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Comparative Evaluation of The Effect of Four Polishing Systems on The Surface Roughness and Translucency of Monolithic Zirconia - An In-Vitro Study

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Abstract

Introduction: Zirconia, an extensively used dental restorative material, when glazed, discourages plaque accumulation and duplicates natural tooth surface luster. Occlusal correction of Zirconia restorations leads to abrasive wear of the opposing dentition and an increased rate of plaque accumulation. Therefore, surface polishing is imperative for the long-term success of the prosthesis.

Aim: To compare the effect of four different polishing systems on the three-dimensional surface roughness and translucency of monolithic zirconia

Method: 55 monolithic zirconia specimens of A2 shade with dimensions of 14x14x2 mm were produced via Computer-Aided Design and Computer-Aided Manufacturing (CAD-CAM). A homogenous layer of Noritake Katana glaze was applied. The samples were divided into five groups. In Group 1, 11 glazed monolithic zirconia blocks were treated as the control group and tested for 3-dimensional surface roughness using a non-contact optical profilometer and translucency using a UV-Vis spectrophotometer. For groups 2, 3, 4, and 5, intraoral occlusal adjustments were simulated by removing the glaze layer with a diamond rotary instrument (MANI DIA BUR TR-11F) for 10 seconds in one direction by using a high-speed handpiece with water spray by a single operator. The samples were polished with IVOCLAR VIVADENT OPTRAFINE Polishing system, EVE DIACERA Polishing system, RENFERT Polishing system and

SHOFU Ceramic Finishing and Polishing Kit respectively, tested for 3-dimensional surface roughness using a micro-surface analyzer and a non-contact optical profilometer, and translucency using a UV-Vis spectrophotometer both before and after being polished.

Results: A statistically significant difference in translucency was observed between the test groups before and after polishing. A significant difference between the control group and the test groups post polishing was also observed. However, while there was no significant difference observed between the groups polished with Eve Diacera polishing system and Shofu Ceramic Finishing and Polishing Kit, it was significant between other groups. A statistically significant difference in surface roughness was observed between the test groups before and after polishing. A significant difference in the surface roughness between the control group and the test groups was also noted, with the exception of the group polished using the Renfert polishing system. A significant difference in surface roughness was observed between the test groups post polishing.

Conclusion: It was concluded that trimming of monolithic zirconia produced an increase in its surface roughness and a decrease in its translucency. All the polishing systems evaluated in the study produced a marked decrease in surface roughness and a marked increase in translucency. Renfert Polishing system produced the highest reduction of surface roughness of monolithic zirconia, followed by Ivoclar Vivadent Optrafine polishing system, Eve Diacera polishing system, and Shofu Ceramic Finishing and Polishing Kit. Renfert Polishing system produced the highest increase in translucency of monolithic zirconia, followed by Ivoclar Vivadent Optrafine polishing system, Eve Diacera polishing system, and Shofu Ceramic Finishing and Polishing Kit, with the latter two yielding comparable translucency values. Hence, amongst the polishing systems evaluated in this study, Renfert Polishing system demonstrated the most outstanding results in terms of both surface roughness and translucency.

Keywords: RENFERT, Plaque accumulation, Translucency, Monolithic zirconia, CAD-CAM.

Introduction

The term ‘zirconium’ is derived from the Arabic word zargon (golden in colour) which in turn comes from the two Persian words zar (gold) and gun (colour). Zirconia, the metal dioxide (ZrO_2), was identified in 1789 by German chemist Martin Heinrich Klaproth.[1] In 1975, Garvie proposed a model to rationalize the good mechanical properties of zirconia, by virtue of which it has been called ‘‘ceramic steel’’.[2]

In the past decade, zirconia-based ceramics have been successfully introduced into the dental clinic to fabricate fixed dental prostheses (FDPs), along with a computer-aided designing /computer-aided manufacturing (CAD/CAM) system.[3] New zirconia ceramics for dental restorations are continually under development, with a goal of maintaining mechanical integrity while improving translucency. The trend is toward monoliths, for greater longevity and avoidance of interfacial and residual stress issues.[4]

Zirconia has been used extensively as a restorative material in a variety of dental restorations because of its aesthetic properties, durability, and biocompatibility.[5] Glazed zirconia least encourages plaque accumulation, and duplicates natural tooth surface lustre and characterization. Glazing aims to seal the open pores on the surface of a fired porcelain. The adjustment of a porcelain restoration for occlusal or contour correction may lead to abrasive wear of the opposing dentition, increase the rate of plaque accumulation and may cause some reduction in the strength of a ceramic restoration. It may also lead to inflammation of the soft tissue it contacts.[6]

Rough zirconia surfaces have a greater surface area and therefore higher surface energy, causing the prosthesis to be more vulnerable to ageing and plaque accumulation in the intraoral environment. The surface of zirconia has a polycrystalline structure, which increases in opacity with increasing surface roughness because of the scattering effect. Increased opacity can decrease the aesthetics of the prosthesis. Therefore, appropriate surface polishing of monolithic zirconia prostheses is important for the long-term success of the prosthesis.[7] Chair-side polishing of all-ceramic restorations is efficient, easy for the clinician and eliminates repeated laboratory procedures.[8] Many clinicians prefer polishing instead of glazing to decrease the number of appointments and to control the surface luster.[5]

Although glazing is a popular method for restoring the high-gloss surface of the restoration, glazed layers can reportedly become worn within 6 months of the restoration. Polishing, however, does not add a layer to the surface of the monolithic zirconia restoration, and this method can produce a surface roughness of 0.2 µm, which is less than or equal to that achieved with glazing. Surface roughness of $\leq$ 0.2 µm provides minimal plaque accumulation and a comfortable tactile sensation.[9] Surface polishing can be subdivided into three major stages: coarse finishing, intermediate polishing, and final polishing. To achieve the desired smoothness, it is recommended that instruments be employed sequentially from coarse to fine with different revolutions per minute (RPM) for each step.[10]

There are a variety of methods currently used to detect the surface roughness induced, which include the visual approach (inspection with the naked eye), the liquid penetrant method, the magnetic particle method and the utilization of a profilometer. For the liquid penetrant method and the magnetic particle method, the surface to be inspected must be cleaned before inspection. Magnetic particle examination is only applicable to ferromagnetic materials. The material is magnetized and covered with fine magnetic particles, which are either sprinkled or poured on the surface in a thin oil. Discontinuities on or near the surface cause a leakage field to form, which acts as a tiny bar magnet. Small magnetic particles will therefore collect at the discontinuities, forming an indication that can be detected visually.[11] A profilometer is a device that measures a surface's profile to quantify its roughness. Profilometers can be divided into two basic types – contact and optical. Contact profilometers physically trace the surface with a stylus. The tip of the stylus of the contact profilometer rides in a line across the surface, moving vertically over the peaks and valleys. Changes in the stylus' height are registered, creating a measured profile. In contrast, optical profilometers use reflections of various types of light to measure surface features in a line or area. Optical profilometers include one-dimensional, two-dimensional and three-dimensional profiling devices. They are relatively large instruments consisting of a light source, optical lenses, and image sensors. Since light travels quickly, measurements can be taken faster than their mechanical stylus counterparts. Optical profilometers give an accurate non-contact method, providing measurement in the form of one-dimensional profiles.[12]

A major disadvantage of the optical profilometer is its inability to detect the roughness of a non-reflective surface. This can be overcome through the utilization of a Micro-Surface Analyzer (MSA), which operates on the principle of LASER (Light amplification by stimulated emission of radiation) Doppler Vibrometry. The MSA provides a non-contact mode of evaluation, with a high displacement high spatial resolution, and a high bandwidth. The surface roughness measurements thus obtained can also be readily transferred on to the optical profilometer software.[13]

Colour and translucency are two factors affecting the aesthetics of all-ceramic restorations, with the latter being of primary importance in aesthetics. To achieve an aesthetic appearance, the optical behaviour of translucent monolithic zirconia needs to be similar to that of the natural tooth.[11] Translucency, determined by a material's ability to transmit light, is influenced by the size and distribution of zirconia grains, fabrication processing, and additives used to enhance the colour and properties.[9]

Prior to cementation, occlusal interferences have to be eliminated by the clinician, which occurs as a chairside procedure and results in an irregular rough surface on the prosthesis, producing a diffuse light reflection, in contrast to a smooth surface. which may exhibit more specular reflection.[11]

Amongst the various instruments used to measure translucency, the spectrophotometer is considered to be nonpareil. It works by passing a light beam through an object to measure the light intensity of the object. The basic spectrophotometer instrument consists of a light source, a digital display, a monochromator, a wavelength sector to transmit a selected wavelength, a collimator for straight light beam transmission, a photoelectric detector, and a cuvette to place a sample. This device is used as an investigative tool to determine optical parameters such as translucency that are integral in achieving aesthetic, natural-looking restorations. [14]

In recent times, most clinicians have opted for polishing of occlusally corrected surfaces of zirconia restorations using commercially available polishing kits rather than sending the corrected prosthesis back to the laboratory for re-glazing. This results in a reduction in the number of patient appointments, thereby increasing patient satisfaction, and nearly simulating the result of glazing. Some of the polishing systems currently available in the market that are used by a majority of clinicians are the Ivoclar Vivadent Optrafine Polishing System, the Eve Diacera Polishing system, the Renfert Polishing system and the Shofu Ceramic Finishing and Polishing Kit. This study aims to simulate the chairside scenario pertaining to the loss of the glaze layer during occlusal adjustments of the zirconia restoration and to evaluate the effects of Ivoclar Vivadent Optrafine Polishing System, Eve Diacera Polishing system, Renfert Polishing system and Shofu Ceramic Finishing and Polishing Kit, on the 3-dimensional surface roughness and translucency of the zirconia restoration and compare it to that of glazed zirconia restoration, thereby revealing which of the four best simulates glazing, and is closest suited to achieve the least surface roughness and highest translucency.

Aim

To compare the effect of four different polishing systems on the three-dimensional surface roughness and translucency of monolithic zirconia.

Methodology

55 monolithic zirconia specimens of A2 shade with dimensions of 14x14x2 mm were produced via Computer Aided Design and Computer Aided Manufacturing (CAD-CAM). To ensure standardization, all specimens were abraded with a grinding machine at a constant speed of 3500 rpm with a silicon carbide bur for 20 seconds with water cooling. The thickness of the specimens was then measured with the help of a digital caliper. The specimens were cleaned using 99% alcohol for 3 minutes. A homogenous thin layer of Noritake

Katana glaze was applied to each surface of the specimen and fired in a VOP porcelain furnace. The samples were divided into five groups:

Group 1: Glazed Monolithic Zirconia Blocks (n=11)

11 glazed monolithic zirconia blocks of A2 shade were treated as the control group and tested for 3-dimensional surface roughness using a non-contact optical profilometer and translucency using a UV-Vis spectrophotometer.

For Groups 2, 3, 4 and 5

Intraoral occlusal adjustments were simulated by removing the glaze layer on both the front and back surface of the blocks with a fine grain diamond rotary instrument (MANI DIA BUR TR-11F) for 10 seconds in one direction by using a high-speed handpiece with water spray by a single operator.

Group 2: Monolithic Zirconia Blocks Polished With Ivoclar Vivadent Optrafine Polishing System (n=11)

11 monolithic zirconia blocks of A2 shade were polished with IVOCLAR VIVADENT OPTRAFINE Polishing system. The finishing of the zirconia surface was done using the light blue Finisher F bur, followed by polishing of the zirconia surface using the dark blue Polisher P bur, at a rotary speed of 10,000 to 15,000 rpm and copious water spray by a single operator. High gloss polishing was done at 10,000 to 15,000 rpm using the high-gloss brush, and no water spray was used here. These blocks were tested for 3-dimensional surface roughness using a micro-surface analyser and a non-contact optical profilometer, and translucency using a UV-Vis spectrophotometer both before and after being polished with the aforementioned polishing system.

Group 3: Monolithic Zirconia Blocks Polished With Eve Diacera Zirconia Polishing System (n=11)

11 monolithic zirconia blocks of A2 shade were polished with EVE DIACERA Polishing system. Finishing and polishing of the zirconia blocks was done by the coarse grit bur, followed by the medium grit bur and then the fine grit bur, at a rotary speed of 10,000 - 15,000 rpm without using a water spray. The blocks were tested for 3-dimensional surface roughness using a micro-surface analyser and a non-contact optical profilometer, and translucency using a UV-Vis spectrophotometer both before and after being polished with the aforementioned polishing system.

Group 4: Monolithic Zirconia Blocks Polished With Renfert Polishing System (n=11)

11 monolithic zirconia blocks of A2 shade were polished with RENFERT Polishing system. Firstly, pre-polishing with Renfert silicon polisher was done, followed by polishing to a high gloss finish using the Renfert Bison brush coated with Renfert diamond polishing paste at a rotary speed of 5000 – 10,000 rpm. In order to enhance the high gloss, Renfert cotton buff and a small amount of the diamond polishing paste was used under moderate pressure to avoid heat generation. A water spray was not used in this modality of polishing. The zirconia blocks were tested for 3-dimensional surface roughness using a micro-surface analyser and a non-contact optical profilometer, and translucency using a UV-Vis spectrophotometer both before and after being polished with the aforementioned polishing system.

Group 5: Monolithic Zirconia Blocks Polished With Shofu Ceramic Finishing and Polishing Kit (n=11)

11 monolithic zirconia blocks of A2 shade were polished with SHOFU Ceramic Finishing and Polishing Kit. Finishing and pre-polishing of the zirconia blocks was done by the ZiL Master Coarse bur followed by ZiL Master Medium bur at 10,000 – 15,000 rpm. Final polishing was done by the ZiL Master Fine bur at 10,000 to 15,000 rpm. A water spray was not used in this modality of polishing. The zirconia blocks were tested

for 3-dimensional surface roughness using a micro-surface analyser and a non-contact optical profilometer, and translucency using a UV-Vis spectrophotometer both before and after being polished with the aforementioned polishing systems.

Testing for 3-dimensional surface roughness

Following the removal of the glaze layer and prior to polishing the monolithic zirconia blocks, the specimens of the control group, i.e., Group 1, were subjected to testing of their 3-dimensional surface roughness using a non-contact optical profilometer, and Groups 2, 3, 4 and 5, were subjected to testing of their 3-dimensional surface roughness using a micro-surface analyser and a non-contact optical profilometer. Groups 2, 3, 4 and 5 were then polished with IVOCLAR VIVADENT OPTRAFINE Polishing System, EVE DIACERA Polishing system, RENFERT Polishing system and SHOFU Ceramic Finishing and Polishing Kit respectively. Subsequently, Groups 2, 3, 4 and 5 were again subjected to testing of their 3-dimensional surface roughness using a micro-surface analyser and a non-contact optical profilometer. Following this, the acquired 3-dimensional surface roughness parameters were compared.

Testing for translucency

Following the removal of the glaze layer and prior to polishing the monolithic zirconia blocks, Groups 2, 3, 4 and 5, along with the control group, i.e., Group 1, were subjected to testing of their translucency using a UV-Vis spectrophotometer. Groups 2, 3, 4 and 5 were then polished with IVOCLAR VIVADENT OPTRAFINE Polishing system, EVE DIACERA Polishing system, RENFERT Polishing system and SHOFU Ceramic Finishing and Polishing Kit respectively. Subsequently, Groups 2, 3, 4 and 5 were again subjected to testing of their translucency using the UV-Vis spectrophotometer. The translucency parameters were acquired from the haze values derived through the UV-Vis spectrophotometer. Following this, the acquired translucency parameters were compared.

Result

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. Results on continuous measurement are presented as Mean±SD and categorical as frequency (percentage). The Analysis of Variance test (ANOVA) compared continuous measurements between the groups. Posthoc Tukey-HSD tests are used to compare two groups. A p-value less than 0.05 was considered statistically significant.

Table 1: Comparison of Haze between the control group and the test groups before and after polishing

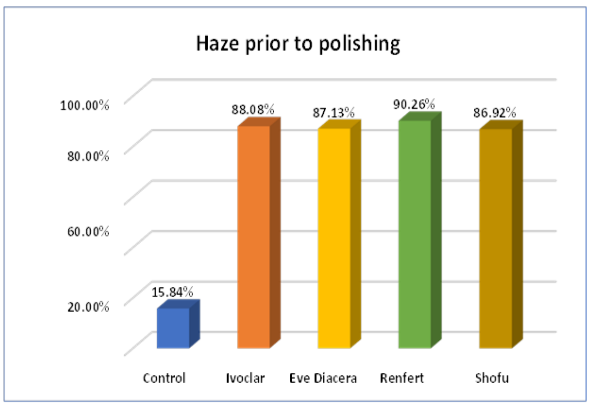
Haze	Group	N	Mean ± SD	Minimum	Maximum	F, p-value
Before polishing	Control	11	15.84%±2.30%	12.52%	18.95%	1508.77, 0.001*
	Ivoclar	11	88.08%±1.44%	85.62%	90.50%	
	Eve Diacera	11	87.13%±3.14%	83.32%	90.46%	
	Renfert	11	90.26%±2.21%	87.83%	94.17%	
	Shofu	11	86.92%±4.01%	79.38%	90.40%	
After polsishing	Control	11	15.84%±2.30%	12.52%	18.95%	113.02, 0.001*
	Ivoclar	11	31.18%±1.33%	28.64%	32.91%	
	Eve Diacera	11	43.55%±2.69%	39.63%	47.06%	

	Renfert	11	24.37%±1.87%	21.98%	28.02%	
	Shofu	11	45.15%±7.65%	22.53%	51.11%	
Difference (Before polishing – After polishing)	Control	11	0.00%±0.00%	0.00%	0.00%	379.29, 0.001*
	Ivoclar	11	56.90%±1.68%	54.50%	59.44%	
	Eve Diacera	11	43.58%±4.57%	37.96%	50.04%	
	Renfert	11	65.89%±2.56%	61.90%	69.52%	
	Shofu	11	41.77%±7.91%	31.68%	62.38%	

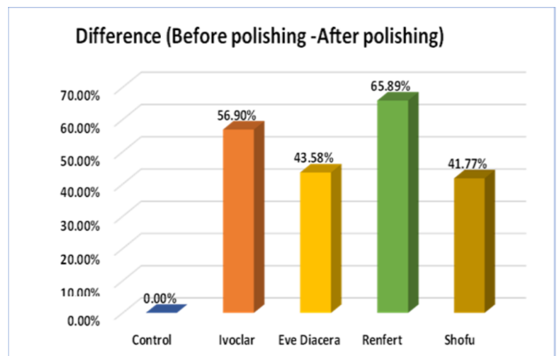
*Statistically significant

Inference: A significant difference was observed between the groups for haze before and after polishing.

Graph 1:



Graph 3:



Graph 2:

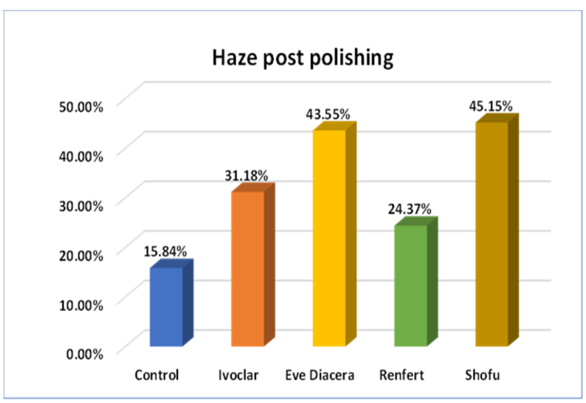


Table 2: Comparison of post-polishing haze values between the control group and the test groups.

Group	Group	Mean Difference	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Ivoclar	-15.34%	1.66%	0.001*	-20.05%	-10.63%
	Eve Diacera	-27.71%	1.66%	0.001*	-32.42%	-23.00%
	Renfert	-8.52%	1.66%	0.001*	-13.23%	-3.81%
	Shofu	-29.31%	1.66%	0.001*	-34.02%	-24.60%

*Statistically significant

Inference: A significant difference between the control and other groups for haze values was observed.

Table 3: Comparison of post-polishing haze values between the test groups.

Group	Group	Mean Difference	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Ivoclar	Eve Diacera	-12.37%	1.66%	0.001*	-17.08%	-7.65%
	Renfert	6.81%	1.66%	0.001*	2.10%	11.52%
	Shofu	-13.97%*	1.66%	0.001*	-18.68%	-9.26%
Eve Diacera	Ivoclar	12.37%*	1.66%	0.001*	7.65%	17.08%
	Renfert	19.18%*	1.66%	0.001*	14.47%	23.89%
	Shofu	-1.60%	1.66%	0.871*	-6.31%	3.10%
Renfert	Ivoclar	-6.81%*	1.66%	0.001*	-11.52%	-2.10%
	Eve Diacera	-19.18%*	1.66%	0.001*	-23.89%	-14.47%
	Shofu	-20.78%*	1.66%	0.001*	-25.49%	-16.07%
Shofu	Ivoclar	13.97%*	1.66%	0.001*	9.26%	18.68%
	Eve Diacera	1.60%	1.66%	0.871*	-3.10%	6.31%
	Renfert	20.78%*	1.66%	0.001*	16.07%	25.49%

*Statistically significant

Inference: No significant difference was observed between the Eve Diacera and Shofu groups, while it was significant between other groups.

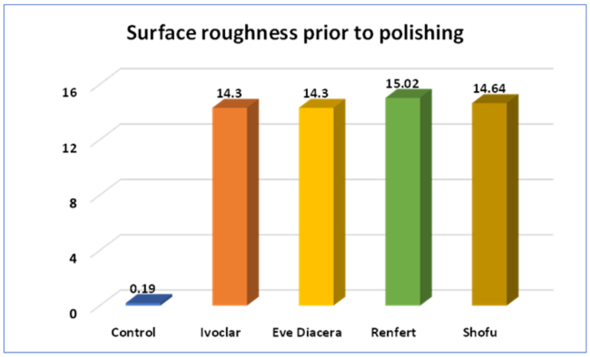
Table 4: Comparison of surface roughness between the control group and the test groups before and after polishing

Surface roughness	Group	N	Mean ± SD	Minimum	Maximum	F, p-value
Before polishing	Control	11	0.19±0.01	0.17	0.21	404.45, 0.001*
	Ivoclar	11	14.30±0.65	13.31	15.37	
	Eve Diacera	11	14.30±0.76	13.03	15.33	
	Renfert	11	15.02±1.57	13.18	17.52	
	Shofu	11	14.64±1.47	12.71	17.38	
After polishing	Control	11	0.19±0.01	0.17	0.21	316.43, 0.001*
	Ivoclar	11	0.86±0.18	0.46	1.07	
	Eve Diacera	11	1.57±0.32	0.93	1.87	
	Renfert	11	0.37±0.07	0.31	0.51	
	Shofu	11	2.82±0.24	2.48	3.14	
Difference	Control	11	0.00±0.00	0.00	0.00	359.85, 0.001*
	Ivoclar	11	13.44±0.68	12.52	14.73	
	Eve Diacera	11	12.73±0.65	11.61	13.61	
	Renfert	11	14.64±1.61	12.81	17.21	
	Shofu	11	11.82±1.41	9.88	14.25	

*Statistically significant

Inference: A significant difference was observed between the groups for surface roughness before andafter polishing.

Graph 4:



Graph 5:

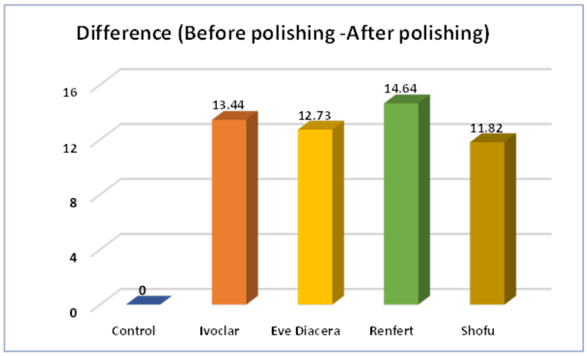


Table 5: Comparison of post polishing surface roughness values between the control group and the test groups.

Group	Group	Mean Difference	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Ivoclar	-0.66	0.08	0.001*	-0.90	-0.42
	Eve Diacera	-1.37	0.08	0.001*	-1.61	-1.13
	Renfert	-0.17	0.08	0.237	-0.41	0.06
	Shofu	-2.62	0.08	0.001*	-2.86	-2.38

*Statistically significant

Inference: There was a significant difference between the control groups and test groups for surface roughness except the Renfert group.

Table 6: Comparison of post polishing surface roughness values between the test groups.

Group	Group	Mean Difference	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Ivoclar	Eve Diacera	-0.71	0.08	0.001*	-0.95	-0.47
	Renfert	0.48	0.08	0.001*	0.24	0.72
	Shofu	-1.96	0.08	0.001*	-2.20	-1.72
	Ivoclar	0.71	0.08	0.001*	0.47	0.95

Eve DIACERA	Renfert	1.20	0.08	0.001*	0.95	1.44
	Shofu	-1.24	0.08	0.001*	-1.48	-1.00
Renfert	Ivoclar	-0.48	0.08	0.001*	-0.72	-0.24
	Eve Diacera	-1.20	0.08	0.001*	-1.44	-0.95
	Shofu	-2.44	0.08	0.001*	-2.68	-2.21
Shofu	Ivoclar	1.96	0.08	0.001*	1.72	2.20
	Eve Diacera	1.24	0.08	0.001*	1.00	1.48
	Renfert	2.44	0.08	0.001*	2.20	2.68

*Statistically significant

Inference: Significant difference was observed between the test groups for post polishing surfaceroughness values.

Discussion

Zirconia-based ceramics have been largely used as a dental restorative material over the past decade.[5] Monolithic zirconia crowns are fabricated from a single, unbroken block of zirconia, and are known for their longevity and avoidance of interfacial and residual stress.[4] Zirconia restorations that have been glazed encourage the least amount of plaque accumulation and duplicate the luster of a natural tooth surface. Adjusting a glazed zirconia restoration for occlusal or contour correction results in the abrasive wear of the opposing dentition, an increase in the rate of plaque accumulation, and inflammation of the soft tissue it contacts. Surface roughness, which refers to the irregularities or micro-features on the surface of a material, directly affects the manner in which light interacts with the material. Translucency, on the other hand, describes the ability of a material to permit the passage of light through it. Reflection haze is an optical phenomenon associated with high gloss surfaces, with its measurement describing the amount of light scattered when light passes through a transparent sample. The lower the haze measurement value, the higher the translucency of the sample. Translucency parameter is therefore a proxy variable of the haze value.

Rough zirconia surfaces cause more antagonistic tooth wear than polished surfaces, cause the prosthesis to become more vulnerable to aging in the intraoral environment, and are more prone to plaque accumulation. When roughness increases, the wear of opposing enamel increases, as does restoration discoloration, staining, and plaque and calculus formation. Additionally, an increase in the surface roughness of zirconia increases its opacity due to the scattering effect of the light incident on it, which decreases the aesthetics of the prosthesis. The tongue can sense roughness changes above 0.3 mm; therefore, patient comfort may be negatively affected by an excessively rough restoration surface. Polished zirconia causes less antagonistic enamel wear and has a more satisfactory soft tissue reaction.[7] The objective of polishing, hence, is to obtain an acceptable contour and occlusion, a healthy embrasure, and a smooth restorative surface.[56]

Different polishing kits are marketed with the purpose of eliminating irregularities and achieving smooth surfaces. Chair-side polishing of all-ceramic restorations is not only an efficient and easy method for a clinician, but also eliminates repeated laboratory procedures.[8] Several recent studies have suggested that a polished surface may be as acceptable as a glazed surface.[5]

An in-vitro experiment study was performed to simulate the chairside scenario pertaining to the loss of the glaze layer during occlusal adjustments of the zirconia restoration, and evaluate the effects of the different polishing systems on the 3-dimensional surface roughness and translucency of the zirconia restorations and compare it to that of glazed zirconia restorations. 55 monolithic zirconia specimens of A2 shade with dimensions of 14x14x2 mm were produced via Computer Aided Design and Computer Aided Manufacturing (CAD-CAM), and a homogenous thin layer of Noritake Katana glaze was applied to each surface of the specimens and fired in a VOP porcelain furnace. These samples were then categorized into five groups, namely, groups 1, 2, 3, 4 and 5, with each group comprising of 11 samples. In group 1, the 11 glazed monolithic zirconia blocks of A2 shade were treated as the control group and tested for 3-dimensional surface roughness using a non-contact optical profilometer and translucency using a spectrophotometer. In groups 2, 3, 4 and 5, intraoral occlusal adjustments were simulated by removing the glaze layer on both the front and back surface of the blocks with a fine grain diamond rotary instrument (MANI DIA BUR TR-11F) for 10 seconds in one direction by using a high-speed handpiece with water spray by a single operator, and were subjected to testing of their 3- dimensional surface roughness using a micro-system analyzer and a non-contact optical profilometer, and testing of their translucency using a spectrophotometer. Groups 2, 3, 4 and 5 were then subjected to polishing using Ivoclar Vivadent Optrafine polishing system, Eve Diacera polishing system, Renfert Polishing system, and Shofu Ceramic Finishing and Polishing Kit respectively. Subsequently, Groups 2, 3, 4 and 5 were again subjected to testing of their 3-dimensional surface roughness using the micro-system analyzer and a non-contact optical profilometer, and testing of their translucency using a spectrophotometer. Following this, the acquired 3-dimensional surface roughness and translucency parameters were compared.

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. The Analysis of Variance test (ANOVA) compared continuous measurements between the groups. Posthoc Tukey-HSD tests were used to compare two groups. In terms of the surface roughness evaluation, a significant difference was observed between the test groups, i.e., Groups 2, 3, 4 and 5, before and after treatment with the polishing systems. This indicated that in all the groups, after occlusal correction of the zirconia restoration, there was an increase in the surface roughness, and this surface roughness was reduced after polishing. This was in accordance with an in-vitro study that evaluated the efficiency of manual polishing over auto-glazed and overglazed porcelain and their effect on plaque accumulation. Thirty-six porcelain discs were fabricated out of which 18 each was subjected for auto-glazing and overglazing. Half surface of the discs was left intact; the remaining half was roughened with medium grit diamond bur. Roughened surfaces were repolished by porcelain polishing kits (Shofu, DFS, Eve). It was concluded that plaque accumulation percentage was the highest on roughened surface, followed by porcelain discs polished by commercial kits. While auto-glazed surfaces were found have the least plaque accumulation, all the polishing kits used in the study reduced the average roughness by approximately 77%.[32]

Upon comparison of the surface roughness between the control group and test groups post polishing, a significant difference was noted between all groups except Group 4, i.e., the test group polished using the

Renfert Polishing System. This indicated that polishing with the Renfert Polishing System resulted in a zirconia surface with surface roughness closest to that manifested by the glaze layer, when compared to the Ivoclar Vivadent Optrafine polishing system, Eve Diacera polishing system and Shofu Ceramic Finishing and Polishing Kit. This was in congruence with a study that evaluated and compared the effect of surface treatment (glazing, polishing with rubber wheel and diamond paste, and polishing with rubber wheel) on pressable porcelain (IPS Emax porcelain) surface roughness in comparison with non-treated surface. Forty-disc shaped specimens of pressable ceramic with 10 mm diameter and 2 mm thickness were prepared and divided randomly into four groups: Group A: no surface treatments, Group B: glazing (paste, HT, Ivoclar, Vivadent, Germany), Group C: polishing with burs (DIAPRO TWIST, EVE, GmbH, Germany), and Group D: polishing with burs (DIAPRO TWIST, EVE, GmbH, Germany) and diamond paste (All in one, RENFERT, GmbH, Germany). For each specimen, the examination of mean roughness profile was performed, and it was noted that group D (Polishing with burs and the All-in-one RENFERT polishing paste) produced the lowest mean surface roughness value.[57]

A significant difference was also observed in the surface roughness values given amongst the test groups post polishing, with Group 5 manifesting the highest surface roughness, followed by Group 3, Group 2 and Group 4. This demonstrated that after occlusal correction, polishing of a zirconia restoration using the Shofu Ceramic Finishing and Polishing Kit produced the least degree of elimination of the induced surface roughness, followed by the Eve Diacera polishing system, the Ivoclar Vivadent Optrafine polishing system and the Renfert Polishing system in a subsequent order. This was in conformance with a study that evaluated the effect of different polishing systems on the surface roughness of dental ceramics. Sixty square specimens (2×14×14 mm) of 3 ceramic systems (monolithic zirconia and feldspathic-based ceramic containing feldspar and fluorapatite) were prepared, glazed, and assigned to 1 of the 5 groups: a control group with no additional treatment after the glaze; in the other groups, the glaze layer was removed, and the surfaces were polished by using 4 different ceramic polishing systems (OptraFine, Shofu, Meisinger, or Komet). The surface roughness was evaluated, and it was noted that polishing of the ceramic surface using the Shofu polishing kit led to the least satisfactory elimination of surface roughness.[58]

Although polished ceramics have been reported to have similar surface roughness to glazed ceramic in various studies, the surface roughness values of the polished specimens have been reported to change depending on the polishing system, rotation speed of the device, the duration and amount of applied pressure, and the presence or absence of water during finishing. The difference in the performance of each polishing system might be explained by variations in the diamond particle type (natural or synthetic), the particle shape, particle size, density, or binding material. When polishing with diamond paste is used as the final step, polished ceramic specimens have been reported to have smooth surfaces comparable with those of glazed specimens, which is consistent with the present study in which RENFERT polishing paste was used. This is in consonance with another study that assessed the ceramic surface smoothness achieved with various commercially available ceramic polishing kits on different commonly used ceramic systems. A total of 350 ceramic surfaces representing 5 commonly available ceramic system (IPS

Empress Esthetic, IPS e. max Press, Cergo Kiss, Vita PM 9, Imagine Press X) were treated with 5 types of ceramic polishing systems (Cerapreshine, 94006C, Ceramiste, Optrafine, Zenostar) by following the manufacturer's guidelines. The surface roughness was measured with a profilometer and it was concluded that the use of a polishing paste was recommended to improve surface smoothness.[38]

In terms of the translucency parameter evaluation, a significant difference was observed between the test groups, i.e., Groups 2, 3, 4 and 5, before and after treatment with the polishing systems. This indicated that in all the groups, after occlusal correction of the zirconia restoration, there was a decrease in the translucency, and this translucency increased after polishing. This is in accordance with a study that evaluated the effect of polishing and glazing on the translucency and spectral distribution of monolithic zirconia. Forty-five monolithic zirconia specimens (16.3 mm × 16.4 mm × 2.0 mm) were fabricated and divided into 5 groups according to the number of A2-coloring liquid applications (Group I to V). Each group was divided into 3 subgroups according to the method of surface treatments (n=3): N: no treatment; P: polishing; G: glazing. Translucency and spectral distribution of five different areas of each specimen were measured according to CIELAB colour space in the reflectance mode relative to the standard illuminant D65 on a reflection spectrophotometer. It was concluded that an increase in translucency could be detected after polishing of monolithic zirconia.[33]

Upon comparison of the translucency between the control group and the test groups post polishing, a significant difference was noted. This indicated that despite an increase in translucency of an occlusally corrected zirconia restoration post polishing with polishing kits, the translucency garnered by a glazed zirconia restoration would always be unsurpassed. This was in accordance with a study that evaluated the effect of polishing pastes on the roughness and translucency of lithium disilicate ceramic. Sixty specimens were obtained from e. max CAD blocks. After ground finishing, each specimen was glazed and randomly divided into one of five groups, including one control group, and were then polished with one of four types of polishing pastes. The groups were group A (Nupro coarse), group B: (Nupro medium), group C (Nupro fine), group D (Cleanic), and one control group. Specimens were polished with these pastes for 2 minutes with a prophy cup mounted on the handpiece under a constant load of 400 gr at 3,000 rpm. The surface roughness and translucency parameters were then measured using a surface profilometer and a dental spectrophotometer respectively. The control group demonstrated a significantly higher translucency compared with the other groups. However, the polishing pastes produced a significant reduction in surface roughness, and improved the translucency of the samples.[59]

A significant difference was also observed in the translucency values given amongst the test groups post polishing, with the exception of Groups 3 and 5, which had comparable translucency values. It can hence be inferred that following occlusal corrections executed on a zirconia restoration, polishing with the Renfert Polishing system provides the most favourable translucency values, followed by the Ivoclar Vivadent Optrafine Polishing system, the Eve Diacera Zirconia Polishing system, and finally, the Shofu Ceramic Finishing and Polishing Kit, with the latter two polishing systems having comparable translucency values and producing the least favourable translucency amongst the polishing systems tested. It can hence be inferred from the aforementioned results that amongst the polishing systems tested, the Renfert Polishing system contributed towards the highest reduction of surface roughness, followed by the Ivoclar Vivadent Optrafine Polishing system, the Eve Diacera Zirconia Polishing system, and finally the Shofu Ceramic Finishing and Polishing Kit, with the latter contributing the least towards the elimination of surface roughness.

Additionally, the Renfert Polishing system provided the most favourable translucency values, followed by the Ivoclar Vivadent Optrafine Polishing system, the Eve Diacera Zirconia Polishing system, and finally, the Shofu Ceramic Finishing and Polishing Kit, with the latter two polishing system having comparable translucency values and producing the least favourable translucency amongst the polishing systems tested. However, neither of the zirconia polishing systems provided a better surface roughness or translucency than glazing.

The limitations of this study included that only a limited number of polishing kits were tested. Additionally, the polishing procedures performed by a single operator using finger pressure with rotational and linear motions were not entirely standardized, because although the manufacturers' guidelines were available, it was difficult to polish consistently with the same pressure, speed and number of cycles. A custom device to ensure polishing at a consistent load is recommended for future studies. Moreover, this study was in-vitro in nature and was consequently not an accurate reproduction of what may happen in the oral cavity. The influence of saliva, food, temperature changes and pH changes were not considered. Therefore, large-scale clinical prospective trials will be required to confirm the results of this study.

Conclusion

Adjustment of a glazed zirconia restoration for occlusal or contour correction results in an increased surface roughness, which brings about wear of opposing enamel, discoloration of the restoration, plaque and calculus formation, and an increase in opacity due to scattering of the light incident on it. Therefore, chair-side polishing of the zirconia restorations is preferred as it is efficient, easy, and eliminates the need to send the restoration back to the laboratory for re-glazing. Additionally, recent studies suggest that a polished surface may be as acceptable as a glazed surface.

Within the limitations of this study, it was concluded that:

- Trimming of monolithic zirconia produced an increase in the surface roughness.
- All polishing systems produced a marked decrease in the surface roughness of the monolithic zirconia.
- Renfert Polishing system produced the highest reduction of surface roughness of monolithic zirconia, followed by the Ivoclar Vivadent Optrafine polishing system, the Eve Diacera polishing system, and the Shofu Ceramic Finishing and Polishing Kit.
- Trimming of monolithic zirconia produced a decrease in the translucency.
- All polishing systems produced a marked increase in the translucency of the monolithic zirconia.
- Renfert Polishing system produced the highest increase in translucency of monolithic zirconia, followed by the Ivoclar Vivadent Optrafine polishing system, the Eve Diacera polishing system, and the Shofu Ceramic Finishing and Polishing Kit in a subsequent order, with the latter two polishing systems yielding comparable translucency values.
- Hence, amongst the polishing systems evaluated in this study, Renfert Polishing system demonstrated

the most outstanding results in terms of both surface roughness and translucency, followed by the Ivoclar Vivadent Optrafine polishing system, the Eve Diacera polishing system, and the Shofu Ceramic Finishing and Polishing Kit in a subsequent order.

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Legend Figures

Figure 1: Armamentarium Used in the Study

Figure 2: Glazed CAD/CAM Fabricated Monolithic Zirconia Blocks

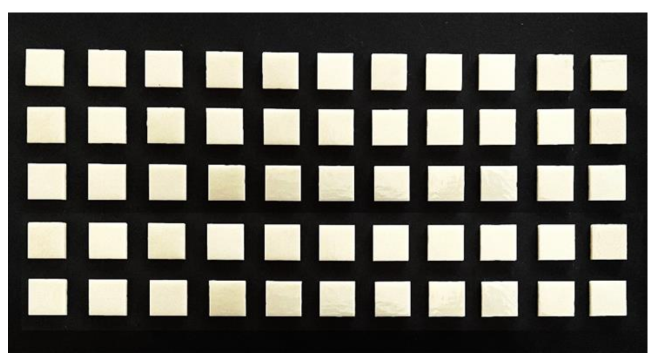

Figure 3: Digital Calipers Demonstrating the Dimensions of the Monolithic Zirconia Samples (14*14*2 Mm)

Figure 4: Monolithic Zirconia Samples Categorised Into Groups

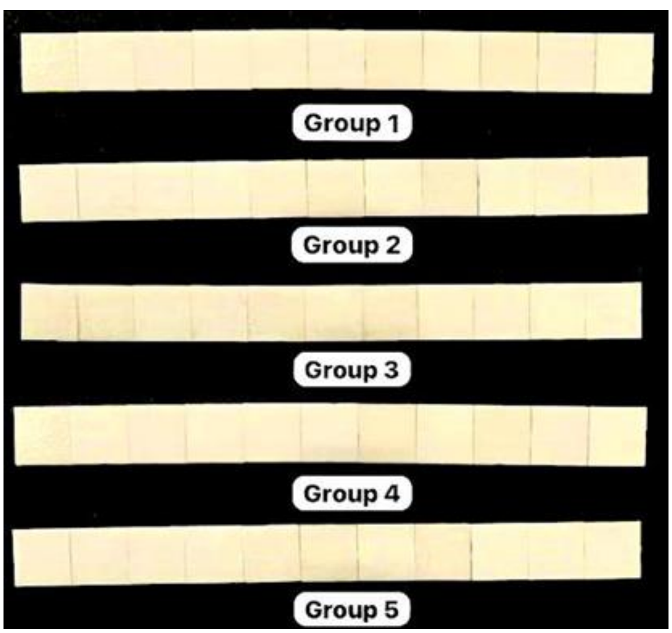

Figure 5: Simulation of Occlusal Correction Using A Mani Dia Tr-11f Bur

Figure 6: Pre-Polishing Surface Roughness Evaluation Using Micro-Surface Analyser and Non-Contact Optical Profilometer

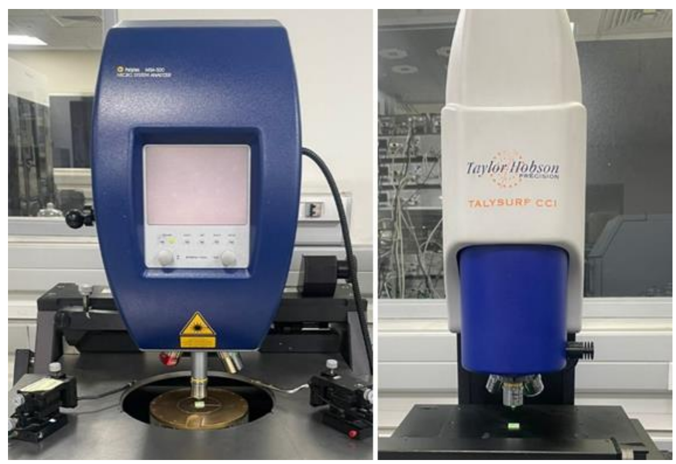

Figure 7: Pre-Polishing Translucency Analysis Using Uv-Vis Spectrophotometer

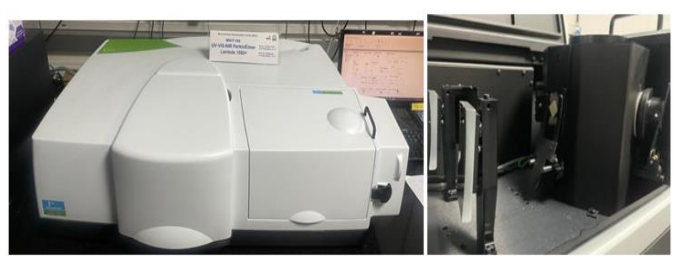

Figure 8: Ivolcar Vivadent Optragloss Polishing Paste

Figure 9: Finishing Using the Ivolcar Vivadent Optragloss Light Blue Finisher F Bur

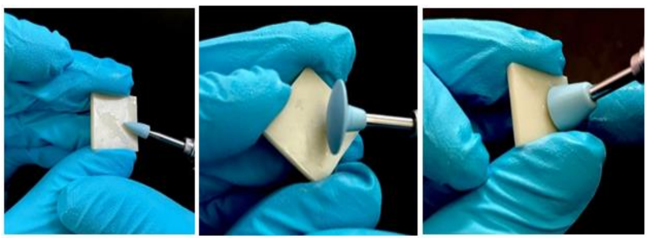

Figure 10: Polishing Using the Ivolcar Vivadent Optragloss Dark Blue Polisher P Bur

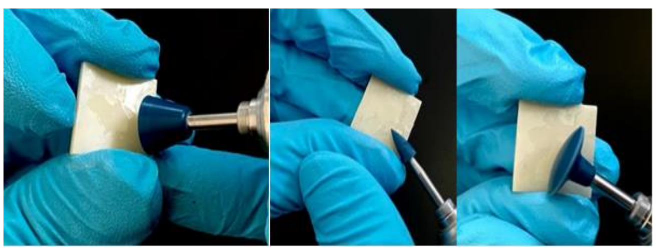

Figure 11: High Gloss Polishing Using the Ivolcar Vivadent Optragloss High Gloss Brush

Figure 12: Eve diacera zirconia polishing system

Figure 13: Finishing using the eve diacera coarse grit bur

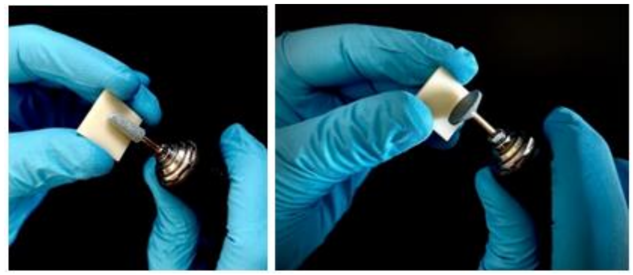

Figure 14: Polishing using the eve diacera medium grit bur

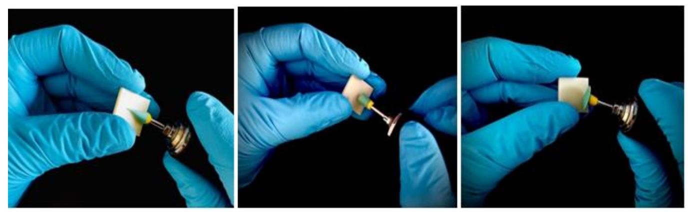

Figure 15: Polishing using the eve diacera fine grit bur

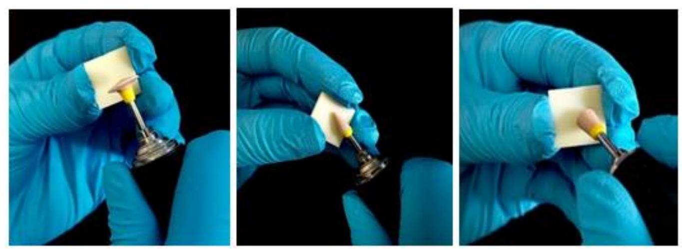

Figure 16: Renfert polishing system

Figure 17: Pre-polishing using renfert silicone polisher

Figure 18: Polishing using renfert bison brush coated with renfert diamond polishing paste

Figure 19: High gloss polishing using renfert cotton buff coated with renfert diamond polishing paste

Figure 20: Shofu ceramic finishing and polishing kit

Figure 21: Pre-polishing using the shofu zilmaster coarse bur

Figure 22: Finishing using the shofu zilmaster medium bur

Figure 23: Polishing using the shofu zilmaster fine bur

Figure 24: Post polishing surface roughness evaluation using micro-system analyser and non-contact optical profilometer.

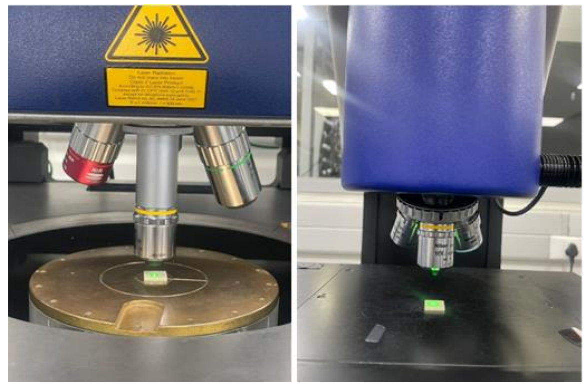

Figure 25: Post polishing translucency analysis using uv-vis spectrophotometer.