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Edited by Ritik Kashwani
E-mail: docritikkashwani@yahoo.com
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Comparative dentin remineralisation of ACTIVA Presto, Predicta Bioactive Bulk, Cention Forte bioactive restorative materials using elemental and microhardness analysis

V. Yoshna Sree, Vijetha Badami*, G. Sanjana Reddy, Kanukurthi Meghana, Peddi Bhavya Sri & Ainan Rauf Hussain

Department of Conservative Dentistry and Endodontics, MNR Dental College and Hospital, Sangareddy, Telangana, India; *Corresponding author

Affiliation URL:

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https://mnrdch.mnrindia.org/

Author contact:
V. Yoshna Sree - E-mail: yoshnasree17@gmail.com
Vijetha Badami - E-mail: drvijethab.mnrdc@mnrindia.org
G. Sanjana Reddy - E-mail: g.sanjanareddy17@gmail.com
Kanukurthi Meghana - E-mail: kanukurthimeghana@gmail.com
Peddi Bhavya Sri - E-mail: bhavyapeddi66@gmail.com
Ainan Rauf Hussain - E-mail: drainanhussain@icloud.com

Abstract:
Dentin demineralisation caused by dental caries weakens tooth structure and compromises restoration longevity. Therefore, it is of interest to evaluate the remineralisation potential of ACTIVA presto, predicta bioactive bulk and cention forte on demineralised dentin. A total of 150 specimens were assessed using energy-dispersive X-ray analysis for Ca/P ratio and Knoop microhardness testing at 24 hours and 7 days. All bioactive materials showed significant increase in mineral content and microhardness compared with the control group. Thus, data shows that bioactive restorative materials may promote dentin remineralisation and improve the long-term durability of restorative treatments.

Keywords: ACTIVA presto, bioactive restorative materials, cention forte, demineralised dentin, energy dispersive x-ray spectroscopy, knoop microhardness, predicta bioactive bulk, secondary caries.

Background:
Dental caries is a complex multifactorial disease initiated by bacterial metabolism, leading to acid production and subsequent demineralisation of enamel and dentin **[1]**. Its progression depends on the dynamic balance between demineralisation and remineralisation influenced by oral biofilms and dietary sugars **[2]**. Secondary caries, defined as lesion formation at restoration margins, remains a major cause of restoration failure due to bacterial infiltration, microleakage and localized acid production **[3]**. Conventional resin composites primarily provide mechanical restoration but lack biological activity to prevent mineral loss or bacterial colonisation **[4]**. In contrast, glass ionomer cements (GICs) release fluoride and chemically bond to tooth structure, reducing secondary caries risk; however, their inferior mechanical properties limit clinical performance **[5]**. These limitations have led to the development of bioactive restorative materials that combine mechanical strength with therapeutic functionality. Bioactive materials, based on the concept introduced by Hench **[6]**, interact with biological tissues through the release of ions such as calcium, phosphate and fluoride, promoting remineralisation and enhancing resistance to acidic challenges **[7]**. These materials incorporate ion-releasing components, including bioactive glass, calcium silicate and phosphate-based fillers, which facilitate apatite formation, stabilize the collagen matrix and reinforce dentin **[7, 8]**. Commercially available materials such as ACTIVA Presto, Predicta Bioactive Bulk and Cention Forte are designed to provide sustained ion release and bioactive effects **[9, 10]**. Their remineralisation potential can be evaluated using Energy Dispersive X-ray Spectroscopy (EDX) for elemental analysis and Knoop microhardness testing (KHN) as an indirect measure of mineral content **[11]**. Therefore, it is of interest to describe and compare the remineralisation potential of ACTIVA Presto, Predicta Bioactive Bulk and Cention Forte on demineralised dentin using EDX and Knoop microhardness analysis.

Methodology:
The study protocol was reviewed and approved by the Institutional Ethics Committee of MNR University (MNR-EC-BHR affiliated to DHR; Protocol No: MNR EC-BHR-07/24). A total of seventy-five freshly extracted human molars, extracted for periodontal reasons, were collected from the Department of Oral and Maxillofacial Surgery, MNR Dental College and Hospital, following written informed consent. Sample size calculation was performed using G*Power software (version 3.1.9.6), with an effect size of 0.443, power of 80% and significance level of 0.05, resulting in a minimum of 15 samples per group. Each tooth was sectioned vertically into two halves, yielding a total of 150 samples. Inclusion criteria comprised intact molars without caries, cracks, restorations, or structural defects. Teeth exhibiting decay, wear, fluorosis, hypoplasia, erosion, abrasion, developmental anomalies, or resorption were excluded to ensure uniformity of specimens. Specimen preparation involved sectioning the roots to create a reference line, followed by longitudinal sectioning of the crowns using a double-sided diamond disc to obtain two specimens from each tooth. A standardized 4 x 4 mm working window was marked on the dentin surface and the remaining areas were coated with varnish. Demineralisation was achieved by applying 37% phosphoric acid to the exposed dentin surface for 60 seconds. The specimens were thoroughly rinsed with deionised water and subjected to ultrasonic cleaning for 5 minutes. Baseline assessment of the calcium-to-phosphorus (Ca/P) ratio was carried out using Energy Dispersive X-ray Spectroscopy (EDX) and Knoop hardness values (KHN) were recorded. Group allocation and restoration involved randomly assigning samples into five groups using stratified random sampling, with each group further subdivided based on time intervals (24 hours and 7 days): Group 1: ACTIVA Presto, Group 2: Predicta Bioactive Bulk, Group 3: Cention Forte, Group 4: Demineralised, no

restoration (negative control) and Group 5: Intact, non-demineralised tooth (positive control). Restorations were performed according to manufacturer instructions. All samples were stored in individual glass vials containing 7 mL of phosphate-buffered saline (PBS), which was replaced every two days and maintained in PBS prepared at pH 7.4 to simulate physiological conditions. The study was blinded to minimize observer bias. Evaluation of remineralisation occurred after storage periods of 24 hours and 7 days, with samples sectioned horizontally at the reference mark. Remineralisation was assessed using Energy Dispersive X-ray Spectroscopy (EDX) to evaluate and compare calcium and phosphorus weight percentages, indicating changes in mineral content between demineralised and remineralised areas and Knoop microhardness test (KHN) to determine surface hardness as an indirect measure of mineral content. Each specimen was subjected to a load of 100 g for 10 seconds and three indentations were recorded per sample. The mean value was calculated to represent the final microhardness. Data were analyzed using IBM SPSS Statistics version 22.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics (mean ± SD) were calculated and normality was assessed using the Shapiro–Wilk test. As the data were not normally distributed, non-parametric tests were applied: Kruskal–Wallis test with post-hoc pairwise comparisons for intergroup analysis, Wilcoxon signed-rank test for intragroup comparisons and Mann–Whitney U test for time-based comparisons (24 hours vs 7 days). A p-value ≤ 0.05 was considered statistically significant.

Results:

All experimental groups showed a significant increase in Ca/P ratio and Knoop microhardness (mean ± SD; n = 15) after remineralisation at 24 hours **(Table 1)** and 7 days **(Table 2)** compared to post-demineralisation values (Wilcoxon test; p =0.001 for Ca/P, p = 0.001 for KHN). A time-dependent improvement was observed, with higher values at 7 days than at 24 hours (p ≤ 0.05) **(Table 3)**. Predicta Bioactive Bulk showed the greatest remineralisation, followed by Cention Forte and ACTIVA Presto. Intergroup comparison (Kruskal–Wallis) showed significant differences among groups at all-time points (p < 0.001), while no differences were observed between time groups after demineralisation (Mann–Whitney U; p > 0.05), confirming uniform baseline conditions. Overall, all materials exhibited remineralisation potential, with Predicta Bioactive Bulk showing superior performance.

Table 1: Mean comparison of Ca/P ratio and KHN values within Groups at 24 hours (Group A)

Group	n	Ca/P(after demineralisation)	Ca/P (after remineralisation)	P value	KHN (after demineralisation)	KHN (after remineralisation)	P value
ACTIVA Presto	**15**	1.42±0.04	1.59±0.09	0.001	17.77±2.41	25.47±1.92	<0.001
Predicta Bioactive Bulk	**15**	1.40±0.02	1.65±0.08	<0.001	16.59±3.22	31.72±2.67	<0.001
Cention Forte	**15**	1.40±0.05	1.63±0.05	0.001	17.49±2.76	29.01±1.37	<0.001
Negative control	**15**	1.41±0.08	1.41±0.06	0.991	16.31±1.28	16.92±1.56	0.480
Positive control	**15**	1.75±0.03	1.75±0.02	0.854	29.79±2.74	29.28±3.03	0.335

Table 2: Mean comparison of Ca/P ratio and KHN values within Groups at 7 days (Group B)

Group	n	Ca/P(after demineralisation)	Ca/P (after remineralisation)	P value	KHN (after demineralisation)	KHN (after remineralisation)	P value
ACTIVA Presto	**15**	1.40±0.02	1.83±0.07	<0.001	16.72±1.78	30.64±1.72	<0.001
Predicta Bioactive Bulk	**15**	1.42±0.07	1.96±0.05	<0.001	17.25±2.73	34.00±1.86	<0.001
Cention Forte	**15**	1.41±0.06	1.91±0.05	<0.001	17.70±1.93	32.78±3.14	0.001
Negative control	**15**	1.40±0.05	1.40±0.04	0.695	16.71±1.76	16.77±1.70	0.821
Positive control	**15**	1.74±0.02	1.74±0.06	0.820	29.03±3.41	29.32±2.24	0.765

Table 3: Mean comparison of Ca/P ratio and KHN values between Group A (24 hrs) and Group B (7 days) after remineralisation

Group		n	Ca/P	P value	KHN	P value
Activa Presto	Group A	15	1.59±0.09	<0.01	25.47±1.92	<0.01
	Group B	15	1.83±0.07		30.64±1.72	
Predicta Bioactive Bulk	Group A	15	1.65±0.08	<0.001	31.72±2.67	0.01
	Group B	15	1.96±0.05		34.00±1.86	
Cention Forte	Group A	15	1.63±0.05	<0.001	29.01±1.37	0.01
	Group B	15	1.91±0.05		32.78±3.14	
Negative control	Group A	15	1.41±0.06	0.616	16.92±1.56	0.736
	Group B	15	1.40±0.04		16.77±1.70	
Positive control	Group A	15	1.75±0.02	0.894	29.28±3.03	0.935
	Group B	15	1.74±0.06		29.32±2.24	

Discussion:

In the present study, three new materials ACTIVA™ Presto™ (Pulpdent Corporation, Watertown, MA, USA), Predicta Bioactive Bulk (Parkell, New York, USA) and Cention Forte (Ivoclar Vivadent) remineralisation was assessed using Ca/P ratio and Knoop microhardness (KHN), both reliable indicators of mineral content and structural integrity. Demineralisation using 37% phosphoric acid resulted in a significant reduction in Ca/P ratio and KHN, confirming the formation of a caries-like dentin model while preserving the collagen matrix **[11]**. Following remineralisation, all three bioactive restorative materials showed a statistically significant increase in Ca/P ratio

and microhardness at both 24 hours and 7 days ($p \leq 0.002$), indicating effective mineral gain. A time-dependent increase was observed, with higher values at 7 days, suggesting sustained ion release and progressive apatite formation. Among the materials, Predicta Bioactive Bulk exhibited the highest remineralisation potential, followed by Cention Forte and ACTIVA Presto. The superior performance of Predicta Bioactive Bulk may be attributed to its ionic resin matrix and enhanced ion-release capacity. Predicta Bioactive is a dual-cure, bulk-fill resin composite **[12]** containing a poly (2-hydroxyethyl methacrylate) (Poly-2-HEMA)–based matrix, which is free from Bis-GMA and characterized by the presence of hydrophilic monomers such as HEMA. This hydrophilic nature may facilitate increased ion exchange, thereby enhancing remineralisation potential **[13]**. The presence of bioactive components such as titanium dioxide (TiO_2) has been associated with enhanced hydroxyapatite formation due to its affinity for phosphate groups **[14]**, while strontium incorporation, which can substitute for calcium in the hydroxyapatite lattice, further contributes to improved bioactivity and mineral deposition. These factors collectively explain the superior remineralisation observed with Predicta Bioactive Bulk, consistent with findings reported by Kunert *et al.* (2024) **[9]**. Cention Forte showed effective remineralisation, which can be attributed to its classification as an alkasite restorative material with alkaline ion-releasing properties. It contains alkaline glass fillers capable of releasing calcium, fluoride and hydroxide ions, contributing to its bioactive behaviour **[15]**. The release of hydroxide ions increases the surrounding pH, thereby neutralizing acidic conditions created by cariogenic bacteria and promoting remineralisation. This alkalizing effect may also help inhibit secondary caries formation. Francois *et al.* (2020) **[16]** described its polymerisation mechanism, while Wuersching *et al.* (2023) **[17]** reported its ability to induce apatite precipitation at restoration margins, supporting the findings of the present study. ACTIVA Presto also exhibited significant remineralisation potential, likely due to its unique resin-modified bioactive composition. It contains a patented Crysta™ molecule, which is a modified calcium phosphate functionalized with methacrylate, maintained in a transitional state that allows sustained release of calcium and phosphate ions. This contributes to continuous mineral exchange with the surrounding tooth structure and supports remineralisation **[9, 18]**. Sarhan *et al.* (2024) reported initial lower phosphate ion release due to the formation of a superficial calcium-rich layer **[19]**. Puspitasari *et al.* (2021) further explained that the open silica network in bioactive resins facilitates water penetration and sustained calcium ion release, enhancing bioactivity **[20]**. Ionescu *et al.* (2025) reported moderate inhibition of demineralisation by ACTIVA Presto **[18]**. Systematic and clinical evidence further supports these findings. Zailai (2025) **[3]** reported a 45% reduction in secondary caries with bioactive restorative materials. Similarly, Pinto *et al.* (2023) **[21]** showed their role in promoting remineralisation and enhancing restoration longevity. However, Holiel *et al.* (2026) **[22]** found no significant superiority of bioactive composites over conventional materials in clinical performance, highlighting the need for further long-term studies. Despite these promising findings, this *in vitro* study does not fully replicate the oral environment, where factors such as salivary proteins, biofilms, pH fluctuations and mechanical stresses influence remineralisation. Additionally, the use of phosphate-buffered saline and the short evaluation period may not reflect long-term clinical performance **[23, 24]**. Future studies incorporating pH cycling, artificial saliva and biofilm models, along with long-term clinical investigations, are recommended. Within these limitations, all bioactive restorative materials showed significant remineralisation potential, with Predicta Bioactive Bulk showing superior performance, followed by Cention Forte and ACTIVA Presto.

Conclusion:

The Ca/P ratio and surface microhardness increased in all demineralised dentin specimens following remineralisation. Predicta Bioactive Bulk showed the highest remineralisation potential and greatest improvement in dentin hardness, followed by Cention Forte and ACTIVA Presto. Thus, bioactive restorative materials are effective in enhancing dentin remineralisation and may aid in preventing secondary caries.

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