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# THE EFFECT OF DIFFERENT ENAMEL SUBSTRATES ON COLOR CHANGE OF GLASS CERAMIC LAMINATE VENEERS

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## ABSTRACT

**Background:** The purpose of this study was to evaluate how the color of glass ceramic laminate veneers was affected by various enamel substrates, including sound enamel, demineralized enamel, demineralized enamel treated with ICON resin infiltration, and demineralized enamel treated with Oli Nano seal.

**Methods:** 40 longitudinal labial halves of maxillary central incisor crowns, embedded in acrylic blocks. labial surfaces of all specimens that facing upward underwent initial preparation process through creation of 0.3 mm depth -orientation grooves using a depth cutting bur, then randomly divided into four equal groups: n=10 G1: Laminate veneer bonded to sound enamel (control group),G2: Laminate veneer bonded to demineralized enamel, G3: Laminate veneer bonded to demineralized enamel treated with ICON resin infiltration,G4: Laminate veneer bonded to demineralized enamel treated with Oli Nano seal. Ceramic bars were prepared and base ling color recordings using spectrophotometer then cementation of the ceramic bars to the working field of all groups, thermocycling and post operative color assessment. The data were analyzed using One way ANOVA and Multiple comparison Tuckey test was used to compare each two groups.

**Results:** The least color change value (Δ E) presented in group III (Specimens with demineralized enamel treated with ICON resin infiltration) followed by group IV (Specimens with demineralized enamel treated with Oli Nano seal), while the highest (Δ E) value recorded in group II (Specimens with demineralized enamel only) with a significant difference between group III (P-value 0.009*).

**Conclusion:** within the limitation of this in-vitro study Laminate veneers which bonded to demineralized enamel treated with ICON resin infiltration showed less color changes in comparison to those treated with Oli Nano seal or with demineralized enamel only.

**KEYWORDS:** laminate veneer, demineralized enamel, remineralization, color, ceramic.

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## INTRODUCTION

Nowadays, porcelain veneers are frequently utilized to provide both function and esthetic, particularly in the esthetic zone. When wear, insufficient morphology, or potential pigmentations prevent aesthetics and functionality from being perfectly addressed with exclusive orthodontic solutions, they can be employed either exclusively or in conjunction with orthodontic treatments.[1]

Demineralization of enamel surrounding orthodontic brackets, clinically known as white spot lesions (WSLs), is one of the most prevalent and disagreeable side effects of fixed orthodontic therapy, affecting about 50% of orthodontic patients. Plaque stagnation around orthodontic brackets, under the arch wires, and between brackets and the gingival border is the primary cause of the lesions' development.[2]

When WSLs are present, the appearance of anterior teeth is harmed. Clinically, WSLs manifest as an early non-cavitated carious lesion encircling the bracket site with an opaque, mat-like, chalky white halo.[3] WSLs look white due to enamel demineralization behind a hyper-mineralized undamaged outer enamel layer of about 10 to 30 mm, while organic fluids replace the decreased interprismatic mineral phase in the porous subsurface layer.[4]

Since light refraction directly affects the degree of mineralization in enamel, the presence of many hydroxyapatite/organic fluid interfaces causes incident light to deflect and diverge, giving WSLs their white appearance. Light refraction determines the refractive index (RI) value. The refractive index (RI) of sound enamel is 1.62, but that of WSLs can vary from 1 to 1.33 based on how wet or dry the enamel surface is.[5]

Non-invasive methods like remineralization, which is the first line of treatment, micro-invasive methods like resin infiltration using ICON or conventional adhesives, minimally invasive methods like porcelain or composite veneers, or even more invasive methods as ceramic crowns are typically used to treat WSLs.[2]

Previous studies suggested several remineralizing agents including Fluoride treatment, Casein phosphopeptide, Diode Laser, Nanoseal® and Zamzam water as non-invasive treatment options for WSLs.[6,7]

Nanoseal® application leads to nanoparticles depositions on the enamel surface porosities on WLSs. Incorporation of calcium and silica ions into superficial enamel lesions reduces demineralization until the same number of ions can be retained or even exceed that of native tooth substrate. Additionally, this layer may create a physical barrier against oral bacteria and acidic food to diminish tooth demineralization.[8]

Remineralization process achieved through various agents is not fast, moreover is not always achieved. Furthermore, No Esthetic Improvement in the optical properties of WSLs is expected when using any existing remineralizing agents.[9]

Limitations of remineralizing processes pushed the scientists towards the concept of resin infiltration as an alternative treatment for WLSs. The purpose of the resin infiltration technique in dentistry was to use low-viscosity light-curing resins to stop the progression of early carious lesions. The porous enamel structure allows the low viscosity adhesive resin to penetrate and spread. The demineralized enamel's pores and in tercrystalline gaps are filled with resin.[10]

As soon as these monomers polymerized it creates a physical barrier that prevents microbes from diffusing acids into the enamel, blocking the admission of acids and halting the growth of lesions. Moreover, they stopped calcium and phosphate ions from leaving enamel despite the acidic environment.[11] When a laminate veneer is intended to be bonded to a tooth using resin cement, the resin infiltration approach for WLSs with conventional adhesive can be useful.[10,12]

By altering the composition of traditional adhesives and increasing their material penetration capacity, Paris et al. established a research line in 2007. As a result of their research, an infiltration resin called ICON (DMG, Hamburg, Germany) was developed especially to treat white spot lesions.[13]

Using hydrochloric acid as an etchant is more effective than using 37% orthophosphoric acid gel at removing the 30–40 mm outer layer of an enamel lesion, which prevents resin from penetrating the lesion.14

According to recent studies, resin infiltration can bring WSLs' color back to a clinically acceptable level because the lesions that Icon infiltrated resembled the surrounding sound enamel, hiding the whitish appearance by filling the lesion's body with resin, which raises the lesion's RI.[13]

There is not enough studies compared the effect of color changes of enamel substrate induced by its demineralization, remineralization and resin infiltration on glass ceramic laminate veneer, so this study was conducted.

## MATERIALS AND METHOD

### Study design:

This study was carried out in a laboratory as an experimental investigation.

### Study setting:

The experimental laboratory study was carried out at Fixed Prosthodontics Department, Faculty of Dentistry, Tanta University.

**Materials:** The materials used in this study are listed in Table 1

TABLE (1) Materials used in the study and their composition, manufacturer (Demineralization solution, Resin infiltrate, Fluoride, Lithium Disilicate Glass Ceramic and Light cure resin cement)

| Material | Manufacturer | Composition |
|---|---|---|
| Demineralization solution | Faculty of Pharmacy, Tanta University | (2.2 mM $CaCl_2$, 2.2 mM $NaH_2PO_4$, 0.05M acetic acid, and 1M KOH) |
| Resin infiltrate (ICON) | Icon-Etch DMG, Hamburg, Germany) | 15% hydrochloric acid |
| | (Icon-Dry, DMG, Hamburg, Germany) | Ethanol |
| | Icon-Infiltrant DMG, Hamburg, Germany) | Chemical characterization (preparation): Acrylate.-resin. TEDMA (70-95%), Camphoro Quinone (< 2.5%) |
| Fluoride (OLINANO SEAL) | (OLIDENT, Podleze 653, PL– 32-003 Podleze, Poland) | Silicone polymer<br>NANO-fluoroapatite<br>NANO-calcium fluoride<br>Amine fluoride Olaflur |
| Lithium- Disilicate Glass Ceramic (IPS-e.max CAD) | Ivoclar Vivadent,, Schaan, Liechtenstein | 70% fine-grain lithium disilicate crystals, $Li_2Si_2O_5$, which are embedded in a glassy matrix<br>$SiO_2$ (in %) > 57, $Li_2$, $K_2O$,$P_2O_5$, $ZrO_5$, ZnO, $Al_2O_3$, MgO Pigments |
| Light cure resin cement (choice 2 veneer cement) | Bisco, Schaumburg, II, USA | Base: Bisphenol-A glycidyl dimethacrylate, uncured dimethacrylate monomer, glass filler.<br>Catalyst: phosphate acidic monomer, glass fillers. |

## METHODS:

### Specimen collection & preparation

The samples were planned to consist of 40 longitudinal labial halves of maxillary central incisor crowns, embedded in acrylic blocks. To prepare the specimens, they were initially cleaned with a fluoride-free pumice slurry& rinsed thoroughly using tap water.

Selected teeth were embedded into acrylic resin blocks at root portion to facilitate handling. Slow-speed carborundm disc (Isomet 4000, Buehler, Brufmaschinen, Zurisch Switzerland) was used to cut each crown just beneath CEJ.

The coronal portion was sectioned into labial and palatal halves, the labial halves of crowns embedded ,cemented into self-curing acrylic resin so that their labialsurfaces faced upwards; this facilitated handling during testing procedures.

### Teeth preparation:

To resemble the clinical situation of laminate veneer preparation, labial surfaces of all specimens underwent initial preparation process through creation of 1mm depth -orientation grooves using a depth cutting bur (Intensive laminate veneer kit). A low-speed straight handpiece, with a double carborundum disc attached, was mounted to the surveying arm of dental surveyor to conduct veneer preparation within enamel surface. **Figure1**

### Standardization of working Field:

To conduct the experiment, a 4 mm x 4 mm piece of adhesive tape was used to isolate the labial working area of each specimen. To guarantee that only the pre-selected buccal surface was exposed to each suggested therapy for WSLs, the remaining coronal surface was thereafter covered with acid-resistant nail varnish. Once the tape was removed, a clean debris-free window measuring 4*4 $mm^2$ on the labial surface remained to standardize the work.

### Sample size calculation:

The total number of sample sizes for this study is 38 samples. The samples were collected based on a pilot study. The significance level was 0.05 and the power sample size was more than 80% for this study and the confidence interval 95% and the actual power is 97.16%The sample size calculated using a computer program G power 3.1.9.

The formula of sample size

$$sample\ size = \frac{Z^2\hat{P}(1-\hat{P})}{C^2}$$

Where:

Z = Z value (1.96 for 95% confidence level)
p = percentage picking a choice, expressed as decimal
c = confidence interval, expressed as decimal.

The sample size was 40, which was intentionally inflated to account for the possibility of failure and enhance the reliability of data.

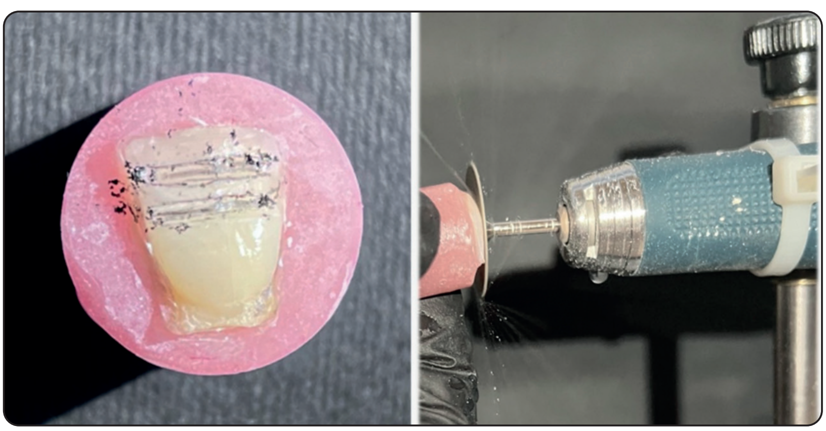

Fig. (1) Tooth sectioning, Depth orientation groves for labial veneer Tooth preparation.

Statistical analyses were conducted using SPSS version 26, which is a statistical package for the social sciences. Descriptive statistics were used to convey numerical variables like range, standard deviation, and mean, while percentage, median, and frequency were used to depict nominal data. If P value is less than 0.05 (*) it refers to significant difference, while being less than 0.001 (**) a highly significant difference was detected.

**Specimen grouping:**

The specimens (N=40) were distributed randomly into 4 groups (n=10) for each:

Group I (control group): teeth with sound enamel bonded to the ceramic bars.

Group II: teeth with demineralized enamel bonded to the ceramic bars.

Group III: teeth with demineralized enamel treated with ICON resin infiltration then bonded to, the ceramic bars.

Group IV: teeth with demineralized enamel treated with Oli Nano seal then bonded to ceramic bars.

**Demineralization for groups II, III& IV:**

Each tooth was immersed in a sterile graduated glass beaker containing 12 milliliters of newly made buffered demineralizing solution (2.2 millimeters $CaCl_2$, 2.2 millimeters $NaH_2PO_4$, and 0.05 acetic acid) for 96 hours at 37 degrees Celsius in an incubator to demineralize the specimens. To prevent supersaturation, the demineralizing solution was refilled daily. Each specimen was constantly cleaned with deionized water for one minute after the allotted time had passe.[15]

**Resin infiltration protocol using Icon system for group III:**

Specimens were washed thoroughly using water stream then dried. Icon-Etch was applied for 2 min followed by rinsing with water for 30 seconds and drying. After that, Icon-dry was applied and given 30 seconds to set. Icon-Infiltrant was then applied to the surface, where it settled and stayed for three minutes.

After which excess infiltrate material was removed and dispersed with air prior to light curing for forty seconds (according to manufacturer instructions).

**Remineralization protocol using Oli Nano seal system for group IV:**

Following the manufacturer instructions, Teeth were rinsed thoroughly with water and dried in an oil- and water free air stream. After giving the Nanoseal bottle a good shake, it was applied in a thin coating to the demineralized surfaces two or three times using a cotton applicator that oscillated in a clockwise manner. It was then allowed to dry air for a minute.

**Cutting of Ceramic bars:**

A total of 40 ceramic bars with rectangular shapes were obtained from IPS e.max CAD glass ceramic blocks of shade HTA1 (Ivoclar Vivadent, Schaan, Liechtenstein). The cutting process was performed using IsoMetI Low Speed Saw (Buehlerl, Illinois, USA) to achieve uniform dimensions for each specimen consisting of 1 mm thickness as well as 4 mm length and width. Subsequently, the precision of bar thickness was validated through the utilization of a digital caliper to ensure consistency across all bars.

**Crystallization of ceramic bars:**

All E-max specimens were placed over crystallization tray. Before crystallization, IPS.emax glaze paste was applied by brush to all specimens' surfaces. Following the manufacturer's instructions, IPS e.max specimens underwent the crystallization process in a ceramic furnace. Following firing, the specimens were allowed to cool gradually on a crystallization tray.

**Baseline color assessment:**

All ceramic specimens were premeasured for color using a Reflective spectrophotometer (X-Rite, model RM200QC, Neu- Isenburg, Germany) after being rehydrated for 24 hours at 37 degrees Celsius in distilled water. Three coordinates (L*, a*, and b*) and the quantitative parameters of the CIE lab system were used to identify color. On a scale ranging from 0 BLACK to 100 WHITE, the tooth value is represented by the L*. Positive (a*) indicates red color, and negative (a*) indicates the color green. a* is the measure along the Red Green Axis. where b* is the measure along the blue-yellow axis; a positive value (b*) denotes the color yellow, while a negative value (b*) denotes the color blue.

**Cementation of Ceramic bars to working field in all groups:**

In all groups, a total of 40 ceramic bars were attached to enamel surface in all specimens by cementation. Ceramic bars working surfaces were first etched for twenty seconds using 9.5% hydrofluoric acid etchant gel, rinsed and dried. The surface appeared dull and frosty. Ceramic surfaces were then cleaned by applying 35% Phosphoric acid and agitated for one minute to remove any salts, rinsed, then dried thoroughly. Finally, one or two coatings of silane coupling agent were applied to ceramic surface for sixty seconds and dried using gentle air syringe.

Second, for Enamel surface in the working field of all specimens; enamel was cleaned, rinsed and dried. Then, the working enamel surface was acid etched for thirty seconds, washed and dried. Afterwards, two coats of all universal bond were applied and scrubbed over enamel ten seconds per coat and light cured for twenty seconds.

Translucent light activated resin cement (Bisco, Schaumburg, II, USA) was utilized to perform the cementation procedure. It was applied generously on the prepared ceramic surfaces and air thinned onto followed by applying constant load of 20 N for five minutes using a loading sarice mounted on universal testing machine (Model 3345; Instron Industrial Products, Norwood, USA).

Light polymerization on labial surfaces lasting for forty seconds was conducted confirming with the manufacturer's instructions utilizing a blue phase LED polymerizing unit (woodpecker, Schaan, Lichtenstein;650-850 m W/cm$^2$).[16]

**Thermocycling:**

Specimens were thermocycled (SD Mechatronic Thermocycler, Germany) 10000times between the maximum and minimum temperatures that subjected to 55±1°C respectively, with a dwell time of 30 seconds in each bath and a lag time 10 seconds simulating one year.[17]

**Post-operative color Assessment:**

.After the ceramic veneers were cemented, a spectrophotometer was used to measure each specimen's color once more. By computing the differences in the values of the post-operative and baseline measures, the color difference ΔE Lab was calculated for each group, resulting in ΔE Lab 1 for group 1, ΔE Lab 2 for group 2, ΔE Lab 3 for group 3, and ΔE Lab 4 for group 4.

The following formula was used to determine the color difference between the two-color measurements ΔE Lab before and after cementation. [18]

ΔELab =

$$\sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

**Statistical Analysis**

The Statistical Package for Social Sciences (SPSS version 26) was used to conduct statistical analysis. The mean, standard deviation, and range of numerical variables were used to express them. The data's normality is assessed using the Shapiro-Wilk test, the color difference (Δ E) results of the groups under study are compared using a one-way ANOVA, and multiple comparison Each of the two groups is compared using the Tuckey test.

## RESULTS

### The color difference measurements:

Analyses of color difference (Δ E) values using:

The data's normality was assessed using the Shapiro-Wilk test, and the color difference (Δ E) results of the groups under study were compared using a one-way ANOVA that expressed the means, standard deviation, and range. A significant difference was defined as a P value <0.05(*), and a highly significant difference was defined as a P-value <0.001(**).

Each of the two groups was compared using the Tuckey test. The color difference (Δ E) results for the groups under study are displayed by mean, standard deviation, and range as shown in **Table 2** that shows Color change (Δ E) results of studied groups using one way ANOVA, With a p-value of 0.012*as there was a significant difference between the tested groups.

The least color change value (Δ E) presented in group III (Specimens with demineralized enamel treated with ICON resin infiltration) (6.09 ±1.35) followed by group IV (Specimens with demineralized enamel treated with Oli Nano seal) (8.17±3.19) with no significant difference between them. while the highest (Δ E) value showed in group II (Specimens with demineralized enamel only) (9.32±3.13) with a significant difference between group III (P-value 0.009*).

TABLE (2) Color change (Δ E) results of studied groups using one way ANOVA test.

| Groups | Δ E | | ANOVA test |
|---|---|---|---|
| | $\overline{X}$ ± S.D | Range | F (P-value) |
| **Group I** | 8.81±1.95 | 4.72—10.93 | 4.248 (0.012*) |
| **Group II** | 9.75±2.16 | 6.10—12.74 | |
| **Group III** | 6.09±1.35 | 4.51—8.59 | |
| **Group IV** | 8.17±3.19 | 1.22—11.49 | |

***There is a significant at P-value< 0.05 (*), and highly significant at P-value< 0.001 (**).***

**The color difference (Δ E) of studied groups expressed by mean, standard deviation and range. There was a significant difference between the tested groups with p-value 0.012*.**

While there was a non-significant difference between group II and group IV (P-value 0. 227) as shown in **Table 3:** (Tuckey test).

TABLE (3) Showes Multiple comparison (Tuckey test) to illustrate the difference between each two groups.

| **Multiple comparison (Tuckey test)** | | | |
|---|---|---|---|
| **Parameter** | **Group I** | **Group II** | **Group III** |
| **Group I** | -------- | -------- | -------- |
| **Group II** | 0.814 | -------- | -------- |
| **Group III** | 0.071 | 0.009* | -------- |
| **Group IV** | 0.931 | 0.459 | 0.227 |

***There is a significant at P-value< 0.05 (*), and highly significant at P-value< 0.001 (**).***

***Tuckey test that used to compare the difference of color change between each two groups.***

***As there was a non-significant difference between group II and group IV (P-value 0. 227).***

## DISCUSSION

The current study was performed to estimate the color stability and changes of Glass Ceramic Laminate Veneers cemented to enamel after demineralization, treating the enamel surface with resin infiltrant, and in comparison, with enamel treated with Oli Nano seal remineralizing system.

In this study, spectrophotometers were used to provide accurate quantitative data for analysis, as well as to eliminate the possibility of subjective color assessment errors and enable an objective evaluation. The total color change is represented by the parameter (ΔE). This method is accurate as it evaluates even small color changes.[19,20]

To prevent significant differences in the patients' reactions to demineralization and various enamel treatments, the teeth in the current investigation were taken from patients in the same age range.[21]

To minimize tooth dryness and to replicate the conditions in the oral cavity, specimens were first preserved in deionized water with (0.1%) thymol added to inhibit bacterial growth. They were subsequently kept in artificial saliva. This is in line with other research that found the chemical and physical characteristics of the human tooth substrate were unaffected by the storage media and disinfectants.[22,23]

Currently, the thermocycling process was connected within the think about this in vitro study to subject the restoration tooth complex to different temperature extremes. This reenacts the fleeting presentation of the environment within the oral cavity and regulates the difference in thermal expansion between the tooth / restoration interface which may have deleterious effect on the restoration strength.[24]

Furthermore, specimens of artificially demineralized enamel were chosen because, as many other studies have shown, they can be compared to the first observable ultrastructural change in the enamel after different treatments.[25]

The choice to evaluate the glass ceramic veneer's shade in this study was made in light of earlier research that found high translucent ceramics to have translucency parameters that are comparable to enamel. Because of these similarities, it is important to estimate CV translucency parameters based on how the enamel surface beneath the veneer is treated and how the ceramic and teeth interact.[26]

The null hypothesis of this study was somewhat rejected as the results cleared that there was a significant difference between the tested groups, group II&III were more responsible than this significance.

These results were consistent with Subramaniam et al.'s report that the difference in refractive indices (RIs) between affected and sound enamel causes demineralized enamel surfaces to display a white color. Group II (demineralized enamel) recorded the highest mean value in color change following thermo-mechanical simulation, but there was a significant difference between all tested groups, and group II was responsible for this significant difference.[27]

This discrepancy is caused by the development of microporosities in damaged enamel lesions. In contrast to sound enamel, which has a RI of 1.62, these microporosities are filled with either water or air with RI=1.33,1.0 respectively). Lesions seem more opaque than healthy enamel tissue when these pores are filled with water and when these pores are dry, they fill with air, which makes the lesion more noticeable. Therefore, the color difference is explained by the difference in RIs between the porosities and the enamel crystals, which causes light to scatter producing a whitish opaque look lesion, particularly when they are dried out from water or saliva.[28]

Additionally, Group III (which received resin infiltration treatment) showed the greatest color improvement. This is because ICON can conceal demineralized enamel lesions more effectively than other tested groups, but there was a significant difference between groups II and III. This was corroborated by Hammad et al.[2], who found that ICON's low viscosity allows it to diffuse inside the micro-porosities on demineralized enamel that were filled with water or saliva (RI=1.33). However, they filled these with resin infiltrant (RI=1.46) rather than water, keeping in mind that the RI of resin infiltration is more closely matched that of enamel (1.62). The lesions have an opportunity to become less white and more translucent, blending in with the surrounding sound enamel due to this slight variation in RI levels.[30]

The resin infiltant's unique characteristics, such as its low viscosity, low contact angle, and strong penetration ability, allow it to spread and be more stable inside the deeper layers of WSLs, allowing for the nearly total obliteration of demineralized enamel or porous WSLs. A closer light RI.30 can restore the color to normal enamel because this obliteration can lessen the scattering of the reflected light.[30]

These recent results also concurred with those of Abdellatif and El-Sebaai, who evaluated the impact of resin infiltrant versus sticky resin on the color of white spot lesions. When compared to other examined groups, the ICON group showed a highly significant improvement in WSL color. Significant color improvement was also seen in the other examined groups, though not to the extent that the ICON group had observed. Their findings were explained by the fact that the infiltrate's physical characteristics, such as its contact angle with enamel, surface tension, and viscosity, influence its diffusion into porous demineralized enamel surface30, increasing its masking efficacy and enhancing the color.[31]

This current result, however, did not align with the findings of de Lacerda et al., who used spectrophotometers to compare the effects of resin infiltration treatment on color masking of artificial white spot lesions (AWSLs) using ICON to various adhesive systems. Based on $\Delta E$ means, all tested treatments under investigation recorded a significant value in masking the color of artificial white spot lesions. These substances that successfully covered up white spots had refractive indices that were strikingly comparable to the ICON product.[32]

Regarding group IV (Nanoseal® remineralizing agent) recorded better color change in comparison to group II (demineralized enamel) without a significant difference, this supports the results of a prior study that used SEM-EPMA to assess the incorporation of calcium and silicon into superficial enamel and dentin following Nanoseal® treatment. According to reports, applying Nanoseal agent increased the likelihood that materials (nanoparticles) would deposit over the fake wounds that were made on the surface of the enamel. Additionally, the use of Nanoseal® reduced the loss of enamel and dentin brought on by demineralization.[33]

This coating of nanoparticles, which was produced by applying Nanoseal®, covered the surface of the enamel and supplied ions to the first carious lesions, decreasing demineralization until the tooth structure was replenished by the same amount of lost ions or possibly more. Another study that looked at the mineral loss in bovine dentin submerged in an acetic acid solution supported this finding. Fluoride varnish and a traditional desensitizing agent were not as effective in reducing the quantity of mineral loss in the dentin as Nanoseal® treatment.[34-36]

These current results were in accordance with **Hammad et al.,**[2] who reported that using Nano-hydroxyapatite remineralizing agent recorded higher color change in comparison to Icon resin infiltration treated group with non-significant difference. As, Nano-HA was deposited on a demineralized surface and created a new homogenous apatite surface layer, which prevents further demineralization from the underlying surface and provide more remineralization. [37]

However, nano-HA promotes the deposition of more minerals on the outer layer rather than the lesion body. This new, highly mineralized layer on the surface can then stop the diffusion of mineral ions into the deeper areas of a lesion. [38] The formation of the highly mineralized outer layer because of this mineral deposition is thought to stop demineralization from progressing and preventing acid seepage into deeper regions of enamel. However, to force enamel recrystallization to the subsurface zone, it might also prevent mineral ions from entering the lesion body.[39] This could explain why administering treatments containing nano-HA to the damaged enamel surface did not result in total remineralization and, consequently, a flawless color improvement of WSLs.

It was found that the E-max ceramic laminate veneers in the mouth are exposed to various mechanical, chemical and thermal factors such as pH changes, hot and cold drinks. However, conducting trials directly in a real-life setting would provide more reliable data on the performance of laminate veneers.

## Conclusions within the limitations of the current study

1. The shade of laminate ceramic veneers can be simultaneously affected by the background color of the treated enamel.
2. The masking ability of resin infiltration to the color of demineralized enamel was higher than other tested materials.
3. Laminate veneers which bonded to specimens with demineralized enamel treated with ICON resin infiltration showed less color changes in comparison to those treated with Oli Nano seal or with demineralized enamel only.

**List of abbreviations:**

**WSL:** White spot lesion.

**RI:** Refractive index.

**CEJ:** Cemento -enamel- junction.

**CIE lab:** International Commission on Illumination.

**Nono-HA:** Nano hydroxy apatite crystals.

**$\Delta$ E:** color difference.

## REFERENCES

1. Pinos NPA, Morales BBR, Cordero LMA and Nugra PAJ. Porcelain veneers as an aesthetic solution after orthodontic treatment. Case report. Revista Odontológica Mexicana 2020 Vol. 24 pp 290-96.
2. Hammad SM, El-Wassefy NA and Alsayed MA. Evaluation of color changes of white spot lesions treated with three different treatment approaches: an in-vitro study. Dental Press J Orthod. 2020; 25:1-7.
3. Srivastava K, Tikku T, Khanna R and Sachan K. Risk factors and management of white spot lesions in orthodontics. J Orthod Sci 2013; 2: 43-49.
4. Arends J and Christoffersen J. The nature of early caries lesions in enamel. J Dent Res 1986; 65: 2-11.
5. Denis M, Atlan A, Vennat E, et al. White defects on enamel: diagnosis and anatomopathology: two essential factors for proper treatment (part 1). Int Orthod 2013; 11: 139-65.
6. Elkabbany S, Mosleh A and Metwally N. Remineralization Effect of Diode Laser, Nanoseal®, and Zamzam Water on Initial Enamel Carious Lesions Induced Around Orthodontic Brackets. J. Nat. Sci. Med. 2021; 4:50-57.
7. Chen H, Liu X, Dai J, Jiang Z, Guo T and Ding Y. Effect of Remineralizing Agents on White Spot Lesions after Orthodontic Treatment: A Systematic Review. Am.J. Orthod. Dentofac. Orthop.2013;143: 376- 382.
8. Miyajima H, Ishimoto T, Ma S, Chen J, Nakano T and Imazato S. In vitro, assessment of a calcium fluoroaluminosilicate glass-based desensitizer for the prevention of root surface demineralization. Dent Mater J 2016; 35:399-407.
9. Paris S, Schwendicke F, Keltsch J, et al. Masking of white spot lesions by resin infiltration in vitro. J Dent 2013; 41: 28-34.
10. Jefferies S.R. Advances in Remineralization for Early Carious Lesions: A Comprehensive Review. Compendium of Continuing Education in Dentistry2014; 35: 237-243.
11. Bahrololoomi Z and Lotfian M. Effect of diode laser irradiation combined with topical fluoride on enamel microhardness of primary teeth. J Dent (Tehran) 2015; 12:85-89.
12. Albamonte, G.S., Sfalcin, R.A., Freire, T.G., Bruschi, R.C. and Puppin, R.M. Evaluation of Polymerization Characteristics and Penetration into Enamel Caries Lesions of Experimental Infiltrants. J. Dent.2013;41, 1014-1019.
13. Paris S and Meyer-Lueckel H. Masking of labial enamel white spot lesions with resin infiltration – a clinical report. Quintessence Int 2009; 40: 713-718.
14. Yim H-K, Min J and Kim B. Modification of surface pretreatment of white spot lesions to improve the safety and efficacy of resin infiltration. Korean J. of Orthodontics. 2014; 44:195-202.
15. Vinod D, Gopalakrishman A, Subraani SM, Balachandran M, Manoharan V and Joy A. Acomparative evaluation of remineralizing potential of three commercially available remineralizing agents: An in vitro study. Int J Clin Pediatr Dent 2020; 13:61-65.

16. Akyle G and Achuor H. Evaluation of Shear Bond Strength of Lithium Disilicate Veneers Using Pre-Heated Resin Composite with Two Conventional Resin Cements: An In Vitro Study. J. BMC2024; 16:744-779.

17. Saadeddin N, Al-Khalil MA, Al-Adel O. Effect of immediate dentin sealing on the fracture strength of lithium disilicate ceramic onlays. Swiss Dent J.2022; 132:482-489.

18. Mokrzycki W and Tatol M. Colour difference δE - A survey. Machine Graphics and Vision 2011; 20:383-411.

19. Topcu F.T., Sahinkesen G., Yamanel K., Erdemir U., Oktay E.A., Ersahan S. Influence of different drinks on the color stability of dental resin composites. Eur J Dent. 2009; 3:50–56.

20. Ceci M., Viola M., Rattalino D., Beltrami R., Colombo M., Poggio C. Discoloration of different esthetic restorative materials: A spectrophotometric evaluation. Eur.J. Dent. 2017; 11:149–156.

21. Zhou C, Zhang D, Bai Y and Li S. Casein phosphopeptide-amorphous calcium phosphate remineralization of primary teeth early enamel lesions. J Dent 2014; 42:21-29.

22. Buzalaf MA, Hannas AR, Magalhães AC, Rios D, Honório HM and Delbem AC. PH-cycling models for in vitro evaluation of the efficacy of fluoridated dentifrices for caries control: Strengths and limitations. J Appl Oral Sci 2010; 18:316-334.

23. Lata S, Varghese NO and Varughese JM. Remineralization potential of fluoride and amorphous calcium phosphate-casein phosphor peptide on enamel lesions: An in vitro comparative evaluation. J Conserv Dent 2010; 13:42-46.

24. Gogna R, Jagadis S and Shashikal K. A comparative in vitro study of microleakage by a radioactive isotope and compressive strength of three nano-filled composite resin restorations. J. Conserv Dent 2011; 14: 128-131.

25. Mosleh A, Niazy M and El-Yassaky M. Clinical and laboratory evaluation of the efficacy of three different treatment modalities in management of dentin hypersensitivity. Azh Dent J for Girls 2018; 5:129-134.

26. Hernandes DK, Arrais CA, Lima Ed, Cesar PF and Rodrigues JA. Influence of resin cement shade on the color and translucency of ceramic veneers. J Appl Oral Sci-2016; 24:391-396.

27. Subramaniam P, Babu KG and Lakhotia D. Evaluation of penetration depth of a commercially available resin infiltrate into artificially created enamel lesions: An in vitro study. J Conserv Dent. 2014; 17:146–149.

28. Kim S, Kim EY, Jeong TS and Kim JW. The evaluation of resin infiltration for masking labial enamel white spot lesions. Int J Paediatr Dent. 2011; 21:241–248.

29. Son J-H, Hur B, Kim H-C and Park J-K. Management of white spots resin infiltration technique and microabrasion. J Korean Acad Conserv Dent. 2011; 36:66–71.

30. Torres CRG, Borges AB, Torres LMS, Gomes IS and de Oliveira RS. Effect of caries infiltration technique and fluoride therapy on the colour masking of white spot lesions. J Dent. 2011; 39:202–207.

31. Abdellatif AB and El-Sebaai HS. Effects of resin application on white spot lesions (laboratory study). J Clin. Pediatr. Dent 2016; 46: 120-126.

32. De Lacerda AJ, Avila DM, Borges AB, Pucci CR and Rocha Gomes Torres C. Adhesive systems as an alternative material for color masking of white spot lesions: Do They Work? J Adhes Dent 2016; 18:43-50.

33. Han L and Okiji T. Effects of a novel fluoride-containing aluminocalciumsilicate-based tooth coating material (Nanoseal) on enamel and dentin. Am J Dent 2013; 26:191-195.

34. Maranhão KM, Klautau EB, Pereira PM, Guimarães RB and Pantoja VG. The effect of solutions on enamel of bovine teeth. Rev Salusvita 2009; 28:129-34.

35. Agrawal N, Shashikiran ND, Singla S, Ravi KS and Kulkarni VK. Atomic force microscopic comparison of remineralization with casein-phosphopeptide amorphous calcium phosphate paste, acidulated phosphate fluoride gel and iron supplement in primary and permanent teeth: An invitro study. Contemp Clin Dent 2014; 5:75-80.

36. Lodha E, Hamba H, Nakashima S, Sadr A, Nikaido T and Tagami J. Effect of different desensitizers on inhibition of bovine dentin demineralization: Micro-computed tomography assessment. Eur J Oral Sci-2014; 122:404-410.

37. Huang S, Gao S and Yu H. Effect of nano-hydroxyapatite concentration on remineralization of initial enamel lesion in vitro. Biomed Mater. 2009;4: 34104-9.

38. Huang S, Gao S, Cheng L, Yu H. Remineralization potential of nano-hydroxyapatite on initial enamel lesions an in vitro study. Caries Res. 2011; 45:460–468.

39. Mielczarek A and Michalik J. The effect of nano-hydroxyapatite toothpaste on enamel surface remineralization An in vitro study. Am J Dent. 2014;27: 287–290.