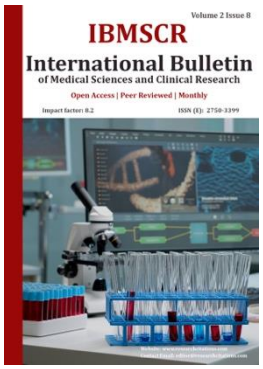

EVALUATION OF THE INTERACTION BETWEEN MODERN ADHESIVE MATERIALS AND BIOLOGICAL TISSUES IN ORTHOPEDIC DENTISTRY.

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Abstract

This article examines the interaction of modern adhesive materials, widely used in prosthodontics, with biological tissues such as pulp, dentin, and epithelium, based on scientific sources. The biocompatibility, potential toxicity, and clinical benefits of various adhesive materials with different chemical compositions are evaluated. The role of bioactive and nano-hybrid technologies in enhancing biological safety and promoting remineralization is also highlighted.

Keywords: orthopedic dentistry, adhesive materials, biological tissues, biocompatibility, pulp, dentin, bioactive adhesives, nano-hybrid technology, toxicity, remineralization.

Introduction

Modern adhesive materials have become essential in orthopedic dentistry, particularly in prosthodontic applications. They provide strong and durable bonds between prosthetic structures and biological tissues such as dentin, pulp, and epithelium. The success of dental restorations relies heavily on the adhesion between the material and the tooth structure. Over the past decades, advancements in adhesive technology, especially the development of bioactive and nano-hybrid adhesives, have significantly improved the properties of these materials, including their physical and biological characteristics.

Bioactive adhesives, which contain compounds capable of interacting with the tooth structure, and nano-hybrid adhesives, which incorporate nanotechnology to enhance bonding strength and reduce microleakage, have garnered much attention. Understanding how these modern adhesives interact with biological tissues, such as dentin and pulp, is crucial to ensure their safety, efficacy, and long-term success in clinical practice. This article reviews the current literature on these adhesives and their impact on biological tissues in orthopedic dentistry.

Materials and Methods

This study is based on a comprehensive review of recent literature (2019-2024), focusing on the composition, properties, and biological effects of various adhesive systems. The review includes traditional etch-and-rinse adhesives, self-etch adhesives, as well as newer bioactive and nano-enhanced formulations. Studies were selected based on their relevance to the biocompatibility of adhesives and their interaction with pulp and dentin.

The key parameters analyzed include the chemical composition of the adhesives, their ability to bond to dentin and enamel, the release of potentially toxic substances, and their effects on the health of the pulp tissue. Data from clinical trials, laboratory experiments, and in vitro studies were reviewed to provide a comprehensive understanding of the topic.

Results and Discussion

The findings from the literature review revealed several important insights regarding the interaction between adhesive materials and biological tissues:

1.Traditional Adhesive Systems (Etch-and-Rinse and Self-Etch):

Traditional adhesives, particularly etch-and-rinse systems, often contain acidic monomers that can lead to a decrease in the pH of the bonding interface. This acidic environment can result in a loss of calcium and phosphate from the dentin, which may impair remineralization and contribute to dentin demineralization. Moreover, these adhesives can cause cytotoxic effects on the pulp due to the release of acidic by-products. In the case of self-etch adhesives, which do not require phosphoric acid etching, the acidic monomers can still penetrate the dentinal tubules, leading to an inflammatory response in the pulp and a risk of pulp necrosis in extreme cases. The potential for long-term toxicity remains a concern with traditional adhesives, especially when used in deep restorations.

2.Bioactive Adhesives:

Bioactive adhesives are designed to interact with the tooth structure and promote the remineralization of dentin. These adhesives often contain compounds such as calcium phosphates or fluoride-releasing agents, which help to restore lost minerals in the dentin and prevent the demineralization process. Studies have shown that bioactive adhesives improve the overall biocompatibility of restorations by reducing the inflammatory response in pulp tissue. These materials have demonstrated the ability to stimulate the regeneration of dentin and are particularly beneficial for patients with compromised pulp health. Furthermore, bioactive adhesives are known to reduce the potential for microleakage, leading to a more stable and long-lasting restoration.

3.Nano-Hybrid Adhesives:

Nano-hybrid adhesives represent the next generation of adhesive systems. These adhesives incorporate nanoparticles into their formulations to enhance the bonding strength between the material and the biological tissue. The inclusion of nanoparticles results in better penetration of the adhesive into the microstructures of dentin and enamel, creating a stronger and more durable bond. Nano-hybrid adhesives also show improved resistance to mechanical stresses, such as masticatory forces, making them suitable for use in high-stress areas like molars. Additionally, these adhesives are characterized by reduced microleakage, which minimizes the risk of bacterial infiltration and secondary caries.

Recent studies have shown that nano-hybrid adhesives also exhibit enhanced biological properties, including reduced cytotoxicity and improved compatibility with pulp tissue. Their ability to bond effectively while maintaining a low level of toxicity is a significant advantage over traditional systems.

4.Toxicity and Biocompatibility:

A significant concern in the use of adhesives in dentistry is the potential for toxicity, particularly in the long term. Some adhesives, especially older formulations, can release monomers and other chemicals that may have adverse effects on the pulp and surrounding tissues. The most commonly observed issues are inflammation, allergic reactions, and in some

cases, pulp necrosis. However, advancements in adhesive technology, such as the development of bioactive and nano-hybrid adhesives, have led to materials that are significantly more biocompatible. These materials minimize the release of harmful substances and encourage tissue regeneration, offering a safer alternative for patients with sensitive dental tissues.

5.Clinical Implications:

The clinical success of adhesive restorations depends not only on the mechanical properties of the adhesive but also on its biological compatibility. Proper adhesion ensures the longevity of the restoration and prevents complications such as post-operative sensitivity, recurrent decay, or pulpitis. Bioactive and nano-hybrid adhesives, by promoting remineralization and reducing microleakage, help to extend the lifespan of restorations and improve overall clinical outcomes.

Conclusion

Modern adhesive materials, particularly bioactive and nano-hybrid adhesives, represent a significant advancement in orthopedic dentistry. These materials offer several benefits over traditional adhesives, including enhanced biocompatibility, improved mechanical properties, and reduced toxicity. Bioactive adhesives promote the remineralization of dentin and support tissue healing, while nano-hybrid adhesives provide better mechanical stability and resistance to wear.

While these adhesives have shown promising results in both laboratory and clinical settings, further research is needed to evaluate their long-term effects, particularly in terms of pulp health and the prevention of microleakage. As technology continues to evolve, the integration of bioactive and biocompatible components into adhesive formulations will play a crucial role in the development of safer, more effective materials for use in dental restorations.

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