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Non-Axial Loads Increase Risk of Cervical Restoration Debonding

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Objectives Achieving durable retention of cervical restorations remains a persistent challenge in adhesive dentistry. Despite widespread speculation on the detrimental roles of non-axial loads, numerical evidence is still lacking. Using in-silico damage mechanics, this study aims to investigate the interfacial damage of a cervical restoration under different load directions.

Methods A finite element model of a maxillary premolar, with a wedge-shaped buccal cervical restoration, was constructed using a mid-sagittal slice from micro-computed tomography data. To simulate debonding at the restoration-tooth interface, a damage mechanics-based cohesive zone model was utilized to define the strain-softening damage behavior based on interfacial stress and fracture energy. Occlusal loads, ranging from 0 to 150N, were applied in three different regimes: (1) obliquely on the buccal triangular ridge, (2) obliquely on the palatal triangular ridge, and (3) axially on both ridges with equal magnitudes. Furthermore, the implications of damage were elucidated by comparing the maximum principal stress distribution between damaged and conventional perfect-bond models.

Results Under buccal oblique loading, damage initiated at 100N and propagated to 88.3% of the interface by 150N. Notably, a higher stress of 42.5MPa was observed at the central groove in the damaged model compared to the perfect-bond model, indicating an elevated risk of tooth fracture. Under palatal oblique loading, damage initiated at 120N and propagated to 43.3% of the interface by 150N. In contrast, damage was initiated at 130+130N under axial loading on both ridges.

Conclusions This study presents the first concrete evidence supporting the tooth flexure hypothesis, revealing the adverse effects of non-axial loads on the cervical bonding interface. To ensure the longevity of cervical restorations, meticulous occlusal assessment prior to treatment is imperative. As debonding markedly alters overall stress distribution, integrating damage mechanics into finite element analysis constitutes a crucial step toward clinically relevant simulations.