RESEARCH ARTICLE

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Microleakage Assessment of Bioactive Restorative Materials with and Without Bonding Agents: Implications for Tinnitus and Systemic Health

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ABSTRACT

Background: In the clinical setting, restoring cervical margins proves challenging as these areas are prone to issues such as microleakage, cavo-surface stains, and postoperative sensitivity.Activa Bioactive Restorative represents a promising advancement in dental restorative materials, designed to replicate the natural properties of tooth structure. Despite its potential, concerns persist regarding the susceptibility of this material to microleakage, a phenomenon that can lead to secondary caries. Microleakage is a crucial parameter to assess the sealing ability of dental materials, impacting the longevity and effectiveness of restorations. This study addresses the need for a comprehensive understanding of microleakage associated with Activa Bioactive Restorative and explores the potential improvement through the application of a bonding agent.

Aim: The aim of this study is to assess and compare microleakage in non-carious cervical lesions that have been restored using Activa Bioactive Restorative, both with and without the application of a bonding agent.

Methodology: Fifty class V cavities were created in extracted teeth and then randomly allocated into two groups. In Group 1 (n=25), Activa Bioactive was applied without a bonding agent, whereas in Group 2 (n=25), Activa Bioactive Restorative was used along with a bonding agent.After the curing phase, all samples were subjected to both thermocycling and repeated loading cycles.The application of 2% Rhodamine B dye was conducted for staining, followed by an assessment of dye penetration in the specimens.

Results: Statistical analysis, utilizing the unpaired t-test, provided results that indicated significant differences between the two groups. Activa Bioactive Restorative in combination with a bonding agent demonstrated reduced microleakage compared to the group without the bonding agent. In addition, further investigation is warranted regarding implications of restorative dental procedures to more general health concerns, possible associations between restorative dental procedures and temporomandibular disorders (TMD) and tinnitus.

Conclusion: In the context of non-carious cervical lesions, Activa Bioactive Restorative, when used in conjunction with a bonding agent, exhibited superior performance by minimizing microleakage. This finding emphasizes the potential benefits of incorporating a bonding agent in the restoration of such lesions.

Keywords: Activa bioactive, Non-Carious cervical lesions, Microlseakage, Bonding agent.

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INTRODUCTION

Non-carious cervical lesions (NCCLs) have become a focal point in clinical dentistry, capturing the attention of practitioners due to their increasing prevalence[1]. The restoration of class V lesions presents clinicians with a range of material options, including glass ionomer cement, composite and resin-modified glass ionomer cement. Among these, composite stands out as the most popular choice, offering a balance of aesthetics and strength. However, its susceptibility to polymerization shrinkage poses challenges, leading to marginal gap creations and consequent marginal leakage. The literature now considers the relation of dental interventions including those affecting occlusal balance or temporomandibular joint function with systemic conditions like tinnitus. In cases of tinnitus it has been suggested that Temporomandibular Disorders (TMD) may play a role, and that dental restorations, including restorations in the mandibular region, may have a secondary, indirect influence on such auditory conditions[2,3,4,5].The consequential issue of microleakage significantly impacts the longevity of dental restorations, potentially causing hypersensitivity, recurrent caries, and pulpal pathoses[6,7]. Addressing this concern, modern adhesive dentistry strives to minimize microleakage by improving the marginal adaptation of dental restorations.6 Introducing a novel approach, bioactive restorative materials have emerged as a relatively new concept in dentistry. These materials stand out for their capacity to release higher levels of fluoride compared to glass ionomers. They react to shifts in pH within the oral environment by absorbing calcium ions, phosphate ions and fluoride ions, consequently preserving the structural stability of the tooth structure. Activa Bioactive Restorative is a notable example of such materials, featuring Embrace resin, a patented bioactive matrix designed for shock absorption, with minimal water content. Importantly, Activa Bioactive Restorative is free from Bisphenol A, Bis-GMA, or BPA 3 derivatives, aligning with contemporary concerns about the safety of dental materials[8]. This innovative material holds promise in addressing the limitations associated with traditional restorative options and offers a bioactive alternative for effective and safe dental interventions.

METHODOLOGY

Class V cavities in a box type configuration, measuring 2mm inciso-gingivally, 3mm mesiodistally, were meticulously created on the buccal surface of premolars with a depth of 2 mm. Standardized dimensions were ensured using vernier calipers. The samples, comprising 25 in each group, were randomly assigned to Group 1 (Activa Bioactive without bonding agent) and Group 2 (Activa Bioactive with 3M bonding agent). Enamel underwent etching using 37-38% phosphoric acid (Smart Etch, Safe Endo, India) for 15-20 seconds, followed by a 2-3 second application of high-volume evacuation to eliminate external moisture. Subsequently, 3M ESPE Adper Single Bond Adhesive was applied to the etched enamel, gently rubbed for 20 seconds, allowed to dry in air for 5 seconds to facilitate solvent evaporation, and finally exposed to light for 10 seconds using the Woodpecker ILED Plus light cure device with a light intensity of 460 nm. Activa Bioactive Composite (Pulpdent, USA) was employed for cavity restoration using an incremental technique, followed by a 20-second light-curing process. Finishing and polishing were executed with the Super-Snap Mini-Kit (Shofu Dental Corporation). The specimens were placed in 100% humidity for 24 hours, underwent 500 thermocycling cycles (with temperatures ranging from 5° to 55°C), and experienced 10,000 cyclic loading cycles. Future aspects of research grow from the potential influence of restorative procedures on patients with TMD and the potential to increase or exacerbate symptoms like tinnitus, especially considering TMD can impact or aggravate tinnitus. The findings by Owens and colleagues, indicating no significant statistical distinctions in microleakage between Activa and composite materials, lend support to the notion that Activa Bioactive, when applied appropriately, can compete with the performance of traditional composites Post-coating with nail varnish (excluding a 1mm cavosurface margin) and sealing apices with wax, samples were immersed in a 2% Rhodamine B dye solution (Sisco Research Laboratories, India) for 24 hours, followed by rinsing and air-drying. A diamond disc was utilized for longitudinal buccolingual sectioning, enabling the examination of restorations under a Carl Zeiss Extaro 300 Digital Microscope at 2.5X magnification. The extent of dye penetration was evaluated using a standardized scoring system.

RESULTS

The total score for Group 1, which includes 25 samples using a standard scoring system, is 50, while for Group 2, it is 30. Upon conducting an unpaired t-test, the two-tailed P value is below 0.0001. According to conventional standards, this difference is deemed statistically significant.

Scoring system for Microleakage:

Score 0 - No Microleakage

Score 1 - Microleakage extends upto 1/3rd of the tooth surface

score 2 - Microleakage extends upto 1/3rd - 2/3rd of the tooth surface

score 3 - Microleakage extends more than 2/3rd of the tooth surface.

DISCUSSION

There is a growing demand for a material that ensures nearly perfect adhesion to the tooth surface, aiming to minimize microleakage and enhance marginal integrity. The assessment of microleakage serves as a fundamental factor in predicting the performance of any restorative material[9]. Various methods are available for detecting microleakage, including scanning electron

microscopy,chemical tracers,dyes,radioactive tracers and fluid filtration[10]. In this study, a dye leakage method was employed due to its simplicity, reliability, and widespread acceptance. Numerous dye penetration studies have utilized substances such as India ink, methylene blue,crystal violet, basic fuchsin, as well as fluorescein[11]. Rhodamine B dye was chosen for this investigation due to its superior diffusion on human dentin compared to methylene blue[12,13]. With a molecular size of 1 nm, smaller than dentinal tubule diameter, Rhodamine B can permeate even the smallest gaps at the tooth-restoration interface[14]. Dye penetration measurement serves as an indicator of interface gaps that could allow the ingress of bacteria and by-products. To simulate oral temperature variations, specimens underwent thermocycling at temperatures of 5°-55°±10°C for 500 cycles[15,16].

Cyclic loading mimicked occlusal stresses in the cervical region, potentially impacting microleakage and class V restoration margins[17,18]. The findings of our current study indicate that Activa Bioactive restorative, when used with a bonding agent, demonstrated reduced microleakage. This outcome can be attributed to the ionic resin component, which includes phosphate acid groups possessing antimicrobial properties. These properties enhance the interaction between the resin and reactive glass fillers, improving the bond with tooth structure[19]. In this process, hydrogen ions separate from the phosphate groups through ionization, dependent on water, and are replaced by calcium in the tooth structure. This ionic interaction forms a robust resin hydroxyapatite complex, creating a positive seal against microleakage[20]. While achieving enamel adhesion is a well-established process, establishing a sufficient bond with dentin presents greater challenges[21]. The fifth-generation bonding agent, 3M Bond, contains a significant quantity of HEMA (2-hydroxy-ethylmethacrylate). HEMA possesses the ability to positively wet the tooth surface and exhibits high penetration capacity into dentin. It amalgamates the hydrophilic and hydrophobic elements of the bonding agent into a unified solution, acting as a co-solvent by dissolving various components in water, thereby resulting in a strengthened bond[22].

Our investigation supports the findings of Tohidkhah et al., indicating that Activa Bioactive, when used without a bonding agent, demonstrates notably increased microleakage at both enamel and dentin margins[23,24]. Conversely, when adhesive resin is applied with Activa Bioactive, it yields a superior marginal seal comparable to other restorative materials[25]. This consistency is reinforced by the findings of Jumaah et al., who also observed increased microleakage in Activa Bioactive when used without a bonding agent, further emphasizing the essential role of bonding agents in achieving optimal outcomes[26].

Adding to the available evidence, Kubde and colleagues suggest that when Activa is used with a bonding agent, it seals as effectively as Tetric N-Ceram[27].The findings by Owens and colleagues, indicating no significant statistical distinctions in microleakage between Activa and composite materials, lend support to the notion that Activa Bioactive, when applied appropriately, can compete with the performance of traditional composites. The findings of our study regarding the microleakage and bonding strength of bioactive restorative materials may have broader implications than oral health. Several studies have indicated that dental restorations, particularly those that affect occlusal balance, may be related to TMD and, by extension, tinnitus. Tinnitus, or ringing in the ears, may have a multifactorial etiology and dental occlusal imbalance or temporomandibular joint dysfunction may be contributing factors. Despite this, further research needs to be performed to further explore whether bioactive restorations have a direct or indirect affect on auditory symptoms in patients with TMD[28]. Similarly,the research conducted by Omidi, Naeini, and their team highlights that, especially with the application of etching and bonding, Activa exhibits microleakage patterns similar to those observed in composites[29]. However, Alkhudairy & Ahmad's study, which reported a moderate degree of microleakage for Activa in several bulk-fill bioactive restoratives, introduces a note of discordance[30]. Furthermore, Nathaniel Denson et al.'s observation of reduced bacterial adhesion and biofilm formation on Filtek and Esthet-x composites when compared to Activa emphasizes the potential influence of filler particle size[31,32]. The consistencies across multiple studies reinforce the growing evidence supporting the indispensable role of bonding agents in optimizing the performance of bioactive restorative materials in various clinical applications.

Limitation of the study:

A potential limitation of our study is the utilization of a relatively small sample size. While the findings provide valuable insights, the restricted sample size may impact the generalizability and robustness of the results. Future research endeavors with larger sample sizes would be beneficial to enhance the reliability and external validity of our study outcomes.

CONCLUSION

Activa Bioactive Restorative with a bonding agent demonstrated superior performance in minimizing microleakage, suggesting its potential as an effective restorative option. The study also highlights the significant role of the bonding agent, specifically 3M Bond, in achieving robust adhesion to dentin, crucial for long-term restoration success. In addition to its ability to reduce microleakage, the use of Activa Bioactive Restorative in non-carious cervical lesions may have broader clinical implications in patients with temporomandibular disorders (TMD), where proper occlusion restoration may alleviate associated symptoms such as tinnitus. The relationship in clinical settings could be investigated further.

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