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RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VII, v.1 2026 | Submission: 09/13/2026 | Accepted: 09/16/2026 | Publication: 09/19/2026

Application of bioactive glass particles in the prevention of white spot lesions during orthodontic treatment.

Application of Bioactive Glass Particles in the Prevention of White Spot Lesions During Orthodontic Treatment

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Marleide Rodrigues

Summary

Orthodontic treatment with fixed appliances can promote the accumulation of biofilm in areas adjacent to brackets and other accessories, hindering hygiene and increasing the risk of enamel demineralization and the development of white spot lesions. In this context, materials with bioactive properties have attracted interest due to their potential.

Contribution to the preservation of dental structure. This study aims to analyze the application of bioactive glass particles in the prevention of white spot lesions associated with orthodontic treatment, considering their properties, mechanisms of action, and possibilities for incorporation into dental materials. Bioactive glasses are biomaterials that can exhibit characteristics related to apatite formation, ion release, pH modulation, and antimicrobial activity, depending on their composition. Their incorporation into adhesive systems and other dental materials has the potential to promote remineralization processes and contribute to the control of conditions related to enamel demineralization. The literature also highlights the importance of the appropriate selection of adhesive materials, the strength of the bonding interface, and the adoption of minimally invasive strategies for the preservation of dental tissues. It is concluded that bioactive glass particles constitute a promising alternative for application in preventive strategies during orthodontic treatment, although their use should consider the physical-mechanical characteristics of the materials, individual clinical conditions, and the available evidence regarding their long-term performance.

Keywords: Bioactive glass. Orthodontics. White spot lesion. Tooth demineralization. Dental materials.

Abstract

Fixed orthodontic treatment may favor biofilm accumulation in areas adjacent to brackets and other orthodontic appliances, making oral hygiene more difficult and increasing the risk of enamel demineralization and the development of white spot lesions. In this context, materials with bioactive properties have attracted interest due to their potential contribution to the preservation of dental structures. This study aims to analyze the application of bioactive glass particles in the prevention of white spot lesions associated with orthodontic treatment, considering their properties, mechanisms of action, and possibilities for incorporation into dental materials. Bioactive glasses are biomaterials that may exhibit properties related to apatite formation, ion release, pH modulation, and antimicrobial activity, depending on their composition. Their incorporation into adhesive systems and other dental materials has the potential to promote remineralization processes and contribute to the control of conditions associated with enamel demineralization. The literature also highlights the importance of appropriate selection of adhesive materials, the resistance of the bonding interface, and the adoption of minimally invasive strategies for the preservation of dental tissues. It is concluded that bioactive glass particles represent a promising alternative for preventive strategies during orthodontic treatment, although their application should take into account the

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physicomechanical characteristics of the materials, individual clinical conditions, and the available evidence regarding their long-term performance.
Keywords: Bioactive glass. Orthodontics. White spot lesions. Dental demineralization. Dental materials.

1 INTRODUCTION

During orthodontic treatment, the presence of brackets, wires, and other accessories can...
hinder proper cleaning of tooth surfaces and promote biofilm accumulation.
in regions with higher water retention. This scenario can contribute to changes in the balance between
the processes of demineralization and remineralization of enamel, increasing susceptibility
to the development of white spot lesions around orthodontic appliances. In addition to
Although these lesions represent an alteration in the mineral structure of the enamel, they have important...
aesthetic repercussions, which may compromise the outcome of the treatment.
Demineralization lesions are a significant concern during therapy.
Orthodontic conditions, especially because they affect areas that are difficult to clean and can progress when...
The etiological factors are not adequately controlled. Sundararaj et al. (2015) point out
Prevalence of decalcification ranging between 15.5% and 40% before the start of treatment.
Orthodontic treatment and between 30% and 70% during its performance. The authors also report an incidence
45.8% of new carious lesions developed during treatment and a prevalence of 68.4%
among patients undergoing orthodontic therapy. These data highlight the relevance of
Adopting preventative strategies capable of preserving enamel integrity during the process.
period of use of the devices.
In this context, the development of materials with bioactive properties has sparked interest.
interest in Dentistry, especially given the possibility of facilitating processes of
remineralization and contribute to the control of the oral environment. Among these biomaterials
Bioactive glass particles are found, consisting predominantly of a matrix.
Made of amorphous silicate and used in different biomedical areas, including Dentistry,
Orthopedics and procedures related to bone regeneration (Guimarães et al., 2023).
In dental practice, bioactive glass particles have been incorporated or
investigated in different applications, including pit and fissure sealants, materials
Restorative approaches to controlling dentin hypersensitivity and treatments
Periodontal (Pereira, 2022). Their characteristics may vary according to the composition of
material, enabling properties such as antimicrobial activity, fluoride release and

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apatite formation, mechanisms potentially relevant for maintaining balance
mineral of dental tissues (Barbosa, 2023).
Given these properties, the use of bioactive glass particles is of interest.
particularly in the context of preventing white spot lesions associated with treatment.
Orthodontic. The possibility of combining mechanisms related to remineralization of
Enamel and microbial control make these materials relevant for the development of
Preventive strategies applicable to orthodontics. In this sense, it becomes pertinent to understand
its properties, mechanisms of action, and potential applications in preserving the structure.
Dental care during orthodontic treatment.

2 LITERATURE REVIEW

2.1 Evolution and clinical performance of self-ligating brackets

The evolution of self-ligating bracket systems is related to the search for mechanisms.
Orthodontic devices capable of simplifying the insertion and maintenance of the archwire inside the slot.
reducing the need for auxiliary ligation elements. Feliciano et al. (2026) report
that, as early as 1935, Russell described in the literature the possibility of using a system
Orthodontic treatment in which the ligatures used to secure the archwire could be dispensed with.
constituting an important historical precedent for the development of systems
Self-ligating braces.

With the advancement of materials and technologies applied to Orthodontics, different models of
Self-ligating brackets have been developed, including alternatives designed to reconcile...
mechanical performance and aesthetics. Da Cunha Silva et al. (2025) highlight, in this context, the
The emergence of the Oyster system, developed by Gestenco International AB of Sweden,
Considered one of the first aesthetic self-ligating systems. The device was manufactured
made of glass fiber reinforced polymer material, a feature that provided greater
The transparency of the bracket improved its aesthetic integration with the tooth surface.
According to Feliciano et al. (2026), in this model, the closure mechanism occurs by
through a lid positioned over the groove in a cervico-occlusal direction, characterizing its
Active operation. A particular feature of this system is the possibility of removal.
from the lid, allowing the bracket to be used in a similar way to the systems
conventional. In this configuration, the use of metal ligatures or
Elastomeric materials for maintaining the orthodontic wire inside the groove.

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Among the clinical aspects attributed to self-ligating systems, Dos Santos et al. (2022)
They highlight potential advantages related to the dynamics of orthodontic treatment. According to the
According to the authors, these devices can contribute to reducing friction during movement.
dental procedures, promoting greater comfort during certain therapeutic steps and facilitating
maintenance and wire replacement procedures. The authors also relate its use to
possibility of reducing the clinical consultation time and, in certain cases, the interval
and the number of interventions required during treatment.

The mechanical efficiency of self-ligating braces is primarily associated with the absence of
Elastomeric or metallic ligatures for conventional archwire retention. This feature
It can reduce the friction between the orthodontic wire and the bracket, favoring the use of...
forces of lesser magnitude during certain dental movements. In addition to these aspects
From a biomechanical standpoint, the ease of opening and closing the system can provide greater
Practicality for the professional during the replacement and adjustment of archwires, with potential for reduction.
of the clinical time allocated to these procedures.

However, the benefits attributed to self-ligating systems should be analyzed.
considering the individual characteristics of the patient, the type of malocclusion, the mechanics
employed and the established therapeutic objectives. Although advantages are described
related to clinical practicality and orthodontic arch control, the cost of these devices
It can be superior to that of conventional systems, constituting a factor to be considered in
therapeutic choice. Therefore, the indication should be based not only on
technological characteristics of the system, but also the specific needs of each case.

Regarding the adhesion of orthodontic accessories, Mendes et al. (2021) state that the
Direct bonding of metal brackets to dental enamel constitutes a procedure.
Widely used in orthodontic practice, providing clinical and aesthetic benefits.
For the procedure to perform properly, however, it is necessary to observe
carefully follow the technical protocols and recommendations established by the manufacturers of
materials used, in order to preserve both the stability of the bracket and the
integrity of the dental structure.

In this context, the identification of color changes on the surface of the adjacent enamel is important.
The metallic components require attention from the professional, especially in light of...
possibility of oxidative processes. The persistence of products resulting from oxidation in
Contact with the dental structure can promote color changes and compromise the
aesthetic result of the treatment. Thus, early identification of these changes and the adoption of
Appropriate clinical measures are relevant to minimizing the possibility of penetration.

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of oxidation products in the enamel structure and prevent unwanted pigmentation (Mendes et al., 2021).

In addition to characteristics related to materials and adhesion, biomechanical behavior The use of brackets is a relevant element for the effectiveness of orthodontic therapy. Dos Santos et al. (2022) identified variations in the magnitude of the moments produced by the systems Self-ligating and conventional braces during the simulation of dental rotation correction. These Differences may be related to factors such as the geometry of the dental arch, the tooth positioning and the rigidity of the mechanism responsible for closing the groove of the bracket.

Additionally, Linhares et al. (2021) emphasize that orthodontic brackets should to exhibit sufficient adhesive strength to withstand the forces resulting from chewing. as well as those produced by the activation of orthodontic mechanics. The stability of the bond between The bracket and the enamel are therefore an important requirement for continuity and... Predictability of treatment is crucial, as adhesive failures can compromise application. appropriate use of planned forces and interfering with therapeutic progress.

Therefore, the analysis of self-ligating systems must consider their various aspects together. historical, structural, biomechanical, and clinical aspects. Although the evolution of these devices has provided alternatives aimed at reducing friction and simplifying procedures. Clinical and aesthetic enhancement, its performance depends on the interaction between the design of the bracket, material properties, closure system, orthodontic mechanics

The choice between self-ligating systems depends on the specific needs of each patient and the approach employed. and conventional methods should be guided by clinical and scientific criteria, considering the Indications and limitations inherent to each therapeutic modality.

2.2 Adhesive materials and minimally invasive approaches in structure preservation dental

Advances in dental materials have contributed to the development restorative approaches that combine mechanical, adhesive, aesthetic and other properties biological. In this context, Ribeiro et al. (2021) identified the possibility of incorporation from antimicrobial oligomers to dental adhesive systems, while maintaining properties with fracture resistance comparable to that observed in commercial materials. This strategy It has the potential to promote the localized release of antimicrobial agents in

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marginal interface of restorations, contributing to the development of materials capable to combine restorative performance and antimicrobial activity.

Concern for microbial control takes on particular relevance given the diversity of microorganisms present in the oral cavity. Gonçalves et al. (2026) address oral colonization. by microorganisms potentially associated with respiratory infections, highlighting that the The microbial load present in the aspirated material constitutes a biologically significant component. plausible in determining this risk. In this way, maintaining oral health and control The role of the oral microbiota is important not only in the dental context, but also due to its potential systemic repercussions.

Alongside the development of materials with enhanced biological properties, the Contemporary dentistry has prioritized interventions capable of preserving the most possible healthy dental tissues. Souto et al. (2025) highlight the principles of minimal intervention. Techniques applied to dental aesthetics include the use of conservative adhesive techniques. especially when the conditions of dental positioning and alignment favor its Indication. The preservation of the dental structure thus becomes one of the fundamental elements. for choosing the restorative approach.

In this context, procedures performed with composite resin can be used for the diastema closure and morphological modifications of teeth, particularly in situations involving dental agenesis, conical lateral incisors, or anatomical alterations. that compromise the harmony of the smile. Depending on the clinical characteristics and the Depending on the individual needs of the patient, these interventions can be performed with some effort. minimal or, in certain situations, without the need for significant removal of the structure. dental, favoring a more conservative approach (Souto et al., 2025).

Among the available alternatives for the aesthetic rehabilitation of anterior teeth, there is also... highlight the ceramic laminate facets. According to Almeida et al. (2025), these materials They can be used to restore aesthetic and functional characteristics in teeth. Previous compromised conditions. However, its indication requires careful planning, since that certain cases may require preparation of the vestibular surface to allow for proper accommodation of the restoration, avoiding overcontouring and providing suitable conditions conducive to mechanical strength and aesthetic integration.

The amount of dental tissue removed during restorative procedures constitutes a particularly relevant aspect in long-term planning. De Sa Barroso (2022) It emphasizes that successive replacements or restorative interventions can result in loss. progressive change in dental structure, making it essential to adopt strategies aimed at its

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Preservation. From this perspective, whenever clinically feasible, these should be considered.
conservative therapeutic alternatives capable of meeting functional needs and
aesthetically pleasing to the patient with the least possible removal of healthy dental tissue.
Structural preservation is also related to the proper selection of materials and to
association between different restorative systems. Oliveira and Limeira (2025) highlight, in this
In this sense, the use of the sandwich technique, which combines materials with distinct properties and
complementary. In this approach, glass ionomer cement (GIC) can be used.
as a base material, while composite resin is used in restorative reconstruction,
seeking to combine adhesive, physical-mechanical, and aesthetic properties.
Although glass ionomer cement (GIC) has important characteristics, such as adhesion to the dental structure, its
Isolated use may be associated with limitations, including reduced [something - likely a typo, needs context].
mechanical and wear resistance, sensitivity to moisture during certain stages of
their prey reaction and less favorable surface characteristics when compared to those of
some resinous restorative materials. The sandwich technique therefore seeks to take advantage of
complementary properties of glass ionomer cement and composite resin, seeking
to provide restorative performance more suited to specific clinical conditions.
(Oliveira; Limeira, 2025).
Thus, the evolution of adhesive systems and restorative materials follows a
A trend towards valuing procedures that are biologically and structurally compatible.
Preservatives. The incorporation of antimicrobial properties into materials, the control of
Microbiological factors, the use of adhesive techniques, and the careful selection of restorations.
Direct or indirect methods are part of an approach focused on preserving dental tissues.
In this scenario, individualized planning becomes fundamental to reconciling aesthetics, function,
Material durability and preservation of tooth structure over time.

2.3 Materials and adhesion mechanisms applied to dental practice

Composite resins occupy a prominent position in contemporary dentistry because...
its aesthetic and mechanical properties, and its association with adhesive systems. Rosin et al.
(2022) emphasize that the clinical performance of these materials is directly related to
longevity of restorations in the oral cavity, a fundamental aspect to reduce the need
of successive replacements and, consequently, minimize the effects of the restorative cycle
repetitive on the remaining dental structure.

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In this context, the improvement of adhesive systems has involved the incorporation of components capable of providing additional benefits to the restorative interface. According to Rosin et al. (2022) state that the introduction of bioactive glass particles into adhesive systems presents potential to promote the remineralization of interfibrillar spaces that have not been adequately infiltrated by the adhesive material. Furthermore, the increase in pH promoted by These components can contribute to controlling bacterial growth, giving the system with potentially protective properties and promoting interface stability. adhesive.

The evolution of materials used in adhesive cementation has also expanded the possibilities. of clinical application, making knowledge of the characteristics and indications necessary. of each system. Trindade (2023) highlights the importance of understanding the different materials and techniques used in cementation protocols, especially with regard to to the compatibility between its components and the mechanisms involved in the process of polymerization. Among the available materials are light-activated resin cements, chemically activated, dual-curing, and self-adhesive resin systems, each of presenting specific characteristics that should be considered during planning. clinical.

According to Trindade (2023), certain chemical characteristics of these materials They can interfere with their behavior and their compatibility with adhesive systems. Chemically polymerized resin cements may contain tertiary amines. involved in the activation process, while certain adhesive systems have acidic monomers in its composition. The interaction between these components must be This is considered in the selection of materials, given the chemical compatibility between the system. The adhesive and the cementing agent are relevant factors for proper polymerization and for the Adhesive interface performance.

The principles of adhesion also have direct application in orthodontics. Da Silva et al. (2025) highlight that malocclusions can negatively impact the quality of life of Orthodontic treatment aims to improve both functional and aesthetic aspects of individuals. In this process, the stability of the bond between the bracket and the tooth surface represents a A fundamental condition for the proper execution of orthodontic mechanics. The bonding of brackets to enamel is achieved using adhesive systems and materials. Specific resins for orthodontic use. According to Da Silva et al. (2025), one of the The mechanisms employed to promote this union consist of conditioning the surface. enamel with phosphoric acid, a procedure that promotes micromorphological changes and

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increases the retention capacity of the resinous material. The penetration of the adhesive system into the The microporosity produced by conditioning thus contributes to retention. micromechanics required for the attachment of orthodontic accessories.

In addition to dental structures, adhesion mechanisms assume significant importance in Treatment of ceramic materials used in restorative procedures. Almeida and De Melo (2024) describes infiltration with glass as a strategy for modifying ceramic surface. In this process, the compatibility between the properties of glass and ceramic surface. ceramic, including parameters related to the coefficient of thermal expansion, the coefficient Poisson's ratio and the modulus of elasticity should be considered to favor the behavior. Mechanical assembly design minimizes the formation of significant residual stresses.

According to Almeida and De Melo (2024), the formation of an integrated structure between glass and Ceramics can provide favorable modifications to the mechanical and aesthetic properties of Material. The infiltration or deposition of glass on the surface and inside the structure. Ceramics can contribute to increasing the overall strength, in addition to producing a potentially more favorable surface for adhesive cementation procedures when compared to homogeneous Y-TZP zirconia.

Therefore, the performance of adhesive procedures in dentistry depends on the interaction among different factors, including the chemical composition of the materials, the mechanism of polymerization, the characteristics of the substrate, and the treatment performed on its surface. From composite resin restorations and the cementation of indirect restorations to... Bracket bonding and ceramic surface treatment, understanding these Mechanisms are fundamental for the proper selection of materials and for obtaining Stable and clinically satisfactory adhesive interfaces.

CONCLUSION

Considering the aspects discussed, it is observed that white spot lesions constitute a significant complications during orthodontic treatment, especially due to the increased risk of complications. difficulty in cleaning the tooth surfaces adjacent to the brackets and other components of fixed appliances. The accumulation of biofilm and the consequent imbalance of Demineralization and remineralization processes of enamel reinforce the need for preventive strategies capable of preserving the integrity of dental tissues throughout the Orthodontic therapy.

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In this scenario, bioactive glass particles exhibit properties of interest for the Dentistry, particularly for its potential to promote apatite formation and release of ions, favorable changes in the local environment, and antimicrobial activity, according to their composition. Its incorporation into adhesive systems and other dental materials may to represent a complementary strategy to promote remineralization and reduce conditions associated with the development and progression of demineralization lesions.

In addition to their bioactive properties, the clinical effectiveness of materials used in orthodontics It depends on factors related to adhesive strength and the compatibility between components. to the characteristics of the tooth surface and the physical-mechanical behavior of the systems employees. In this way, the incorporation of bioactive particles should not compromise fundamental requirements for the stability of orthodontic accessory bonding and for the proper execution of the planned mechanics.

It can be concluded, therefore, that bioactive glass particles have significant potential as component of strategies aimed at preventing white spot lesions during the Orthodontic treatment. However, its use must be based on careful selection. of the materials and under the specific conditions of each clinical application. Further studies, Clinical investigations and long-term evaluations, in particular, are important for expanding... an understanding of its effectiveness, durability, and influence on the properties mechanical and adhesive properties of dental materials, contributing to the establishment of Safer and more predictable clinical protocols.

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