), 22.15 ± 2.84 MPa (TiO_2), 17.85 ± 3.15 MPa (Ag), and 20.95 ± 2.62 MPa (hybrid). The silver nanoparticle group demonstrated significantly reduced bond strength compared with the control ($p < 0.05$), whereas the TiO_2 and hybrid groups showed no significant differences. Antimicrobial testing revealed substantial reductions in Streptococcus mutans growth in the silver (88.4%) and hybrid (82.1%) groups compared with the control ($p < 0.001$).*

Conclusion: *Hybrid incorporation of titanium dioxide and silver nanoparticles provides effective antimicrobial activity while maintaining clinically acceptable shear bond strength. This approach represents a promising strategy for reducing white spot lesion development during fixed orthodontic treatment.*

Keywords: *orthodontic adhesives, nanoparticles, shear bond strength, antimicrobial activity, silver, titanium dioxide, white spot lesions*

Cite This Article as:
Alfawzan A.A., Alam M.K., Hajeer M.Y. (2026). In-Vitro Evaluation of Nanoparticle-Reinforced Orthodontic Adhesives for Enhanced Shear Bond Strength and Antimicrobial Activity; The New Armenian Medical Journal, vol.20 (2), 23-29; DOI: https://doi.org/10.56936/18290825-2026.20v.2-23

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