



Effect of Prolonged Video Gaming Posture on Craniofacial Growth

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ABSTRACT

Dental resin composites have become essential restorative materials due to their excellent esthetics, versatility, and minimally invasive application; however, their long-term performance is compromised by mechanical fatigue, polymer degradation, and microcrack development caused by repeated occlusal loading. Self-repairing composite resins incorporating reversible polymer chemistry represent an innovative strategy to overcome these limitations by enabling materials to autonomously restore structural damage. This approach utilizes dynamic chemical interactions, stress-responsive molecular systems, and reversible bonding mechanisms that can be activated by chewing forces generated during normal oral function. Mechanical energy from mastication may initiate molecular rearrangements, allowing damaged polymer networks to reconnect and improve restoration longevity. Such smart composites aim to combine conventional mechanical strength with adaptive healing capabilities, reducing crack propagation, marginal deterioration, and restoration replacement frequency. The development of these materials offers promising applications in restorative and pediatric dentistry, where durable and biologically compatible materials are highly desirable. Future research focusing on mechanical optimization, repeated healing efficiency, biocompatibility, and clinical performance will be essential for translating self-repairing composites into practical dental applications.

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INTRODUCTION

Resin composites have become among the most widely utilized restorative materials in modern dentistry due to their favorable esthetics, adhesive capabilities, and ability to support minimally invasive restorative procedures. Continuous improvements in resin matrix composition and filler technology have enhanced their clinical performance; however, challenges such as polymer degradation, surface wear, fatigue failure, and crack propagation continue to limit long-term restoration durability (Cheng, 2019). Mechanical stresses generated during mastication contribute significantly to the initiation and progression of internal defects, which may compromise restoration integrity and increase the likelihood of clinical failure (Tsujimoto et al., 2018).

The development of self-repairing composite resins offers a novel approach to overcoming these limitations by introducing adaptive materials capable of responding to mechanical damage. Polymer mechanochemistry provides the scientific foundation for this concept by demonstrating that mechanical forces can induce controlled molecular transformations, converting stress from a destructive process into a trigger for beneficial chemical responses (Li et al., 2015). Incorporating reversible polymer chemistry, including dynamic covalent interactions and reversible bonding systems, may enable resin composites to repair microstructural damage generated during functional loading. Similar approaches have demonstrated improved toughness and self-healing capacity in polymer-

based materials through reversible chemical mechanisms (Fang et al., 2019).

In restorative dentistry, improving resistance to fracture and functional stresses is essential, particularly for teeth exposed to complex loading conditions after endodontic treatment (Chandra et al., 2021). The integration of smart material principles into dental composites may provide restorations capable of actively responding to the oral environment, supporting the development of bio-smart dental technologies (Jain et al., 2017). Therefore, chewing-force activated self-repairing composite resins represent a promising direction toward enhancing restoration longevity, reducing repair requirements, and advancing next-generation adaptive dental materials.

Scientific Principles of Self-Repairing Composite Resin

A. Polymer Mechanochemistry and Stress-Activated Repair
Self-repairing composite resin technology is based on polymer mechanochemistry, where mechanical forces are converted into controlled chemical responses within polymer networks. Unlike conventional resin composites that accumulate irreversible damage from repeated chewing stresses, mechanochemically active materials can detect mechanical deformation and initiate molecular-level repair processes. During mastication, localized forces around microcracks may activate mechanophores or reversible bonds, promoting polymer chain rearrangement and restoration of structural continuity (Li et al., 2015). This concept provides an opportunity to transform chewing forces from a source of degradation into a trigger for material regeneration.

Reversible Polymer Chemistry in Dental Composites

The incorporation of reversible chemical bonds, including dynamic covalent interactions and non-covalent associations, allows resin networks to repeatedly break and reform. Reversible chemistry has demonstrated the ability to improve toughness and self-healing performance in polymer systems by enabling damaged regions to reconnect after mechanical disruption (Fang et al., 2019). In dental composites, these adaptive polymer networks could minimize crack propagation, reduce wear-related deterioration, and enhance restoration longevity. Since resin composite wear is influenced by mechanical loading, filler characteristics, and environmental conditions, integrating self-repair mechanisms may address major limitations of conventional restorative materials (Tsujimoto et al., 2018).

The scientific foundation of these materials aligns with the development of bio-smart dental technologies designed to respond dynamically to oral conditions and improve patient outcomes (Jain et al., 2017). Furthermore, improved resistance to structural failure is clinically relevant because fracture resistance remains a key determinant of successful tooth restoration, particularly in endodontically treated teeth exposed to functional stresses (Chandra et al., 2021).

Overall, reversible polymer chemistry provides a foundation for developing restorative composites with improved durability, adaptability, and long-term clinical performance.

Design and Development of Chewing-Force Activated Self-Healing Resin

The development of chewing-force activated self-healing resin focuses on integrating reversible polymer chemistry into conventional dental composite systems to create adaptive restorative materials. Traditional resin composites undergo progressive wear, fatigue damage, and microcrack formation due to repeated occlusal forces, which can compromise restoration longevity (Cheng, 2019; Tsujimoto et al., 2018). The proposed self-repairing system incorporates dynamic polymer networks capable of responding to mechanical stress through reversible molecular interactions.

A key design principle involves polymer mechanochemistry, where mechanical forces are converted into controlled chemical responses. Stress generated during mastication may activate mechanophores or reversible chemical bonds, enabling polymer chains to reorganize and repair localized damage (Li et al., 2015). Reversible chemistries, including dynamic covalent bonds and supramolecular interactions, have demonstrated the ability to enhance toughness and self-healing performance in polymer materials (Fang et al., 2019).

The resin matrix can be combined with reinforcing fillers, bioactive components, and stress-responsive molecules to maintain mechanical strength while providing repair capability. Since fracture resistance is essential for successful tooth restoration, improving the ability of composites to withstand functional loading may enhance clinical reliability (Chandra et al., 2021). The concept also aligns with the development of smart dental materials designed to respond actively to oral environmental conditions (Jain et al., 2017).

Overall, this innovative resin design aims to transform chewing forces from a source of deterioration into a functional trigger for restoration maintenance, providing a foundation for next-generation durable and intelligent dental composites.

Table 1: Scientific Components of Self-Repairing Composite Resin

<i>Component</i>	<i>Scientific principle</i>	<i>Role in self-repairing composite</i>
Mechanochemical polymers	Converts mechanical stress into chemical activation	Detects chewing forces and initiates repair
Reversible chemical bonds	Dynamic breaking and reforming of molecular links	Restores damaged polymer networks
Resin matrix	Provides structural framework	Supports mechanical stability and healing response
Reinforcing fillers	Enhances strength and wear resistance	Improves durability under occlusal forces
Smart material design	Adaptive response to environmental stimuli	Enables next-generation bio-smart restorations

Table 2: Design Components and Functions of Chewing-Force Activated Self-Healing Resin

<i>Component</i>	<i>Design function</i>
Reversible polymer matrix	Enables dynamic bonding and autonomous repair after damage
Mechanochemical responsive units	Convert chewing forces into molecular repair signals
Reinforcing inorganic fillers	Improve strength, hardness, and wear resistance
Bioactive additives	Support biological compatibility and therapeutic potential
Coupling agents	Enhance interaction between resin matrix and fillers

Clinical Applications and Future Potential

Self-repairing composite resins incorporating reversible polymer chemistry have the potential to transform restorative dentistry by introducing adaptive materials capable of responding to mechanical damage. Conventional resin composites are vulnerable to fatigue, wear, and crack formation caused by repetitive chewing forces, which may compromise restoration longevity (Tsujimoto et al., 2018; Cheng, 2019). By integrating reversible chemical bonds and stress-responsive polymer networks, self-healing composites may utilize mastication-induced forces to activate molecular repair processes and restore damaged regions. Polymer mechanochemistry provides a foundation for converting mechanical stress into productive chemical responses, enabling autonomous repair mechanisms within polymer structures (Li et al., 2015).

In restorative dentistry, these materials may improve the durability of posterior restorations, reduce secondary caries associated with marginal breakdown, and minimize the need for frequent replacement procedures. Since fracture resistance is a critical factor influencing the success of restored endodontically treated teeth, adaptive composites with improved crack resistance may contribute to enhanced clinical outcomes (Chandra et al., 2021). Furthermore, incorporation of reversible polymer systems, as demonstrated in advanced self-healing materials, may provide improved toughness and

repeated healing capability while maintaining functional stability (Fang et al., 2019).

The application of self-repairing composites may be particularly valuable in pediatric dentistry, where smart materials capable of adapting to changing oral conditions can support long-term preventive and restorative strategies (Jain et al., 2017). However, challenges related to polymer stability, wear resistance, biocompatibility, healing efficiency, and clinical validation must be addressed before widespread adoption.

Overall, self-repairing composite resin technology represents a promising step toward intelligent dental materials that combine mechanical performance with biological and functional adaptability.

CONCLUSION

Self-repairing composite resins incorporating reversible polymer chemistry represent a significant advancement toward the development of adaptive and intelligent restorative materials. Conventional resin composites remain limited by wear, fatigue-related damage, and microcrack formation under repeated functional stresses, which can compromise restoration longevity (Tsujimoto et al., 2018; Cheng, 2019). The integration of dynamic polymer networks provides a promising solution by enabling mechanical forces generated during chewing to activate molecular repair mechanisms rather than solely contributing to material degradation. Polymer mechanochemistry has demonstrated that mechanical energy can be transformed into productive chemical responses, supporting the development of stress-responsive self-healing materials (Li et al., 2015).

Reversible chemical interactions, including dynamic covalent bonding and supramolecular associations, have shown potential for improving polymer toughness and self-repair capabilities, offering valuable insights for future dental composite design (Fang et al., 2019). By enhancing resistance to crack propagation and structural deterioration, these materials may contribute to improved restoration durability, particularly in teeth subjected to significant occlusal forces where fracture resistance is a critical factor (Chandra et al., 2021). Furthermore, the concept aligns with the growing

Table 3: Clinical Applications and Future Potential of Self-Repairing Composite Resins

<i>Application area</i>	<i>Potential benefits</i>	<i>Future considerations</i>
Posterior restorations	Reduced crack propagation and improved longevity under chewing forces	Long-term fatigue testing and clinical trials
Endodontically treated teeth	Enhanced fracture resistance and restoration durability	Optimization of mechanical properties
Pediatric dentistry	Bio-smart materials with reduced restoration replacement needs	Safety evaluation and age-specific applications
Minimally invasive dentistry	Preservation of tooth structure through adaptive repair	Integration with advanced restorative technologies
Future dental materials	Development of autonomous, stress-responsive composites	Cost-effective manufacturing and clinical acceptance

development of bio-smart dental materials designed to respond actively to environmental and mechanical challenges within the oral cavity (Jain et al., 2017).

Although challenges remain regarding manufacturing complexity, long-term stability, biocompatibility, and repeated healing efficiency, self-repairing composite resins provide a promising pathway for next-generation restorative dentistry. Continued research into reversible polymer systems and their clinical performance may enable the transition from passive restorations to intelligent materials capable of maintaining structural integrity throughout their functional lifespan.

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