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An Evaluation of the Effect of Different Surface Treatments on Surface Roughness of the Polymer-Infiltrated Ceramic Network

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KEYWORDS

Polymer infiltrated ceramic network, PICN, hybrid ceramic , VITA Enamic, surface treatment.

ABSTRACT:

Introduction: The advantages of glass ceramics are combined with those of resin in hybrid ceramics. There are, however, few studies concerned concerning the characteristics of surface roughness in hybrid materials.

Objectives: The roughness of dental restorations milled from hybrid CAD/CAM blocks will be studied to determine the effect of different surface finishing techniques.

Methods: Twenty-four (24) polymer infiltrated ceramic network (Enamic) samples were made, each measuring (3 millimeters in length, 8 millimeters in breadth, and 3 millimeters in height). Enamic samples consist of three subgroups. (8) samples categorised by surface treatment. A universal testing instrument was used to evaluate the surface roughness. To test for a statistically significant difference between the three groups, a one-way analysis of variance (ANOVA) was used. When differences between groups are found to be statistically significant using analysis of variance (ANOVA), the data are put through the Least Significant Difference (LSD) test for further examination. T-test to determine where the deviations are coming from.

Results: On -way (ANOVA) test was used to analyses the results, the differences between the groups were statistically significant.

Conclusions: In this study, all surface treatments provided adequate surface roughness values compared with them, but (FE) and (DE) show smoother surface than (GE) .

1. Introduction

Since its production in 2013, VITA ENAMIC has been the sole commercially available PICN (VITA Zahnfabrik, Bad Säckingen, Germany). It is polymerized under high heat and pressure from a sintered, the matrix is composed of a polymer infiltration and a porous ceramic matrix (weighing in at 14% of the total). Enamic (VITA, Bad Säckingen, Germany) is a polymer-infiltrated ceramic network (PICN) material made using an innovative production method. The ceramic particles in this material were partially sintered before being infiltrated with a polymer with a low viscosity by capillary action. PICNs, in contrast to resin composites, are made up of two separate networks, each of polymer and ceramic [1]. Enamic (VITA, Bad Säckingen, Germany) is an advanced polymer-infiltrated ceramic network (PICN) material. In this material, ceramic particles are only partially sintered before being infiltrated with a low-viscosity polymer by capillary action. When compared to resin composites, PICNs are unique because they contain not only a single but two networks: polymer and ceramic [2].

The material can be suitable for in-chair dentistry because it does not need to be burned or sintered after milling. The manufacturer suggests using PICN for crowns (both traditional and implant-supported) on a single tooth, inlays, onlays, partial crowns, and veneers. The hardness of PICN materials is higher than that of composites, making them more wear-resistant, and their qualities are similar to dentin and enamel, according to a number of studies. Additionally, PICN materials generate less abrasion on opposing teeth surfaces than other dental ceramic materials [3]. There are a number

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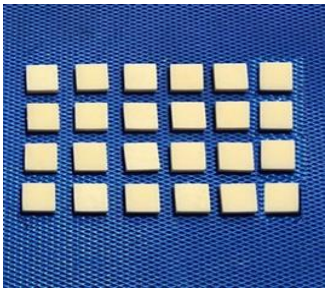
of benefits to using hybrid ceramics in dentistry .Using hybrid composite has several advantages such as, Milling hybrid materials is simple because no sintering is needed. The workflow has been improved as a result. Even though after final cementation, the restoration might be characterized and smoothed or polished. Hybrid ceramics have a modulus of elasticity that is closer to dentin than porcelain. As a result, it prevents the opposing teeth from grinding [4] . The CAD/CAM hybrid ceramic Vita Enamic is a product of VITA Zahnfabrik. Since the ceramic matrix (Feldspar) is combined with polymer networks (UDMA and TEGDMA) to form a dual network structure. A ceramic's high strength and resistance to wear are combined with the composite's flexibility to create a material that is highly fracture-resistant. When compared to natural teeth, Vita Enamic appears to have similar mechanical properties [5]. The surface roughness, gloss, and colour stability of the restorative material all play a role in the final appearance of the replaced teeth. Polishing and finishing the restoration materials is an important step that modifies all of these characteristics. It is usual practice to utilize optical and mechanical profilometers, as well as AFM (atomic force microscope) to evaluate the surface roughness of restorative materials [6].

2. Methods

In the present study, Twenty four (24) each measuring (3 millimeters in length, 8 millimeters in breadth, and 3 millimeters in height) (Figure 1) , samples of Enamic were divided to three subgroups according to the surface treatment used . Custom made holder was fabricated from cold cure acrylic resin to facilitate handling the sample during the process of polishing. this holder has the dimensions (2 cm × 2 cm × 2 cm) with hole in the center to place the sample and four grooves from every side to facilitated removing of sample after complete the finishing (Figure 2)



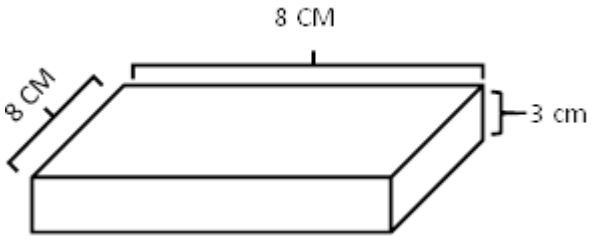


Figure 1. (a) samples of study, (b) sample dimensions

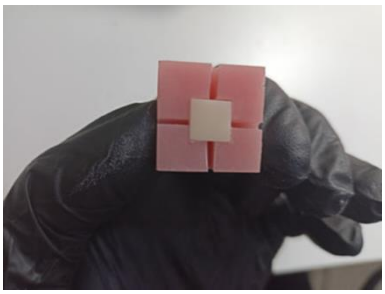


Figure 2. Custom made holder was fabricated from cold cure acrylic resin

1-Group FE : (8) Enamic samples were polished with special Enamic polishing kit (Figure 3) . In order to achieve a glossy finish, the surface was mechanically polished in two stages using the prescribed polishing set (Vita Enamic polishing set technical, VITA Zahnfabrik, Bad Sackingen, Germany), [4]. Under water cooling, samples were polished using a slow-speed handpiece spinning at 8000 rpm and applying light pressure. Each sample was polished in one direction for 15 seconds and then in the opposite direction for another 15 seconds, with the two directions at a 90 degree angle to one another, [2].

Figure 3. ***special Enamic polishing kit.***

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2-Group DE : (8) Enamic samples were polished with polishing kit and diamond paste (Figure 4). Diapol, a diamond polishing method designed specifically for porcelain, and Diapolisher, a diamond polishing paste, were used to achieve the desired surface finish. Following the manufacturer's instructions, a final high-gloss polish was done using diamond polishing paste and a Buff brush. Following the manufacturer's recommendations, this technique was carried out with a straight hand piece spinning at a low speed of 10.000 rpm, under mild pressure, and at a predetermined angle. Each phase of finishing and polishing took 15 seconds, and the polishing paste was left on for 20 seconds, [7].

Figure 4. ***(a) polishing kit and diamond paste, (b) during polishing***

3-Group GE : (8) Enamic samples were glazing with special Enamic glaze material , Brushes were used to apply the photo-cured glaze before being polymerized using LED lights (UV light box for light-curing) for 30 s (3200 mW/cm^2) (Figure 5) [8] .

Figure 5. ***(a)*** **UV light box for light-curing, (b) glazed samples during polymerization**

All of the sample surfaces were covered in an even, thin coating of glaze material using a disposable applicator brush (Vita Enamic Microbrush), and then it was subjected to polymerization with a dental led light source for 30 seconds. The accuracy of the polymerization can be confirmed by testing the surface after polymerization in order to be sure there is no adherence [4] .

Surface roughness measurement

The mean surface roughness profile (Ra) of each specimen's surface was determined. The specimens were protected by a unique metal stand . The holder was attached to a Profilometer (TR200, China) used to measure the roughness of a surface. And then each specimen was measured three times, and then the average Ra was used to describe the surface roughness of each sample [9, 10].

3.Result:

Statistical package for the social sciences (SPSS version 21) was used for statistical analysis, and the Excel programme was used to create charts and graphs from the data obtained.

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Surface roughness values of all samples (Ra) were measured in (Mm) . Minimum, maximum, averages, standard deviation, and standard error for Ra levels across all Enamic groups are displayed in Tables (1) and Figure (6), respectively. Table (1) shows that the (GE) group had the highest mean Ra levels, while the (DE) group had the lowest.

Table 1 *: Summary Statistics for the Micrometer (m) Surface Roughness Test Across All Groups.*

	N	Lower bound	Upper bound	Mean	SD
FE	8	0.50	0.55	0.5316	.00596
GE	8	0.70	0.76	0.7235	.00713
DE	8	0.49	0.55	0.5193	.00641

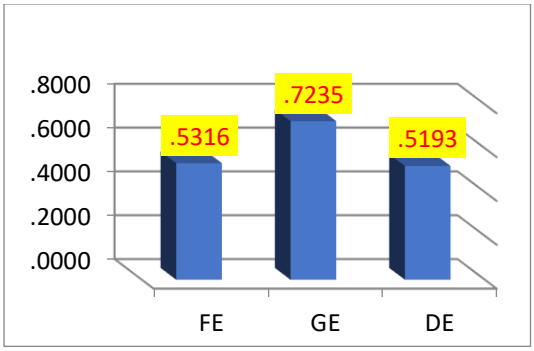

Figure 6. ***Bar chart Demostrating the Means Difference in roughness groups***

Table (2) shows that there is a statistically significant difference in roughness between the ENAMIC groups at the P0.001 level, as determined by a one-way ANOVA test.

Table 2 ***:Across-groups one-way analysis of variance (Surface roughness test)***

	F	P-value	Sig
Group to Group	8054.736	0.000	HS

*P<0.001 High significant

Table (3) further shows that while there was a highly significant difference between the (FE) and (GE) groups, there was no such difference between the (FE) and the (DE) groups.

Table 2: ***LSD between all groups of Surface roughness test.***

(I) VAR00014	(J) VAR00014	Mean Difference (I-J)	Std. Error	P-value	Sig
FE	GE	-.19188	.00800	0.000	HS
	DE	.01237	.00800	0.129	NS
GE	DE	.20425	.00800	0.000	HS

**P>0.05 Non significant
**P<0.001 High significant

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3. Discussion

Hybrid CAD/CAM materials, which feature the greatest qualities of both ceramic and composite materials, were compared with respect to their surface roughness in this study. Mechanical and physical properties of the material are enhanced through surface finishing techniques. Restorations with a glossy surface are more aesthetically pleasing since they more closely match natural teeth. Dental plaque develops up less frequently and is easier to remove from a flat surface. The surface of the restoration is glazed or polished to make it smoother and glossier [4] .

Effect of finishing on ENAMIC materials

The purpose of the finishing and polishing processes is to smooth out the rough edges left by the contouring and finishing techniques, thereby achieving the ideal anatomical shape and occlusion. Moreover, dental ceramic restorations need to have their surface roughness minimized so that they look better, are more durable, cause less damage on the opposing teeth, and generate less plaque. [2] . Multiple elements, including the substrate's structure and mechanical qualities, the abrasive particles' size and shape, and the binder's physical properties, contribute to the effectiveness of finishing and polishing equipment [4].

Greater roughness was observed in the ENAMIC glazed group (GE) compared to the FE and DE groups. Because the ceramic that makes up the bulk of this material has a higher lustre and smoother surface after being glazed than it does after being processed using conventional finishing and polishing methods, this may be the caseIt is preferable for materials with an interpenetrating network structure to have filler and network structure components with similar physical and mechanical properties. However, the network, being stronger and in the form of a mesh, sometimes stick around after the fillers have worn out and migrated elsewhere. As a result, the surface roughness rises, and the opposing tooth is abraded [4] .

Effect of diamond paste using on material

After the diamond burs had scratched the surface, a series of polishing products with progressively smaller abrasive particles were used. As a result, the material's surface is scratched to such a small degree that it is no longer visible to the naked eye. There was a significant increase in surface roughness across the entire surface, with all materials achieving values greater than 0.2 mm. Not applying the diamond paste after polishing with the diamond infused rubber wheels likely caused this surface roughness. Despite the fact that it's yet another operation, [11] have shown that the inclusion of a diamond polishing paste step is recommended to improve the surface smoothness [12]. Besides, the additional diamond paste application made after regular finishing and polishing reduced the surface roughness of al samples even more [6] . The research found that polishing led to significantly less rough surfaces. Polishing and glazing use different processes to achieve their smoothing effects. Polishing is associated with generating uniform particles and reducing roughness due to its capacity to remove defects and flaws from the treated surface. The application of a glaze made from low fusing glass coating seals microcracks, hides porcelain porosities, and softens the edges of surface cracks. Previous research into the roughness of dental ceramic surfaces indicated that the polishing procedure may be used to achieve surfaces as smooth as glazed ones. Similar to prior research, it was found in this study that the polishing method produced smoother surfaces than the glazing methods. The capacity of different finishing methods to diminish the depth and/or sharpness of key faults across different materials accounts for these variations. The study's findings suggest that polishing kits and disc systems are more effective than glazing at reducing the roughness of ceramic surfaces, and that polishing procedures can be employed to achieve a suitable smoothness of surfaces.

The results of polishing or glazing procedures and the likelihood of microstructural failures of constituent materials are affected by an extensive number of variables, including but not limited to the technicians' skill, the amount of pressure applied, the rotation speed of the grinders, the angle between the samples and the grinders, the length of polishing time, grain size, and glaze layer thickness. Surface roughness can also be significantly influenced by a number of other factors [13] .

Effect of glazing on ENAMIC materials

Glazing PICN ceramics, however, is nearly impossible because the polymer phase would be "melted" away

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during the fire process, rendering the ceramics useless [14]. For the ENAMIC glazing method, we used a resin-based light cure glaze substance to accomplish this. The glaze was applied using a disposable applicator brush to all of the sample surfaces in a thin, even layer without any wrinkles [4]. However, it is important to highlight that, in contrast to FE and DE, the PICN ceramic groups in the current research resulted in a rougher surface [14] . The discrepancy between our findings and those published by may be due to the different polishing methods employed in this investigation [7, 15], who discovered that a technical kit [silicon carbide pink rubber disc, grey] was superior to glazing when completing and polishing VITA Enamic restorations. The material is layered onto the surface in the form of glaze. The powder-liquid mixture is then brushed to the surface with a brush. Although a glossy appearance can be achieved by applying a glaze, a high roughness value may be the result if the glaze is not applied uniformly across the surface using a brush without properly mixing the powder into the liquid. The procedure of polishing is executed with no additional coating on top. This is why polishing can result in such low Ra levels. Our findings indicate that glazed hybrid materials had rougher surfaces than their polished counterparts [4] . The PICN surfaces were protected from damage by the polymeric glazing layer. These results agree with those found by [16] , who found that a glaze layer showed confirm in increasing the durability of characterization in hybrid ceramics. As a clinical are important PICN reduces when it comes into touch with antagonists found in enamel and other restorative materials [8]. Surface roughness is affected by a number of factors, including the ceramic material type and the polishing procedure used [17]. It has been suggested in some research [18, 19]. Having a surface as smooth as glass is the holy grail of finishing and polishing. VITA Enamic restorations that have been finished and polished with a technical kit have glazed surfaces instead of rough ones [7].

Atomic force microscope

One of the most reliable methods for assessing the topography and morphology of dental materials' surfaces is the atomic force microscope (AFM). In this investigation, the roughness parameters of the dental ceramics were calculated for two different scan sizes using the AFM topographic pictures produced. Glass ceramics, like all dental materials, rely heavily on surface roughness. Restorations' aesthetics and bacterial adhesion are both impacted by this. It has been found that ceramic restorations with a high roughness on the inner surface attach better to hard dental tissues and last longer. To avoid or lessen problems like plaque buildup, bacterial adhesion, gingival irritation, and secondary caries, the external surface of a dental ceramic restoration should be as smooth as feasible, [17]. Both AFM and profilometry are effective methods for characterising the surfaces of biomaterials. Although profilometry provided a less precise surface topography than the AFM, it was able to scan far more quickly. When the surface roughness was less than 0.2m, both methods yielded comparable results [18]. [4, 19] As part of our research, we used a profilometer and an atomic force microscope to quantify the roughness of ENAMIC surfaces that had been treated using a variety of surface finishing processes.

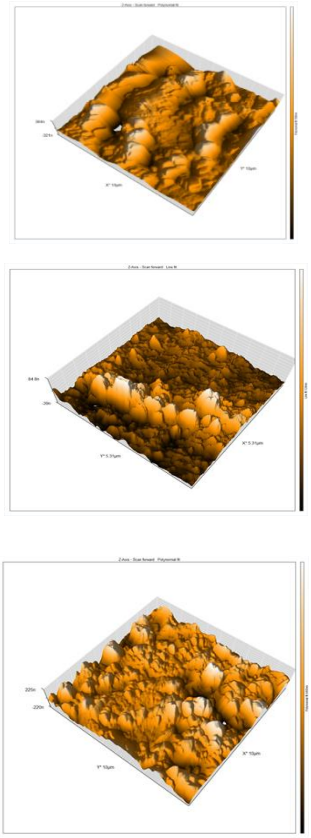

Figure 7.*(a) FE sample under AFM view ,(b) DE sample under AFM view ,(c) GE sample under AFM view*

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5. Conclusion

Instead of glazing, this study used a technical kit [silicon carbide pink rubber disc, grey] to finish and polish VITA Enamic restorations, resulting in a smoother material surface.

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Conflict of Interest

This study is part of master thesis in the college of health and medical technique at the Middle technical University .

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