

Advancements in Smart Restorative Dentistry: A Pioneering breakthrough

Abstract:

Aims and Objectives: The field of dentistry has undergone a revolution with the use of biomimetic smart materials. Promising materials like Cention N and ACTIVA BioACTIVE restorative showing increased reliability and effectiveness, offering a bright future for the field. The aim of this case report is to assess the effectiveness of these two restorative materials in permanent molars over a period of 6 months. The evaluation includes various factors such as surface texture, marginal integrity, cavosurface marginal discoloration, anatomic contour, secondary caries, color match, and gross fracture.

Materials and Methods: Standardized Class I cavities were prepared and restored with Cention N and ACTIVA according to the manufacturers' instructions. At intervals of 1 month, 3 month and 6 months modified Ryge's USPHS Criteria were adjusted for clinical examination.

Results: ACTIVA BioACTIVE Restorative outperforms Cention N in terms of clinical performance.

Conclusion: This study assesses the already accessible "smart material" employed in dentistry as we move toward a new era of bio-smart dentistry

Key-words: : Cention N, ACTIVA BioACTIVE Restorative, Smart restorative materials, Permanent molars, Modified USPHS Ryge's criteria

Introduction:

The future of dental restorative materials is determined by the demand for superior oral healthcare. Smart materials possess characteristics that can be deliberately modified by various stimuli, including stress, temperature, moisture, pH levels, and electric or magnetic fields.[1] They have the ability to sense changes in the environment and return to their original state after removal of stimulus.[2,3] These materials have changed the landscape by being responsive and transformative in nature to various local changes in the environment, thereby significantly improving the quality of dental treatment. They can be controlled to significantly alter one or more properties, such as pressure, temperature, moisture, pH, and electric or magnetic fields[4]. Paediatric dentists should be aware of these smart materials in order to make the best use of their properties in daily practice and deliver high-quality, holistic treatment.\

There is no denying the crucial role of the first permanent molar in facilitating efficient chewing and ensuring a harmonious occlusion. It serves as an essential component in achieving proper mastication and occlusion. The permanent molar tooth is prone to decay due to its deep fissures. Immediate treatment should be done to ascertain function and esthetics. When considering restoration goals for children,

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several objectives must be taken into account, such as sealing cavities, preventing further damage to the tooth, making the tooth and restoration resistant to decay, and ease of use in clinical situations.

An ideal restorative material should possess three key characteristics: pleasing aesthetics, preservation of crown strength, and maintenance of the occlusal surface's natural anatomy. Amalgam and glass ionomers have long been popular choices for filling materials due to specific reasons. Glass ionomer cement has a low flexural strength, and amalgam exhibits an inherent gray coloration, which limit their extensive utilization in restorative dentistry. Both products undeniably possess certain limitations, indicating that they involve a clinical trade-off in one aspect or another. Recently introduced, Cention N is a novel bulk filling, tooth-coloured aesthetic restorative material.[5] It contains an alkaline filler that releases acid-neutralizing ions, making it an effective alkasite restorative.[6] Another different material named ACTIVA BioACTIVE-Restorative is a type of composite material that is considered bioactive due to its ionic resin matrix, resin component that can absorb shock, and fillers that mimic the properties of natural teeth. It releases and replenishes calcium, phosphate, and fluoride ions, providing patients with long-term benefits and improved oral health care.[7]

The effectiveness of restorations can be evaluated by different methods. The USPHS assessment system, also known as Ryge's criteria, is the most frequently employed direct approach for ensuring the quality of restorations.[8] It was devised to indicate differences in acceptability (whether or not they meet the criteria) rather than measuring degrees of success.

Furthermore, there is limited information available regarding the clinical quality and effectiveness of alkasite and bioactive materials used in dental restorations. Thus, the objective of this article is to present an *in-vivo* evaluation of the clinical effectiveness of Cention N and ACTIVA BioACTIVE restorative, drawing a comparison between the two materials' performance.

Case Report

Case 1

A 7-year-old female with no relevant systemic history reported with carious upper and lower permanent first molars to the Department of Pediatric and Preventive Dentistry, Babu Banarasi Das College of Dental Sciences (BBDCODS), Lucknow. On examination 16,26,36 and 46 had moderate pit/fissure caries (Mount and Hume classification,1998). The patients' short case history was recorded and written informed consent was obtained from the parent before further treatment. The chosen participant was briefed and was given an appointment for restorative procedure.

Case 2

A eight-year-old female patient reported to the Department of Pediatric and Preventive Dentistry, BBDCODS, Lucknow with a chief complaint of decay in upper and lower posterior left and right teeth region of mouth for 4 months. After clinical and radiographic examinations, mild to moderate pit/fissure cavity(Mount and Hume classification,1998)on the occlusal surface was seen with respect to 16,26, 36 and 46. The patient were scheduled for the restoration after obtaining the consent from her parents.

Case 3

A seven year old male with no relevant systemic history reported with carious lower permanent molars to the Department of Pediatric and Preventive Dentistry, BBDCODS, Lucknow. On examination 36 and 46 were moderately carious (Mount and Hume classification,1998). The patient's brief medical history was obtained, and written consent was obtained from the parent before proceeding with any further treatment. The selected participant was informed and scheduled for a restorative procedure.

Summary of the Treatment:

The participants for this study were divided into two groups randomly using the split-mouth technique. A total of 10 samples were tested (with 5 samples per group) to assess the clinical effectiveness of the two restorative materials using modified Ryge's USPHS Criteria. The patients received treatment on each side of the mouth, divided as quadrant or as

sextant. Group A comprised of permanent left maxillary and mandibular first molars, which were treated with Cention N. On the other hand, Group B consisted of permanent right maxillary and mandibular first molars, which received the ACTIVA BioACTIVE Restorative treatment.

CENTION N :

(Ivoclar, Vivadent, Liechtenstein) (Fig 3)

Cention N is a tooth-coloured, basic filling material for direct restorations. It is self-curing with optional additional light-curing which is available in powder and liquid form. Isolation of the teeth was done using a rubber dam. Standardized cavity with respect to 26 and 36 were prepared by removing the decayed area, and a Class I cavity was made using a high-speed diamond point under water spray (Fig 2). The liquid bottle of the Cention N was gently squeezed to dispense a single drop onto a mixing pad, ensuring that it didn't touch the bottle. The liquid bottle was then tightly closed for future use. The bottle of powder was shaken before using the measuring spoon to add the required amount. The powder and liquid were mixed in a 1:1 ratio using a plastic spatula until a consistent mixture was achieved (Fig 4, Fig 5). After that it was placed in the prepared cavity followed by its condensation. The working time was 2 minutes and 30 seconds, once the setting time of 4 minutes was reached the occlusion was checked and adjusted necessarily with the articulating paper. The excess material was then removed using finishing diamond point.

Activa™ Bioactive – Restorative™ (Puldent, USA) (Fig 6)

ACTIVA BioACTIVE RESTORATIVE is the first dental resin that mimics the physical and chemical properties of teeth. It elicits a natural response that stimulates apatite formation and the natural remineralization process that knits the restoration. Isolation was done using a rubber dam. Cavity preparation was limited to removal of carious lesion. Standardized Class I cavity for 16 and 46 were prepared initially using a high-speed and refined using slow speed diamond points (Fig 2). The cavity walls were then planed using a chisel. The cavity was washed and cleaned properly with saline. Etchant was applied for 20 seconds in the cavity prepared and washed with water (Fig 7). Excess moisture was

removed from the cavity. Auto mix syringe was applied to the ACTIVA BioACTIVE - Restorative tube and the cement was placed into the cavity prepared with a bendable cannula (Fig 8). The material was adequately compacted and any surplus was eliminated. The visible light beam was applied for 20 seconds (Fig 9). The use of articulating paper was employed to verify occlusion.

Patients of both the groups were advised to brush their teeth twice daily (using toothbrush and toothpaste) and practicing no other oral hygiene measures both professional and home based. Patients were then recalled at the interval of 1 week, 1 month, 3 months and 6 months respectively.

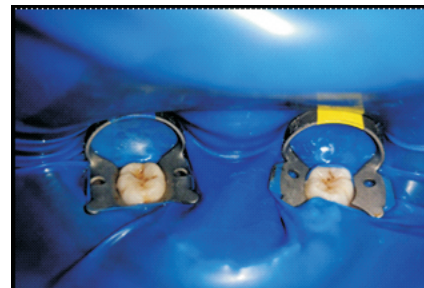


Fig 1: Preoperative carious 1st permanent molars

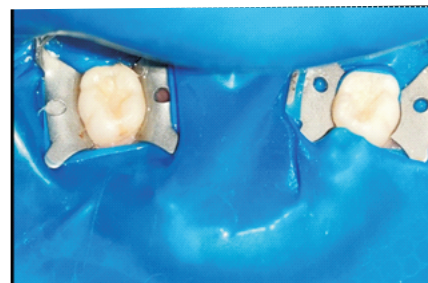


Fig 2: Caries removed with high speed airrotor handpiece



Fig 3: Cention N



Fig 4: Powder:Liquid=1

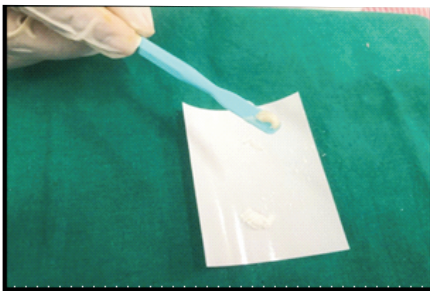


Fig 5: Homogeneous mixture

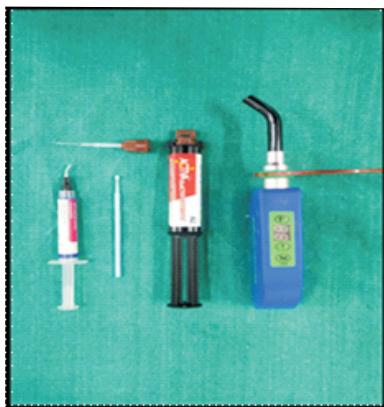


Fig 6: Activa Bioactive Restorative

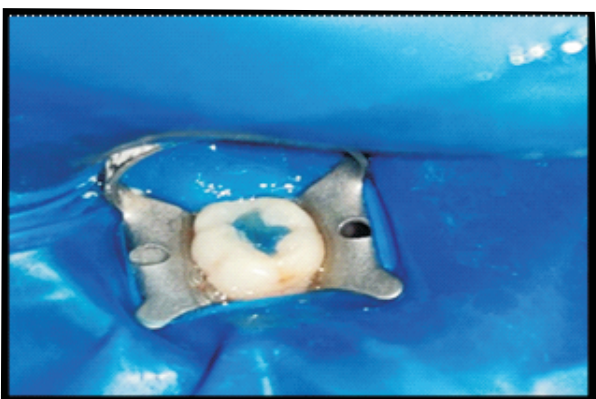


Fig 7: Application of etchant gel

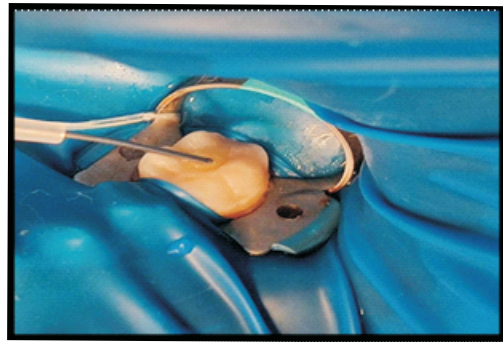


Fig 8: Restoration with ACTIVA BioACTIVE-Restorative

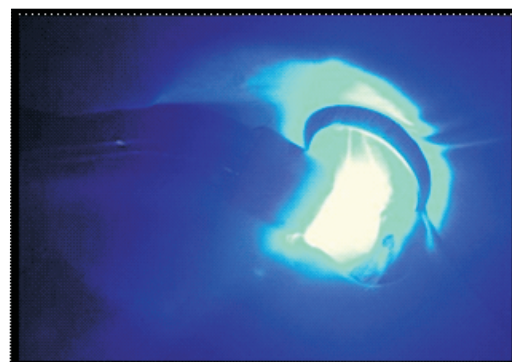


Fig 9: Curing of tooth

Follow-up

Clinical evaluation of the restorations was done and was scored using modified Ryge's USPHS criteria for color match, cavosurface marginal integrity, secondary caries, anatomic contour, marginal integrity, surface texture and gross fracture

Modified United States Public Health Service (USPHS) Ryge Criteria for Direct Clinical Evaluation of Restoration

COLOR MATCH	ANATOMIC CONTOUR
<p>Alpha (A) Visual inspection The restoration appears to match the shade and translucency of adjacent tooth tissues.</p> <p>Brown (B) Visual inspection The restoration does not match the shade and translucency of adjacent tooth tissues, but the mismatch is within the normal range of both shades. (Within normal range. Similar to silicone cement restorations for which the dentist did not quite succeed in matching tooth color by his choice among available silicone cement shades.)</p> <p>Charlie (C) Visual inspection The restoration does not match the shade and translucency of the adjacent tooth structure, and the mismatch is outside the normal range of both shades and translucency.</p>	<p>Alpha (A) Visual inspection and explorer The restoration is a continuation of existing anatomic form or is slightly flattened. It may be unperforated. When the side of the explorer is placed tangentially across the restoration, it does not touch two opposing cavosurface line angles at the same time.</p> <p>Brown (B) Visual inspection and explorer A surface concavity is evident. When the side of the explorer is placed tangentially across the restoration, it does not touch two opposing cavosurface line angles at the same time, but the dentin or base is not exposed.</p> <p>Charlie (C) Visual inspection and explorer There is a loss of restorative substance such that a surface concavity is evident and the base and/or dentin is exposed.</p>
CAVSURFACE MARGINAL DISCOLORATION	MARGINAL INTEGRITY
<p>Alpha (A) Visual inspection There is no visual evidence of marginal discoloration different from the color of the restorative material and from the color of the adjacent tooth structure.</p> <p>Brown (B) Visual inspection There is visual evidence of marginal discoloration at the junction of the tooth structure and the restoration, but the discoloration has not penetrated along the restoration in a pulpal direction.</p> <p>Charlie (C) Visual inspection There is visual evidence of marginal discoloration at the junction of the tooth structure and the restoration that has penetrated along the restoration in a pulpal direction.</p>	<p>Alpha (A) Visual inspection and explorer The explorer does not catch when drawn across the surface of the restoration toward the tooth, or, if the explorer does not catch, there is no visible crevice along the periphery of the restoration.</p> <p>Brown (B) Visual inspection and explorer The explorer catches and there is visible evidence of a crevice, which the explorer penetrates, indicating that the edge of the restoration does not adapt closely to the tooth structure. The dentin and/or the base is not exposed, and the restoration is not mobile.</p> <p>Charlie (C) Explorer The explorer penetrates crevice directly extended to the dentin-enamel junction.</p>
SECONDARY CARIES	SURFACE TEXTURE
<p>Alpha (A) Visual inspection The restoration is a continuation of existing anatomic form adjacent to the restoration.</p> <p>Brown (B) Visual inspection There is visual evidence of dark keep discoloration adjacent to the restoration (but not directly associated with cavosurface margins).</p>	<p>Explorer Surface texture similar to polished enamel as determined by means of a sharp explorer.</p> <p>Explorer Surface texture gritty or similar to a surface subjected to a white stone or similar to a composite containing separator-coated particles.</p> <p>Explorer Surface pitting is sufficiently coarse to inhibit the continuous movement of an explorer across the surface.</p>
GROSS FRACTURE	
<p>Alpha (A) Restoration is intact and fully related.</p> <p>Brown (B) Restoration is partially retained with some portion of the restoration still intact.</p> <p>Charlie (C) Restoration is completely missing.</p>	

Discussion:

Recent research is focused on developing and implementing new materials and restorative techniques with an aim of minimizing the detrimental effects of the materials.[22] The goal is to improve the material's ability to adapt to the cavity walls, provide better sealing, and increase the longevity of restorations.

The clinical performance of these two restorative materials in permanent molars that meet modified Ryge's USPHS criteria has not been widely studied in the literature. As a result, these findings were compared to those of previous studies that utilized different dental restorative materials.

Color is one of the most important attributes of aesthetic restorations. Based on the current case, there were no significant changes in the color match of the restorative materials observed after 1 week, 1 month, and 3 months. However, after 6 months, a slight change in the color of the teeth restored with Cention N was noticed. Color stability is influenced by factors such as filler particle size, polymerization depth, and coloring agents. Since the composition of resin matrix and fillers varies among different composites, their interaction with stains may differ as well.[9] This interaction can be attributed to the chemical composition of the staining substance itself. Celik C et al. conducted a study which indicated that both resin composite and universal light-curing nanohybrid resin composite exhibited favorable color stability.[10] Arhun N et al. concluded that nanohybrid resin composite offered a broader range of available color shades, whereas resin composite was only accessible in a single universal shade.[11]

Marginal discoloration is often associated with imperfections at the margin of the restorations such as gaps and fractures. The results of our case report show Cention N showed a considerably higher level of cavosurface marginal discoloration in both the restorations as compared to ACTIVA BioACTIVE RESTORATIVE. Manhart et al. investigated the efficacy of resin composite, a bulk-fill composite, over 18 months.[12] The study revealed a significant increase in marginal discoloration over time, and it was believed that the root cause of these defects was the fracture of tiny pieces of

resin composite material that extended onto the enamel surfaces close to the cavity borders.

In our cases, none of the participants who received either of the two restorations developed secondary caries, as assessed at 1 week, 1 month, 3 months, and 6 months post-treatment. Not only the type of restorative material used can contribute to the development of secondary caries, but also factors like the size of gaps around the restoration, the patient's cavity risk, and the skill level of the dentist are considered to be more significant. According to Mjor et al., deterioration of marginal integrity and development of secondary caries is not only due to the material itself.¹³ Clinical environment, patients' previous history of caries experience, criteria for replacements, different handling properties appeared to affect clinical results. The absence of secondary caries in this study aligns with the observations made by Hugar SM et al., who reported a mere 1% recurrence of caries after one year.[14] It is likely that the absence of marginal gaps played a role in the non-appearance of secondary caries at the occlusal margins.

As part of our case study, we also considered the anatomical contour as a factor. The term "contour" refers to the level of convexity and concavity present on the outer and inner surfaces of teeth, respectively, which serve to protect the supporting tissue during the process of mastication. Both the restorative materials were used to create a seamless continuation of the existing anatomical form. When an explorer was placed on the restorations at a tangent, it didn't touch two opposing cavity surface line angles simultaneously. At the six-month interval, no significant variation in anatomic contour was seen in either group.

The marginal integrity of restorations is an important parameter as marginal gap formation is associated with recurrent caries and pulpal diseases. In our present case, the teeth in both the groups at the end of 6 months had intact marginal integrity. Cention N incorporates a polymerization shrinkage stress reliever that possesses a low modulus of elasticity.[15] This component acts as a microscopic spring, dampening the forces produced during shrinkage.[16] By minimizing polymerization shrinkage, it leads to decreased

volumetric shrinkage, enhanced marginal integrity, and reduced stress force on the surface of the restoration and adhesive bond. However, ACTIVA aids the natural remineralization process by releasing calcium, phosphate and fluoride ions which provide patients with long-term benefits.[7] As a result, it allows for the preservation of "white" areas of decalcified enamel instead of requiring their removal during preparation.

In the present case report, the surface texture was measured with an explorer. Gold standard Cention N showed greater increase in surface roughness at an interval of 1 month and 3 months with surface texture being gritty or similar to a surface subject to a white stone or similar to a composite containing supramicron-sized particles, whereas ACTIVA showed no surface roughness or any changes in the surface texture at all the four intervals. Dodiya P et al.[17] concluded that Cention N, which is available in both liquid and powder forms, exhibited poorer surface qualities compared to Tetric N Cream after one week. The differences were attributed to several factors, including the mixing technique and particle size of the material. Lardani L et al.[18] showed that SDR Bulk-fill and Activa BioActive Composite have similar aesthetic behavior in class I cavities.

The flexural strength of the materials refers to their ability to resist fracture was examined. None of the restorations in either group experienced any fracture at the 1 week, 1-month, 3-month, or 6-month intervals. The correlation between flexural strength and clinical performance was shown by Heintze et al.[19] According to them, composite fillings with a flexural strength lower than the ISO norm of 80 MPa for polymer-based restorative materials are more likely to fracture. According to Sujith R et al., the highest mean compressive and flexural strength was found in hybrid composite, followed by Cention N and least in GIC, which was statistically significant.[20] The rubberized resin component in ACTIVA provides exceptional strength and resilience. The term toughness refers to a material's ability to withstand stress and resist fracture when subjected to a load, which was measured using a 3-point bend test. ACTIVA was found to have 2 to 3 times higher break deflection than composites and 5 to 10 times greater break deflection than GICs and RMGICs.[7]

Clinical trials on the behavior of restorative materials have only yielded medium-term results, with few trials explicitly stating the depth and size of the cavities involved. As scientific knowledge progresses, it is important to conduct more clinical studies that evaluate specific details of using this restorative method in order to fully explore its benefits.

Maxillary Arch:

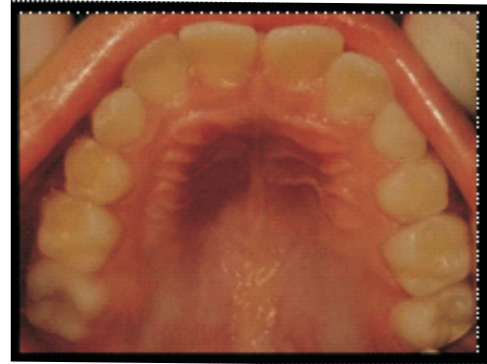


Fig 10: 1 Month

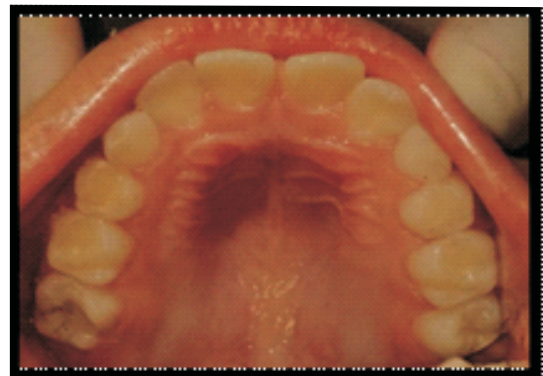


Fig 11: 3 Months



Fig 12: 6 Months

Mandibular Arch:

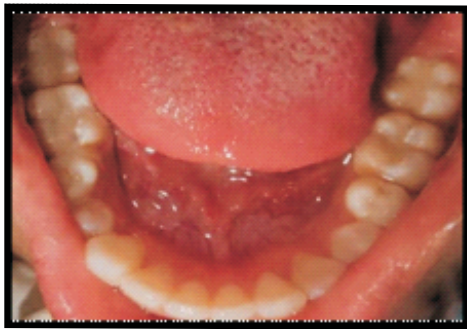


Fig 13: 1 Month

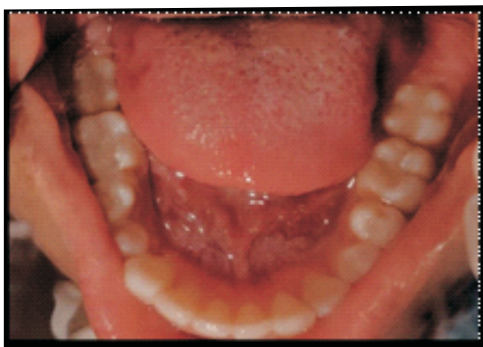


Fig 14: 3 Months



Fig 15: 6 Months

Conclusion:

ACTIVA BioACTIVE RESTORATIVE proved to be an efficient restorative material than Cention N because of its longer duration of fluoride releasing property and good overall clinical performance. The bioactive smart material has benefits in terms of convenience and enhanced visual appearance. This is because it is supplied in an automix syringe, which eliminates the need for additional mixing equipment, and its capability to form a chemical bond with the tooth structure for a more natural look.

The distinctive feature of the study is that it is the first *in-vivo* study of its kind to compare the clinical performance of these two materials, using patients of the same age group who were evenly distributed between both study groups.

The development of this bio-responsive dental restorative material will allow for a proactive method of treating patients' oral health needs. The effectiveness of some recently developed materials over extended periods is uncertain and subject to debate due to inconsistent clinical findings. To assess the long-term performance of restorations, the study employed the USPHS criteria (also known as Ryge criteria), which is the sole widely recognized criterion for evaluating restorations over time and allows for comparisons between studies conducted over varying observation periods.

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