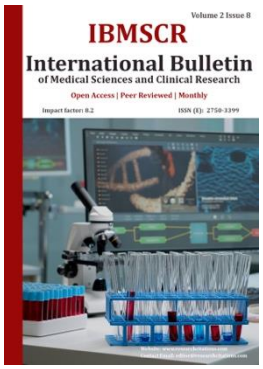

CARIES REMOVAL AND ADHESION IN BIOMIMETIC DENTISTRY

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Abstract: This scientific article studies the role of adhesion in the correct removal and restoration of caries-damaged tissue in biomimetic dentistry. Biomimetic dentistry is a new field of dentistry based on preserving tooth vitality, healthy tissue, and restoring lost natural tooth structures as close to their structure as possible. This field is also based on adhesion. This scientific article shows that good adhesion and the importance of removing caries to preserve healthy tissue are important, and the use of dyes for caries removal and the correct application of adhesive materials are studied.

Keywords: Biomimetics, Tooth vitality, Adhesion, Caries removal, Dyes, Peripheral seal zone.

To understand biomimetic restorative dentistry, it is first necessary to understand what the term "biomimetic" means. In the 1950s, biophysical engineer Otto Schmitt first used the term "biomimetic." The term is derived from the Latin words "bio" (life) and "mimetic" (to imitate or copy something). Thus, biomimetic restorative dentistry is a branch of restorative dentistry that deals with the restoration and preservation of tooth structures using materials that mimic natural tooth structures. The main task of biomimetic restorative dentistry is to restore the full function of the hard tissues of the tooth (enamel and dentin) by adhesion, approaching their structure. This allows functional pressures to be transmitted through the tooth, which turns the entire crown into a unit that provides an approximate normal function, biological and aesthetic result. Unfortunately, there is no biomaterial that has the same mechanical, physical, and optical properties as tooth structures (i.e., enamel, dentin, and cementum), only materials that are closer to tooth structure.

Biomimetic Paradigms

Biomimetic restorative dentistry is built on the following four main paradigms:

Maximum Bond Strength leads to the development of a hybrid layer to reduce the polymerization pressure, which increases the bond strength by 300% to 400%. The bond strength to dentin is in the range of 30 MPa to 60 MPa, which is in the same range as the tensile strengths of enamel, dentin-enamel junction, and dentin. This strong bond allows the biomimetically restored tooth to withstand functional stresses similar to natural teeth.

Long-Term Marginal Seal allows us to achieve a strong and reliable bond during biomimetic restorations, withstand functional pressures for a long time, and maintain the quality of the restoration.

Increased Pulp Vitality By maintaining a highly bonded seal, we prevent recurrent caries, tooth fracture in the restoration, and achieve long-term function without pulp death. A tooth with preserved pulp vitality is three times more resistant to fracture than a depulped tooth.

Decreased Residual Stress - Although it is difficult to imagine residual stress, it leads to deformation of the tooth ridges, disruption of the bond, cavities, cracks, pain and sensitivity, as well as recurrent caries. Reducing residual stress while maintaining maximum bond strength is the main goal of biomimetic restorative dentistry.

Caries removal techniques:

Histologically, microscopically, biochemically, biomechanically and microbiologically, two layers of caries are distinguished. They are very different in structure. The outer layer is a layer of highly infected dentin, acidic and demineralized. This layer can be removed without anesthesia, as it is not sensitive to impact. In this layer, the collagen network does not return to its normal state, therefore it is not capable of remineralization.

The inner layer is an affected dentin, slightly infected and partially demineralized. Removing it without anesthesia is painful, as the collagen fibers remain intact and therefore remain sensitive. Dentin with internal caries is divided into three zones:

Opaque layer

Transparent zone

Semitransparent zone These zones border the normal dentin.

Basic principles of caries removal:

External carious dentin should be completely removed, as it is infected and incapable of remineralization. Internal carious dentin should be protected. The inner layer does not need to be completely removed, as it has the ability to remineralize due to the presence of collagen fibers. Preservation of this layer helps to maintain the strength of the tooth. Stimulation of remineralization: it is necessary to use appropriate materials to preserve the inner layer and remineralize it.

Key components of treatment:

Creation of a peripheral seal zone - the creation of a peripheral seal zone that includes the enamel, dentin-enamel junction, and normal upper dentin near the dentin-enamel junction. The absence of caries in this zone serves as the basis for a highly adhesive restoration. The peripheral seal zone should be free of external and internal carious dentin. Lightly stained internal carious dentin is left within the peripheral seal zone and can be remineralized in teeth that have retained their vitality.

Preservation of internal carious dentin: Preservation of internal carious dentin within the peripheral seal zone. This layer can be bonded with a force of 30 MPa.

Removal of highly infected external carious dentin: Highly infected external carious dentin within the peripheral seal zone should be removed without exposing the pulp chamber. A small amount of external carious dentin may be left to avoid exposing the pulp.

Neutralization and sealing of residual bacteria: Neutralization and sealing of residual bacteria within the peripheral seal zone. This is an important factor in preventing residual infection and promoting remineralization.

Use of adhesive techniques: Use of adhesive techniques that provide maximum bond strength to the peripheral seal zone and the internal carious dentin. This ensures the strength and long-term preservation of the restoration we have made.

In the picture above, we can see the 4th generation adhesive system, which is still considered the gold standard today.

Experiments showed that the average bond strength at the traditional composite-dentin bonding interface was around 25–30 MPa. The samples using the biomimetic approach increased to 30–40 MPa, i.e. an increase of approximately 20–30%. The results showed that the old interface had less mineralization and larger water compartments, while the biomimetic interface had a significant reduction in water content due to intrafibrillar mineralization.

Modulus of elasticity and mechanical stability. While the modulus of elasticity of the bonding interface was measured around 8–10 GPa in the control samples, it was found that this value reached 16–19 GPa in the interfaces using biomimetic remineralization. These indicators ensure the approximation of the natural mechanical properties of dental tissues and the long-term durability of the restoration. The main aspects of adhesive biomimetic dentistry: remineralization of demineralized dentin, i.e. restoration of its mechanical and

biological properties by remineralization of the dentin collagen matrix demineralized as a result of dental caries or other factors. Biomimetic remineralization methods provide intrafibrillar and interfibrillar mineralization by directing amorphous calcium phosphate (ACP) nanoclusters into collagen fibers, which helps restore the natural structure of dentin.

Biomimetic modification of adhesive systems: By introducing biomimetic additives into traditional adhesive systems, their mechanical and biological properties can be improved. For example, when biomimetic materials such as nanocrystalline hydroxyapatite (nano-CHAp) are added to adhesives, their microhardness and degree of polymerization increase, which ensures the durability of restorations.

Mechanical properties of adhesive interfaces: Adhesive interfaces formed by biomimetic remineralization have high bond strength and elastic modulus, which ensures long-term stability of restorations. Studies have shown that such interfaces are less prone to degradation over time, which increases clinical success.

Clinical results and studies: In restorations using biomimetic remineralization methods, degradation of adhesive interfaces was significantly reduced over a 12-month follow-up period and the need for replacement of restorations was delayed.

Laboratory studies confirm the effectiveness of biomimetic approaches in improving the mechanical properties of adhesive systems, which indicates that the clinical application of adhesive systems based on biomimetics leads to promising results.

In conclusion: adhesive biomimetic dentistry is an effective approach to restore the natural structure and function of dental tissues, which can provide high-quality and long-lasting restorations. Through biomimetic remineralization and modification of adhesive systems, it is possible to improve the mechanical and biological properties of dental restorations, which is of great importance in clinical practice.

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