ORIGINAL RESEARCH

Remineralization Potential of a Novel Biomimetic Material (Self-assembling Peptide P_{11-4}) on Early Enamel Caries: An *In Vitro* Study

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Abstract

Aim: To assess the remineralizing potential of self-assembling peptide P_{11-4} and compare it to the remineralizing potential of fluoride varnish using DIAGNOdent™, as well as the amount of mineral gain after application of fluoride varnish and self-assembling peptide P_{11-4}.

Materials and methods: This study included 20 premolars extracted during orthodontic therapy with all surfaces intact and free of hypoplastic regions, white spot lesions (WSL) and dental caries. The teeth sample for Curodont Repair™ (self-assembling P_{11-4}) and Bifluorid 10® (fluoride varnish) was equally divided. On each tooth surface, a 2 × 2 mm window was created. The samples were immersed in a demineralizing solution for 96 hours before being subjected to DIAGNOdent™ pen reading, ICDAS-II scoring, and scanning electron microscopy–energy-dispersive X-ray (SEM–EDX) analysis on one half of the sample. The remineralizing agents were applied to the second half of the sample according to the manufacturer's instructions and placed in artificial saliva for 21 days, with the artificial salvia being replaced every 24 hours. After 21 days, the second half of the sample was subjected to DIAGNOdent™ pen reading, ICDAS-II score, and SEM–EDX analysis.

Results: Following remineralization, the DIAGNOdent™ pen and ICDAS-II score values differed statistically between the two groups, with the Bifluorid 10® group reporting higher mean values ($p > 0.05$) using *t*-test analysis. Energy-dispersive X-ray analysis using the *t*-test revealed a statistically significant result for remineralization ($p < 0.05$), with Curodont™ Repair group (55.150.84) reporting better mean values than Bifluorid 10® for phosphorus and calcium, but Bifluorid 10® reporting a higher result in remineralization ($p < 0.05$) than Curodont™ Repair for fluoride.

Conclusion: Curodont™ Repair showed better remineralizing potential compared with Bifluorid 10® varnish. In terms of the mineral gain, Curodont™ Repair showed better results for calcium and phosphorus post-remineralization. Whereas Bifluorid 10® showed a higher gain in terms of fluoride. Self-assembling peptide P_{11-4} can be used as an alternative to fluoride varnish for remineralizing WSL.

Clinical significance: Self-assembling polypeptide P_{11-4} is a novel remineralizing agent for initial enamel lesions, which is the least-invasive method of enamel remineralization.

Keywords: Demineralization, Fluoride varnish, Remineralization, Self-assembling P_{11-4}, White spot lesions.

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Introduction

Dental caries is a common chronic condition marked by inorganic demineralization and organic tissue damage. Periods of demineralization and remineralization occur during the formation of caries. The enamel crystal's demineralization process starts at the elemental level and continues until it is stopped.[1] In the last few decades, the dental profession has become interested in the concept of remineralization. The term "remineralization" refers to the process of replacing minerals that have been lost due to demineralization.

The finding of a link between caries progression and the use of minimally invasive dentistry (MID) to treat dental caries has ushered in a new era in dental caries management. To prevent disease progression and improve tooth strength, esthetics, and function, MID aims to inactivate noncavitated lesions using noninvasive strategies such as biofilm modification, dietary modification, and the use of remineralizing agents, as well as microinvasive strategies such as sealants and caries infiltration methods.[2]

Among the most significant milestones in dentistry was the discovery of fluoride as a preventative agent for dental cavities.[3] In the latter half of the 20th century, widespread fluoride-containing dental care products have been credited with a major decline in caries prevalence rates.[4] Fluoride remains the gold standard for preventing caries lesions, as evidenced by multiple comprehensive studies.[5–9] Fluoride is now available to children in a variety of forms. As a result, they may be at a higher risk of acquiring dental fluorosis.[10] In addition to fluorosis in children, surface-only remineralization, which occurs frequently in the presence of high topical fluoride concentrations, can cause hidden caries ("fluoride syndrome") in people of all ages. The halo effect of fluoride is to

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blame for the abrupt increase in permanent tooth mottling.[11] New materials and technology for remineralization of early lesions are necessary to supplement fluoride and bridge the gap in fluoride's remineralizing capabilities. In recent years, there has been a change in caries care, with an emphasis on preserving tooth structure and rebuilding only when necessary.

The recently discovered self-assembling peptide P_{11-4} for remineralization of enamel in children using a nonfluoridated biomimetic regeneration system is a unique approach to the treatment of early noncavitated carious lesions that is currently being investigated. The self-assembling peptide P_{11-4} marketed as Curodont™ Repair showed promise in regenerative biomimetic remineralization of early carious lesions. For children and adolescents with early caries, this technique is a safe and effective preventive and less intrusive treatment.[12] As there is limited literature available regarding self-assembling polypeptide, this study was designed to evaluate its role on remineralizing early enamel lesions.

The aim of this current *in vitro* study was to assess the effectiveness of self-assembling peptide P_{11-4} (Curodont™ Repair) and fluoride varnish (Bifluorid 10®) in remineralizing early enamel lesions. The objectives were to compare the remineralizing potential of fluoride varnish to self-assembling P_{11-4} using DAIGNOdent and to assess the amount of mineral gain after using fluoride varnish and the self-assembling peptide P_{11-4}. This present study proposes a null hypothesis that both self-assembling peptide P_{11-4} and fluoride varnish have the same remineralizing capacity.

Materials and Methods

This study was carried out at the Manipal College of Dental Sciences, Manipal, Department of Biochemistry, Kasturba Medical College, Manipal, The Innovation Centre, Manipal Institute of Technology, and the National Institute of Technology Karnataka, Suratkal. The total time period for the study was 6 months from July 2021 to December 2021. This study was approved by Institutional Ethics Committee (IEC: 811/2019). G-power software 3.1.9.2 was used to calculate a sample size of 10 with a power of study of 80. Twenty permanent teeth that were extracted for orthodontic treatment were obtained. Teeth without stains, white spot lesions (WSLs), or hypoplastic lesions were included in the study. Following extraction, the teeth were cleaned of any soft-tissue and hard-tissue remnants, rinsed, and kept in saline. The crown and the roots were separated horizontally using a micromotor handpiece and diamond disc after which the crown part was further divided into two halves vertically.

Preparation of Demineralization Solution

In this study, WSLs were created with a demineralization solution of ten Cate and Duijsters[13] using 2.2 mM $CaCl_2{\cdot}2H_2O$ + 1.1 mM NaH_2PO_4 + 50 mM CH_3COOH; the pH was adjusted to pH 4.4 using 1 M KOH during 96 hours, the solution was maintained at 37°C such that every half premolar would have a lesion depth of 150–200 m. Without causing surface erosion, this approach resulted in subsurface enamel demineralization.

Induction of WSL

The window of 2 × 2 mm was made on each tooth surface using plaster tape. Plastic containers were taken and 12 mL of the demineralizing solution was added to it. One sample (both halves of the sectioned crown) was inserted in each container and maintained at 37 °C for 96 hours. Thus, subsurface lesions were produced on each tooth. By using simple randomization, the groups were allocated to a certain form of remineralization. In group A, 10 maxillary premolars were treated with a fluoride varnish that was Bifluorid 10® and in group B, 10 maxillary premolars were treated with self-assembling P_{11-4} that was Curodont™ Repair.

Recording of Readings

In this present study, three different investigations were carried out, i.e., ICDAS-II criteria, DIAGNOdent™ readings, and scanning electron microscopy–energy-dispersive X-ray (SEM–EDX) analysis. All the samples were scored based on ICDAS-II criteria and DIAGNOdent™ at baseline, post-demineralization, and remineralization. In this investigation, DIAGNOdent™ probe B was employed. The equipment was calibrated against its ceramic standards before each measurement session, as recommended by the manufacturer. The greatest value was taken after collecting fluorescence from the whole tooth surface. DIAGNOdent™ was used at room temperature (22°C).

The samples were cleaned with deionized water and dried before collecting the DIAGNOdent™ results. The DIAGNOdent™ readings were recorded following the manufacturer's instructions on both halves of the sectioned crown. Calibration of the tip was done against a porcelain reference object before the examination. The tip was held perpendicular to the tooth surface with a gentle touch. The tip was then removed over the surface, and the highest value will be recorded. Following DIAGNOdent™ evaluation, one half of the sample was gold-sputtered and subjected to SEM–EDX analysis for Ca, P, and F levels at 15 Kv, 500x, 1000x, 1500x, 2000x, and 2500x after induction of WSLs by immersing in demineralization solution. The application of materials was done in both groups in the second half of the sample. The manufacturer's instructions were followed in group A (control) (Bifluorid 10® by VOCO) and group B (experimental) (Curodont™ Repair created by Credentis). Following that, samples were preserved in artificial saliva for 21 days, with the artificial saliva being replaced every 24 hours.

Revaluation of Test Parameters

After 21 days of remineralization regime, all the samples were subjected to ICDAS-II scoring, DIAGNOdent™ evaluation, and SEM–EDX analysis to estimate mineral gain.

Statistical Analysis

Data were analyzed using the Statistical Package SPSS 22.0 (SPSS Inc., Chicago, IL) and the level of significance was set at $p < 0.05$. Descriptive statistics were performed to assess the mean and standard deviation of the respective groups. The normality of the data was assessed using the Shapiro–Wilk test. Inferential statistics to find out the difference between the groups was done using independent *t*-test and repeated measures of ANOVA followed by Tukey's HSD *post hoc* analysis to find out the difference between any two groups.

Results

The mean DIAGNOdent™ pen values in group A at baseline, post-demineralization, and post remineralization were 0.80.91, 13.9 ± and 11.9. For group B, the mean values were 0.5 14.2, and 2.4.

DIAGNOdent™ pen values between groups (Table 1) were analyzed using *t*-test that reported no statistically significant result regarding baseline value (0.80.91; 0.5) and post-demineralization (13.9 ± in Bifluorid 10® group and Curodont™ Repair group (11.9 respectively.

Table 1: DIAGNOdent readings at baseline, post-demineralization and post remineralization

	Bifluorid	*Curodont*	*p-value (independent t-test)*
Baseline (A)	0.8 ± 0.91	0.5 ± 0.52	0.37
Post-demineralization (B)	13.9 ± 1.10	14.2 ± 0.63	0.45
Post remineralization (C)	11.9 ± 3.84	2.4 ± 1.17	0.0001*
p-value (repeated measures of ANOVA test)	0.0001*	0.0001*	
p-value (*post hoc* Tukey's HSD test)			
A vs B	0.0001*	0.0001*	
A vs C	0.0001*	0.0001*	
B vs C	0.16	0.0001*	

*$p < 0.05$ is statistically significant

Table 2: ICDAS-II criteria of various goups at baseline, post-demineralization, and post remineralization

	Bifluorid	*Curodont*	*p-value (independent t-test)*
Baseline (A)	0 ± 0	0 ± 0	–
Post-demineralization (B)	1.4 ± 0.51	1.5 ± 0.52	0.66
Post remineralization (C)	1832 ± 0.81	0.1 ± 0.31	0.0001*
p-value (repeated measures of ANOVA test)	0.0001*	0.0001*	
p-value (*post hoc* Tukey's HSD test)			
A vs B	0.0001*	0.0001*	
A vs C	0.0001*	0.79	
B vs C	0.05	0.0001*	

*$p < 0.05$ is statistically significant

Whereas the DIAGNOdent™ pen values between the two groups showed statistically significant results regarding post remineralization, where Bifluorid 10® group (11.9 reported greater mean values ($p > 0.05$) using *t*-test analysis. Intragroup analysis using repeated measures of ANOVA followed by Tukey's HSD *post hoc* test shows a statistically significant difference at all intervals ($p < 0.05$) concerning the Curodont™ Repair group.

Whereas the Bifluorid 10® group reported significant results ($p < 0.05$), except between post-demineralization vs post-remineralization values ($p > 0.05$).

Comparison of ICDAS-II Criteria

ICDAS-II score between Bifluorid 10® and Curodont™ Repair showed no statistical difference between baseline and post-demineralization ($p > 0.05$). ICDAS-II between-group analysis using *t*-test reported statistically significant results between post-remineralization values where Bifluorid 10® group 2reported higher mean values ($p > 0.05$) as compared with the Curodont™ Repair group (0.1 Intragroup analysis using repeated measures of ANOVA followed by Tukey's HSD *post hoc* test shows a statistically significant difference at all intervals ($p < 0.05$), except baseline vs post remineralization ($p > 0.05$) concerning the Curodont™ Repair group.

Whereas Bifluorid 10® group reported such significant result ($p < 0.05$), except post-demineralization vs post-remineralization values ($p > 0.05$) (Table 2).

Comparison of Energy-dispersive X-ray Spectroscopy Analysis

Energy-dispersive X-ray analysis in weight% for fluoride between-group analysis using t-test reported a statistically significant result in remineralization ($p < 0.05$) in which Bifluorid 10® group (23.13 ± 0.44) reported a higher mean value than Curodont™ Repair (13.15 ± 0.76). Intragroup analysis using *t*-test shows a statistically significant difference in demineralization (4.01 and remineralization (23.1 of Bifluorid 10® and Curodont™ Repair groups ($p < 0.05$), respectively.

Energy-dispersive X-ray analysis of phosphorus between groups using *t*-test reported statistically significant results in remineralization only ($p < 0.05$), where Curodont™ Repair group reported better mean values (31.48. Intragroup analysis using *t*-test shows a statistically significant difference in Bifluorid 10® group only ($p < 0.05$) between demineralization (24.75 ± 0.79) and remineralization (31.55 ± 0.22).

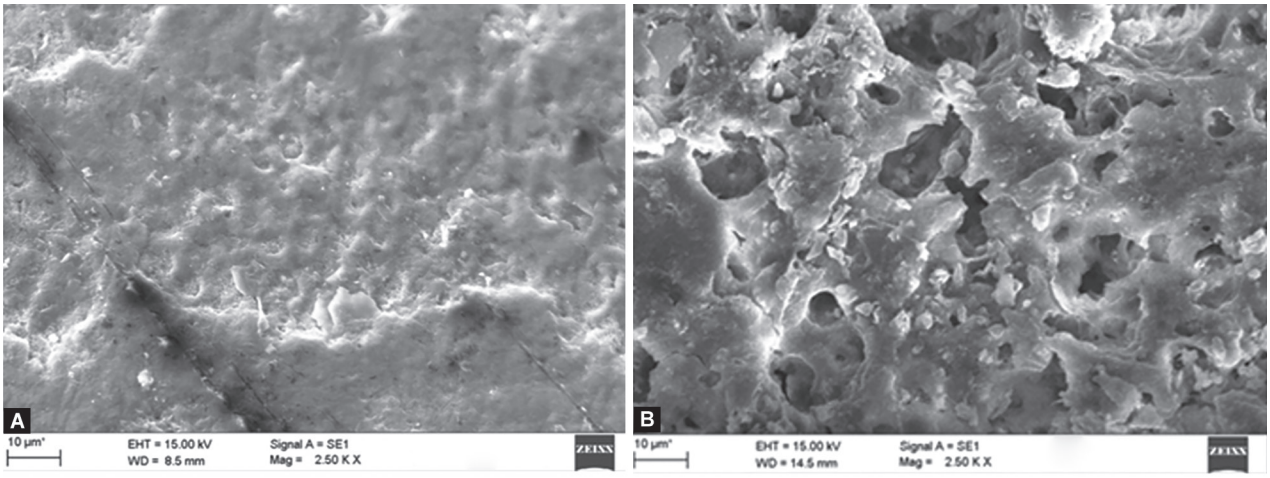
Energy-dispersive X-ray analysis of calcium between groups using *t*-test reported statistically significant results in remineralization ($p < 0.05$) where Curodont™ Repair group (64.35 ± 0.92 reported better mean values than Bifluorid 10® (63.95 ± 0.32 Intragroup analysis using *t*-test shows a statistically significant difference between demineralization and remineralization of Bifluorid 10® (51.54 ± 0.52; 63.95 ± 0.32) and Curodont™ Repair (55.15 ± 0.84; 64.35 ± 0.92), respectively ($p < 0.05$) (Table 3).

Scanning Electron Microscopy Analysis

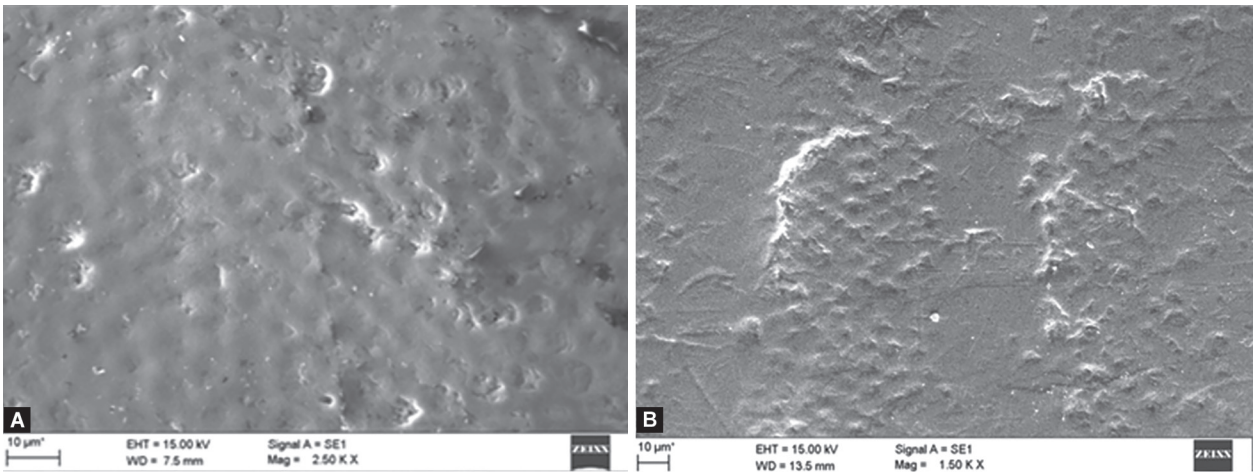
Scanning electron microscope pictures were taken after 96 hours of demineralization. All of the study groups had a deterioration of surface integrity. Enamel had an uneven surface that looked like a honeycomb design. It was possible to discern porous defects, indicating the loss of prismatic enamel and the presence of destructed enamel rods. After a 21-day remineralization period, materials were examined again using scanning electron microscopy. In the Bifluorid 10® (group A), porous defects were

Table 3 : EDX analysis of fluoride, phosphorus, and calcium

	Fluoride		*Phosphorus*		*Calcium*	
	Bifluorid	*Curodont*	*Bifluorid*	*Curodont*	*Bifluorid*	*Curodont*
Demineralization	4.01 ± 0.49	4.19 ± 0.48	24.75 ± 0.79	31.72 ± 0.38	51.54 ± 0.52	55.15 ± 0.84
	23.13 ± 0.44	13.15 ± 0.76	31.55 ± 0.22	31.48 ± 0.41	63.95 ± 0.32	64.35 ± 0.92
p-value (independent *t*-test)	0.0001*	0.0001*	0.0001*	0.19	0.0001*	0.0001*



Figs 1A and B: Group A SEM images. (A) Post-demineralization and (B) Post remineralization



Figs 2A and B: Group B SEM images. (A) Post-demineralization and (B) Post remineralization

observed, suggesting the loss of prismatic enamel and the presence of destructed enamel rods. The surface integrity of the Curodont™ Repair (group B) was restored as all of the porosity faults were filled.

Based on the results in this current study, Curodont™ Repair showed better remineralizing potential compared with Bifluorid 10®. In terms of the mineral gain, Curodont™ Repair showed better results for calcium and phosphorus post remineralization and Bifluorid 10® showed more fluoride gain (Figs 1 and 2).

Discussion

White spot lesions (WSLs) are the initial clinical signs of enamel demineralization and can be used to diagnose dental caries. A WSL is characterized by subsurface enamel demineralization, as well as increased porosity due to mineral loss from the exterior surface. It can be active, with a rough, opaque enamel surface, or it can be inactive, with a smooth, shining enamel surface.[14]

For the detection of early enamel lesions, various means have been utilized worldwide to detect demineralization and remineralization *in vitro*.

In recent years, the DIAGNOdent™ pen has grown in popularity. It is based on the use of a laser light to quantify fluorescence.[15] A study conducted by Sridhar et al. has shown the DIAGNOdent™ pen to be a trustworthy instrument with better sensitivity and specificity than radiographic, optical, and tactile approaches, others have found it to be unreliable.[16,17] Other studies have found

it to have low values of specificity and have claimed that it can be used only as an adjunct to conventional diagnostic aids.[18] Hence, SEM–EDX analysis was also done to assess the microstructure and mineral gain.

Remineralization of the enamel has been investigated for more than a decade, and it has been asserted that it constitutes the largest advance in the therapeutic management of the condition as a noninvasive intervention for early caries lesions.[19] Many studies show that early identification or detection of WSL, as well as the use of noninvasive therapies like fluoride, are essential techniques for preventing caries from developing.[20] Fluoride varnishes are also being researched for their ability to reverse WSLs. The main purpose of applying varnish is to maintain fluoride in contact with the tooth for as long as possible.[21] On the tooth surface, concentrated fluoride ions in fluoride varnish have been found to produce globules of calcium fluoride-like substance. This reaction lowers calcium and phosphate ion solubility, allowing fluoride ions to enter the dental microenvironment and increasing calcium and phosphate ion saturation. This prevents calcium and phosphate ions from dissolving and/or enhances reprecipitation or remineralization of lost minerals.[22] Depending on the pH, the fluoride in calcium fluoride dissolves at a variable pace. At lower pH, the coating is removed, and the rate of calcium fluoride dissolution accelerates. Fluoride and calcium ions are released. Fluoride ions may settle in empty areas on the tooth structure's crystal lattice, generating fluorapatite or hydroxyfluorapatite, which is more acid-resistant than hydroxyapatite. Calcium fluoride globules provide a dependable supply of free fluoride ions during a cariogenic challenge. Plaque fluoride has several consequences on enamel degradation. Individual enamel crystals may be coated with a fluoride-rich layer as a result of simultaneous hydroxyapatite dissolution and fluorapatite reprecipitation, resulting in a fluoride-rich layer with a total fluoride concentration similar to fluorapatite.[23,24]

Fluorides promote remineralization while also preventing additional demineralization.[25] Most preventative therapies rely on patient behavior modifications, which are not always easy to obtain, especially in children and teenagers.

The self-assembling peptide P_{11-4}, which was newly published, offers an alternative to traditional therapies for managing initial noncavitated carious lesions. Within demineralized carious lesions, this peptide generates a 3D matrix, allowing Novo hydroxyapatite crystal synthesis and the repair of the lost enamel structure. The peptide self-assembles into a viscous fibrous scaffold under the influence of the circumstances seen in a carious environment. The anionic groups in peptide P_{11-4} attract calcium ions and can precipitate hydroxyapatite crystals from scratch. The nucleator pulls ions out of tissue fluids and organizes them into a crystalline structure. The crystals will only grow once the crucial nuclei have been stabilized. The scaffold matrix is responsible for this stabilization. This mechanism is similar to what happens naturally prior to tooth eruption when the enamel matrix proteins self-assemble to guide hydroxyapatite crystal precipitation.[26]

In this current study, the self-assembling peptide P_{11-4} Curodont™ Repair was compared with the fluoride varnish Bifluorid 10®. The agents were used as per the manufacturer's instructions. DIAGNOdent™ pen, ICDAS-II score, and SEM–EDX analysis were used to examine the demineralization and remineralization capability of the two materials.

The extremely concentrated fluoride in varnish attaches to the surfaces of the enamel hydroxyapatite crystals, forming calcium fluoride, according to the literature. These calcium fluoride-precipitated globules operate as a reservoir, slowly releasing fluoride during successive acid assaults. Several processes have been proposed to explain how the released fluoride inhibits enamel demineralization and decreases caries susceptibility. Fluoride can be incorporated into enamel hydroxyapatite by filling or displacing hydroxyl vacancies, therefore stabilizing the crystal structure and decreasing the product's solubility. Bifluorid 10® contains 5% calcium fluoride that aids in remineralization, hence this material was used as a control group.

Bifluorid 10® is a fluoride supplement with 5% sodium fluoride (equal to 22,600 ppm fluoride) and 5% calcium fluoride. This present study is the first to compare Curodont™ Repair to Bifluorid 10® in remineralizing early enamel lesion.

In this current investigation, DIAGNOdent™ pen readings were compared between baseline, demineralization, and remineralization. Self-assembling peptide P_{11-4} (Curodont™ Repair) outperformed fluoride varnish (Bifluorid 10®). Similarly, Curodont™ Repair performed better in terms of ICDAS-II score. A DIAGNOdent™ pen is an excellent tool for assessing remineralization. Various studies have found that, despite the DIAGNOdent™ pen's limited specificity, it is capable of detecting enamel defects. Furthermore, this instrument exhibited high repeatability and was more trustworthy than bitewing radiography in several investigations.

This study showed similar results to the study done by Nilüfer Üstün,[27] where the DIAGNOdent™ pen findings revealed considerable remineralization effectiveness from the first day of P_{11-4} administration and, when compared to other time intervals, demonstrated the highest remineralization at the end of 30 days.

According to a study conducted by Kobeissi et al.,[28] WSL healing was much better in the self-assembling peptide group utilizing the DIAGNOdent™ pen. In this study, there was a lesser reduction in DIAGNOdent™ pen values in the fluoride varnish, possibly because the detection signal of the DIAGNOdent™ pen comes from the body of the lesion, which cannot be completely remineralized. Similar results were seen by Giray et al.,[29] where the reduction in DIAGNOdent™ pen values in the fluoride varnish group was lower compared with the experimental material, the reason explained was that the body of the lesion did not remineralize to the same level as the surface zone after fluoride application.[30]

Scanning electron microscopy is one of the most sensitive and well-established techniques for assessing the demineralization and remineralization of carious lesions *in vitro*, as indicated in the earlier study.[31] In this study, a scanning electron microscope was used to investigate enamel surfaces in various treatments. To improve image quality, samples were dried and sputtered with gold before using a scanning electron microscope. Because gold sputtering can result in sample loss, each tooth was divided into two sections. The demineralized enamel specimens were studied at various magnifications. Numerous depressions in a honeycomb pattern were seen at 500× magnification where the loss of surface integrity in enamel's uneven surface resembling a honeycomb pattern was observed in all research groups. Porous defects could be seen, suggesting the loss of prismatic enamel and the presence of corroded enamel rods. After 21 days of remineralization, in the Bifluorid 10® group, porous defects were still visible suggesting the loss of prismatic enamel and the presence of destructed enamel rods, indicating a lack of remineralization (Fig. 1), whereas in Curodont™ Repair group all porous defects had been filled, and the surface integrity had been restored (Fig. 2). The mineral content was determined by EDX analysis post-demineralization and post

remineralization, allowing for easier assessment of mineral content changes before and after treatment.

Scanning electron microscopy images of the sound enamel showed well-organized enamel rods. The enamel crystals were homogeneously arranged with a clear outline. In contrast, the demineralized enamel was disorganized with loss of structural characteristics. The test groups demonstrated either amorphous crystals or particles scattered on the surface or lines of remineralization along the prismatic borders. The results were found similar to the study conducted by Soares et al.[32]

Bifluorid 10® reported higher fluoride gain when compared with the Curodont group. In the intragroup comparison between remineralization and demineralization of Curodont™ Repair, there was a statistically significant increase seen in the weight% gain. The same was noted in the Bifluorid 10® group also.

Curodont group reported higher phosphorus gain when compared to the Bifluorid 10® group weight% gain of phosphorus in the intragroup comparison between remineralization and demineralization of Curodont™ Repair, there was no statistically significant increase seen. Whereas in the Bifluorid 10®, a statistically significant decrease was seen.

Concerning calcium weight%, Curodont group reported higher calcium gain when compared with the Bifluorid 10® group. In weight% gain of calcium in the intragroup comparison between remineralization and demineralization of Curodont™ Repair, there was no statistically significant increase seen. Whereas in the Bifluorid 10®, a statistically significant decrease was seen.

Vicente et al.[33] conducted a study to assess the quantitative and qualitative changes to enamel caused by demineralization cycles after the application of the fluoride varnishes Profluorid and Clinpro White. The results indicated that enamel that had been reduced had a somewhat lower Ca and P content than enamel that had not been reduced. Other studies found that mineral density, as well as the weight percent of Ca and P, declines from the upper surface layers to the more interior layers, as reported by He et al.[34,35] This study is in accordance with their findings. Based on the findings of this investigation, this current study rejects the null hypothesis that both the materials, Curodont™ Repair and Bifluorid 10®, have the same remineralizing capability. Sindhura et al. found that the Ca:P ratio in the SAP P_{11-4} group increased overtime at 1 and 3 months.[36] The tooth samples in this current study were exposed to a continuous cycle of remineralization for only 21 days without any demineralizing environment, creating the perfect conditions for remineralization. The oral cavity lacks such a substantial environment, which can be viewed as a limitation.

Conclusion

Curodont™ Repair revealed better remineralizing capacity than Bifluorid 10® when tested using the DIAGNOdent™ pen and ICDAS-II criteria. After remineralization, Curodont™ Repair produced better mineral gain results for calcium and phosphorus. Bifluorid 10®, on the other hand, showed a larger fluoride increase. To remineralize WSLs, self-assembling peptide P_{11-4} can be used as an alternative to fluoride varnish.

Further clinical studies with longer follow-up are required to demonstrate the efficacy of this biomimetic material for enamel remineralization.

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