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Influence of Finishing Procedures on Surface Roughness and Biaxial Flexural Strength of High-translucent 4Y-PSZ, 5Y-PSZ, and 6Y-PSZ Monolithic Zirconia

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ABSTRACT

Objective: This study aims to investigate the effects of glazing, polishing and polishing with a polishing paste of newly developed highly translucent materials on the flexural strength of these materials and aims to illuminate where there is not much study yet on the finishing procedures to be done.

Methods: Three different high translucency Y-PSZ (Yittria partially stabilized zirconia): KST (Katana STML), KUT (Katana UTML), NCQ (Nacera Pearl Q3 Multi-Shade) and one translucent 3Y-TZP (3-yttria stabilized tetragonal zirconia polycrystalline): NCMS (Nacera Pearl Multi-Shade) zirconia system were used. A total of 120 specimens were prepared in the form of discs with a diameter of 14 mm and dimensions of 1.2 ± 0.2 mm. Three experimental groups (n = 30) were formed from each type of material, using three finishing protocols: Diamond Polishing system (DP); Diamond Polishing system followed by Polishing Paste (PP); Glaze Application (GP). Surface Roughness (Ra) was measured by using a contact profilometer, and a biaxial flexural strength test was applied to determine their flexural strength. The obtained data were analyzed using the Weibull distribution. All results were evaluated statistically.

Results: For Ra values, there was a statistical difference between all the procedures applied in the KST material as in the NCQ material. However, there was no statistical difference between GP and PP procedures in Ra values in the NCMS material and between DP and PP procedures in the KUT material. The characteristic strengths of DP applied to NCMS and NCQ material, PP applied to KST, and KUT material had the highest value. The highest m values for DP were determined in KST, NCMS, NCQ materials, while in KUT material, PP was determined in the finishing procedure.

Conclusion: Finishing procedures have significant effects on surface roughness and flexural strength values for translucent zirconia materials. The lowest Ra value and the highest flexural strength were found in the DP group of NCMS. In KST and KUT materials, the highest flexural strength results were found in the PP procedure while NCQ was not affected by finishing procedures.

Keywords: Translucent zirconia, monolithic, surface roughness, biaxial flexural strength

1. INTRODUCTION

Yttria stabilized tetragonal zirconia polycrystalline (Y-TZP) have become superior in use in dental restorations due to their excellent mechanical properties (1,2). Zirconia is a polymorphic material that can be found in three different phases: monoclinic (m), tetragonal (t), and cubic (c) (2,3). External stresses such as grinding, sandblasting, polishing, and low-temperature degradation can stimulate the t-m phase transformation of Y-TZP. This conversion causes 3 – 4% volume expansion which seals the crack tip and prevents further crack propagation. However, this protective effect is not fixed and predictable (4). This transformation can also be triggered by occlusal adjustments such as airborne particles, polishing, and grinding. In addition, Y-TZP can be degraded by the t→m transformation, which can occur spontaneously in humid environments. This phenomenon is called low-temperature degradation and begins at minor surface defects (1). Also, the biggest disadvantage of Y-TZP is its high opacity (5). Translucent monolithic zirconias have been developed to solve these problems (6).

New methods were used to improve Y-TZP; increasing the amount of yttria by adding cubic phase zirconium; decreasing the amount of Al_2O_3 from 0.25% to 0.1% by weight; adding 0.2 mol% La2O3 to Y-TZP is to change the sintering time and temperature, and reduce the grain size, which can increase the translucency of zirconia (7-9). However, increased yttria content inhibited the transformation hardening mechanism and affected flexural strength (9-12).

The microstructure difference between conventional zirconia and partially stabilized zirconia (PSZ) was due to the amount

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of cubic phase in their content. 3Y-TZP consisted of ~20% by weight cubic zirconia, while PSZ stabilized with 4-6% mol yttria contained 40−70% by weight cubic zirconia (8). Cubic zirconia was non-birefringent (6) and did not undergo phase transformation under stresses and water conditions (13).

Occlusal adjustment may be required to obtain an occlusal relationship. Due to the hardness of zirconium, adjustments were usually made with diamond burs, which affected the uppermost glaze layer and the original smoothness of the surface. When monolithic zirconia was exposed to the oral environment in this way, saliva and other factors could disrupt the structure of the zirconia restoration (1). Occlusal adjustment caused more stress on the surface indirectly increasing the deterioration of the material and reducing its aesthetics and longevity (14). Therefore, if zirconia is to be used monolithic, it is important that it is well polished (15).

Various techniques have been advanced to restore the smoothness and gloss of monolithic zirconia surfaces, such as grinding, polishing, polishing with diamond rubber polishers, and the use of fine diamond burs. Considering the benefits of a polished surface, some polishing procedures can lead to the improvement of the cracks that can weaken the structure (14). Khayat et al. reported that the polishing procedure by reducing the irregularities on the surface contributed to increasing the flexural strength of the restorations (7).

Various manufacturers offer dentists polishing sets used in the rough (grinding) to fine (high gloss finish) stages, which are made especially for zirconia, usually consisting of a set of two or three stages. These sets are also suggested with the use of different polishing pastes, and it is possible to obtain a smooth surface depending on the successive application of all polishing steps (16). However, information on the effects of different surface treatments on newly developed high translucent zirconia ceramics is limited in the literature.

The null hypothesis of this study is that different finishing procedures applied will not affect the surface roughness and flexural strength of the tested materials.

This study aims to investigate the effects of glazing, polishing, polishing with a paste of different highly translucent materials on the flexural strength of these materials, and illuminate the places where there has not been much work on the finishing procedures to be made on these newly developed materials.

2. METHODS

2.1. Specimen Preparation

Four different yttria content monolithic zirconia material; 3Y-TZP (Nacera Pearl Multi Shade, Doceram Medical Ceramics Gmbh, Dortmund, Germany) (NCMS), 4Y-PSZ (Katana STML, Kuraray Noritake Dental Inc., Tokyo, Japan) (KST), 5Y-PSZ (Katana UTML, Kuraray Noritake Dental Inc., Tokyo, Japan) (KUT), and 6Y-PSZ (Nacera Pearl Q[3], Doceram Medical Ceramics Gmbh, Dortmund, Germany) (NCQ) are used in this study and shown in Table 1. A total of 120-disc shaped specimens (n=30/ for each material) were prepared according to ISO 6872-2015 guidelines with absolute dimensions of 1.2 ± 0.2 mm in thickness and 14 mm in diameter.

Table 1. *Composition of the materials tested in this study.*

Monolithic Zirconia Materials	Content	Manufacturer	Sintering cycle	Indications	Lot No
Katana STML (Ultra Translucent Multi-Layered) Zirconia	ZrO_2+HfO_2 %88-93 (Y_2O_3) %7-10 Other oxides %0-2	Kuraray Noritake Dental Inc., Tokyo, Japan	2 h at 1550 Cº	Frameworks, monolithic crowns, monolithic bridges, inlays, onlays and veneers	EAUWN
Katana UTML (Ultra Translucent Multi-Layered) Zirconia	ZrO_2 + HfO 2 %87-92 (Y_2O_3) %8-11 Other oxides %0-2	Kuraray Noritake Dental Inc., Tokyo, Japan	2 h at 1550 Cº	Frameworks, monolithic crowns, monolithic bridges, inlays, onlays and veneers	DOZBT
Nacera Pearl Multi-Shade	ZrO_2+HfO_2+ Y_2O_3 > %99, Y_2O_3 %4,5 – %6	Doceram Medical Ceramics Gmbh, Dortmund, Germany	2 h at 1450 Cº	Single crowns, bridges consisting of up to 16 units. In the posterior region, the span between the abutments must not exceed two units	5146158
Nacera Pearl Q[3] Multi-Shade	Yitriya-stabilize %40 Tetragonal, %60 cubic zirkonya polikristal (%6 mol Y_2O_3)	Doceram Medical Ceramics Gmbh, Dortmund, Germany	2 h at 1450 Cº	-Single crowns -Bridges in the front and side tooth areas consisting of up to 3 units.	5057862

The specimens were designed using Solidworks CAD software (Solidworks, Dassault Systems SolidWorksCorp., Waltham MA). The design was transferred with 3Shape CAM Software (3Shape, Copenhagen, Denmark) and the position of the samples in the zirconia blocks was arranged. . Then presinterized zirconia discs were milled using CAM system (imes-icore GmbH Im Leibolzgraben 16 D-38132 Eiterfeld/ Germany). Before the sintering procedure, all specimens were ground using 800 grit and 1200 grit silicon carbide paper to remove any irregularities and obtain standardized and smooth surfaces. Specimens were sintered in the furnace (Tabeo – 1/S/Zirkon-100, Germany) according to the instructions of the whole material manufacturer (Table 1). All specimens were ground with 1200 grit silicon carbide paper. The specimens' diameters and thicknesses were measured with a digital caliper (Alpha Tools Digital Caliper, Alpha Professional Tools, Oakland, USA) and were checked for standardization.

According to the ISO 6872-2015 standard, the specimens prepared with the final dimensions of

1.2 ± 0.2 mm in thickness and 14 mm in diameter were divided into 3 subgroups (n = 10) of each material according to the finishing procedures to be applied.

2.2. Finishing Procedures

The materials, manufacturers, and lot number used in the finishing procedure are shown in Table 2.

Table 2. *The materials, manufacturers, and lot number used in the finishing procedure*

Finishing Procedure	Materials	Manufacturers	Lot No
Diamond Polishing System	Diacera Medium, Diacera Fine G&Z Instrumente	G&Z Instrumente GmbH, Lustenau, Austria	434914
Glaze	IPS e.max Ceram Glaze powder and IPS e.max Ceram Glaze and stain liquid	Ivoclar Vivadent AG	Z00B5Z
Polishing Paste	Nacera Shine Zr	Doceram Medical Ceramics Gmbh, Dortmund, Germany	7777YO118

Finishing procedure were performed by the same operator according to the manufacturers recommendations. Diamond polishing system (DP): Samples were sampled using a micromotor handpiece (NSK Micromotor ULTIMATE XL-DT, Japan) using a medium followed by fine diamond bur (Fig. 1) (Diacera Medium, Diacera Fine G&Z Instrumente GmbH, Lustenau, Austria) polished. Each diamond bur was applied at 10,000 rpm for 60 seconds. The diamond polishing system followed by polishing paste (PP): The specimens were polished with the same diamond polishing system and techniques as a diamond polishing system. The polishing paste (Nacera Shine Zr, Doceram Medical Ceramics Gmbh, Dortmund, Germany) was applied with a goat hair brush for 60 seconds at 10,000 rpm. Glaze application (GP): The zirconia discs were glazed with glaze powder and liquid (IPS e.max Ceram Glaze powder and IPS e.max Ceram Glaze and stain liquid, Ivoclar, Vivadent) following to the manufacturer's instructions. A thin glaze layer was applied to one surface with a brush and fired in the ceramic furnace at 925 Cº (Programat P300, Ivoclar Vivadent, Schaan, Liechtenstein).

After all finishing procedures, all specimens were cleaned in an ultrasonic bath (Euronda; Eurosonic Energy, Italy) containing distilled water for 10 minutes and allowed to dry at room temperature before the analysis.

2.3. Surface Roughness (Ra) Analysis

Ra (roughness average) and Rz (average maximum height of profile) values of surface roughness of all specimens before the finishing procedure and after the finishing procedure were measured using a contact profilometer device (SJ-301, Mitutoyo Corporation, Takatsu-Ku, Kawasaki, Kanagawa, Japan) (λ=5x0.25 mm). Before the measurement of each group, the device was calibrated. Measurements were made from the surface of each specimen 3 times in 3 different directions.

2.4. Biaxial Flexural Strength Test

A biaxial flexural strength test was applied to determine the flexural strength of the specimens whose surface roughness were determined. Biaxial flexural strength was conducted following by ISO 6872-2015 in a universal testing machine (Lloyd Instruments, Ametek Inc, Florida, ABD) with a piston on a three-ball system. The finishing surface of disc-shaped specimens was placed on the support circle to balance the tension load during the test. Specimens were loaded at a crosshead speed of 1 mm/min until failure in the universal test machine. The load at the point of the fracture for each material was recorded. The biaxial flexural strength values of the specimens were calculated with the following equation:

$$\sigma = -0.2387\, P(X-Y)/b^2$$

$$X = (1 + v)\ \ln(r2/r3)^2 + ((1-v)/2)\ (r2/r3)^2$$

$$Y = (1 + v)\ (1+ \ln(r1/r3)^2) + (1-v)\ (r1/r3)^2$$

Where; σ represents the maximum tensile stress (MPa), P is the total load at fracture (N), and b is the thickness at the fracture origin (mm), respectively. In which; v= Poisson's ratio (0.3 for zirconia), r1 (5 mm) is the radius of the support circle, r2 (0.7 mm) is the radius of the loaded area, and r3 (7 mm) is the radius of the specimen.

2.5. Statistical Analysis

Initially, it was examined whether the data discussed in the study came from a normal distribution before starting the analysis. Kruskal Wallis was used at the 5% significance level to measure the differences between the experimental groups according to the normality test result because both the surface roughness data and the flexural strength data assumed a non-parametric distribution.

The reliability of the materials used in the study was obtained by Weibull analysis of flexural strength data according to the following equation:

$$P = 1 - e^{-\left(\frac{\sigma}{\sigma_0}\right)^m}$$

where P is the failure probability; m, Weibull modulus; σ is the material fracture tension and σo is the characteristic strength. Statistical analysis was performed using MATLAB (R2018b) software, and the significance level was 5%.

3. RESULTS

The Average Surface Roughness (Ra) values of materials are listed in Table 3. In Table 3, the results show that there is a significant difference between the finishing procedures applied with each material in terms of Ra values. Different capital letters indicate statistical differences within the same material group in columns. For Ra values, there is a statistical difference between all the procedures applied in the KST material and in the NCQ material. However, there is no statistical difference between GP and PP procedures in Ra values in the NCMS material (*p= .1583*). There is also no statistical difference in the polishing and paste procedures applied to the KUT material in terms of Ra (*p= .2206*) values.

According to the Ra values given in Table 3, different small letters indicate statistical differences per surface treatment across different materials in rows. Ra values of the Glaze procedure applied to Group KST, KUT, and NCQ showed the lowest mean values except for Group NCMS. The lowest value of NCMS is the polishing procedure applied to the NCMS Group.

Table 3.*Mean (SD) R_a values for all experimental groups.*

	KST	KUT	NCMS	NCQ
GP	0.05 (0.02) ^{A,a*}	0.07 (0.02) ^{A,b*}	0.16 (0.06) ^{A,c*}	0.07 (0.03) ^{A,b*}
DP	0.14 (0.06) ^{B,a*}	0.09 (0.01) ^{B,b*}	0.09 (0.02) ^{B,b*}	0.09 (0.02) ^{B,c*}
PP	*0.11 (0.04)* ^{C,a*}	*0.12 (0.07)* ^{B,a*}	*0.15 (0.06)* ^{A,b*}	*0.15 (0.08)* ^{C,b*}

GP: Glaze application, DP: Diamond Polishing system , PP: The diamond polishing system followed by polishing paste, KST: Katana STML, KUT: Katana UTML NCMS: Nacera Pearl Multi Shade, NCQ: Nacera Pearl Q^3 SD: Standard Deviation

-Similar letters indicate lack of statistically difference (p> .05)

-Capital letters indicate statistical differences within the same material group.

-Small letters indicate statistical differences per surface treatment across different materials.

**Significant difference between pre-procedure and post-procedure roughness values (p< .05).*

Table 4. *Mean (SD) flexural strength values for all experimental groups.*

	KST	KUT	NCMS	NCQ
GP	732.70 (158.76) ^{A,a}	715.08 (175.46) ^{A,a}	753.56 (123.50) ^{A,a}	644.71 (119.13) ^{A,a}
DP	728.94 (48.73) ^{A,a}	554.14 (146.72) ^{B,b}	1344.22 (154.16) ^{B,c}	665.86 (92.13) ^{A,a}
PP	1474.72 (246.12) ^{B,a}	1402.23 (180.71) ^{C,a,b}	1028.76 (421.09) ^{A,B,b}	542.93 (138.15) ^{A,c}

GP: Glaze application, DP: Diamond Polishing system , PP: The diamond polishing system followed by polishing paste, KST: Katana STML, KUT: Katana UTML NCMS: Nacera Pearl Multi Shade, NCQ: Nacera Pearl Q^3 SD: Standard Deviation

Similar letters indicate lack of statistically difference (p>0.05)

Capital letters indicate statistical differences within the same material group in columns.

Small letters indicate statistical differences per surface treatment across different materials in rows.

The descriptive analysis of the flexural strength data is made to obtain mean and standard deviation (SD) listed in Table 4. It was examined whether there was a significant difference between procedure group flexural strength values within the same materials in columns. According to the results, it was observed that there was no significant difference between the finishing procedures applied to NCQ material (*p= .0612*).

The flexural strength measurements in terms of finishing procedures applied to materials determined by the Weibull analysis are summarized in Table 5 and Figure 2. The highest m values for DP and KST was determined in NCMS and NCQ materials, while in KUT material, PP was determined in the finishing procedure. The characteristic strengths of PP applied to KST material had the highest value, whereas the paste applied to NCQ material had the lowest value. In addition, the lower and upper limit values corresponding to these characteristic strengths at 95% reliability are given in Table 4. Breaking probabilities for applied power values in finishing procedures applied to materials are given in Figure 3.

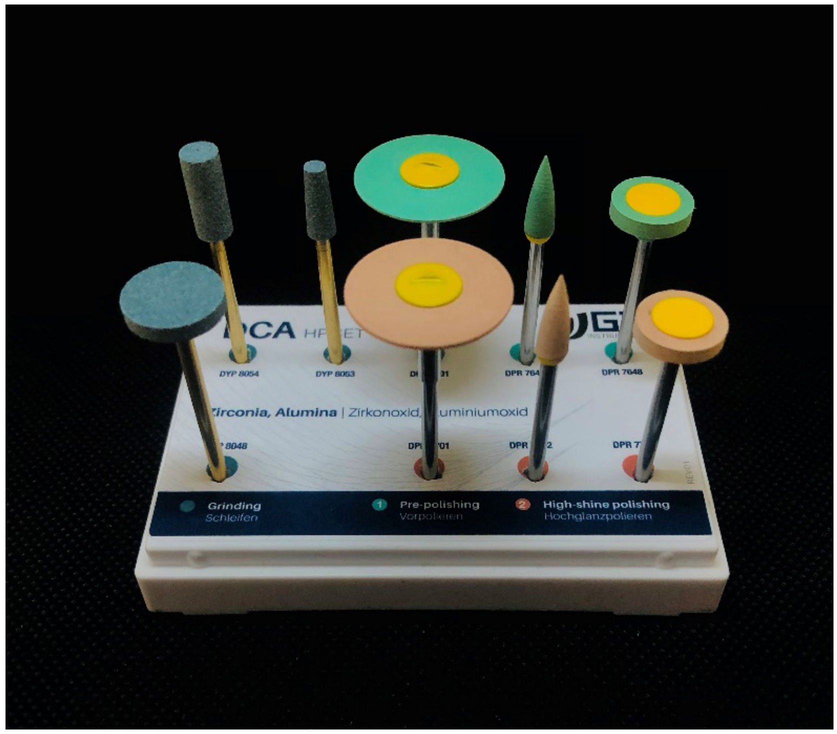

Figure 1: *Diamond Polishing system*

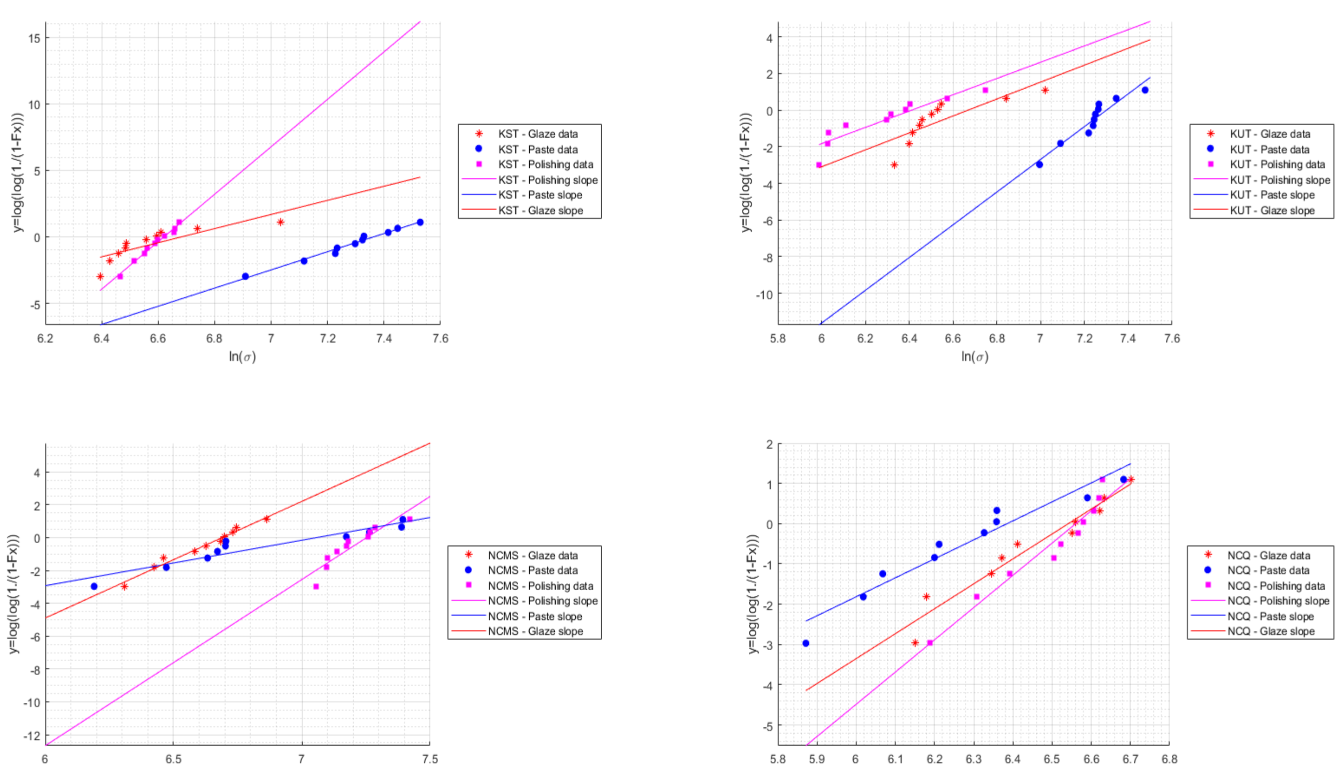

Figure 2. *Weibull analysis*

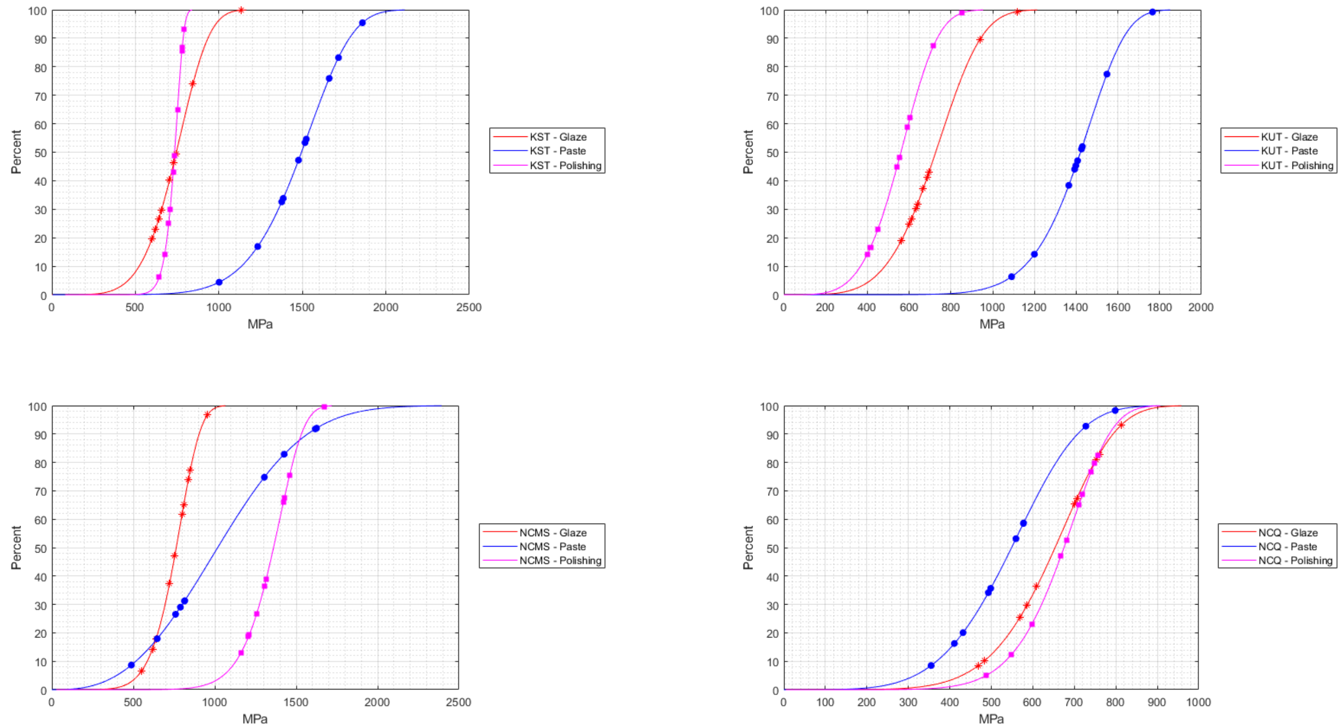

Figure 3. *Breaking probabilities*

Table 5. *The mean strenght (MPa), Standard deviation, Characteristic strength, Weibull moduli and Confidence interval (CI) (95%) results in terms of finishing procedures applied to materials.*

Material	Procedure	Mean strenght (MPa) (S.D)	Characteristic strength			Weibull modulus			R^2
			MPa	95% CI		m	95% CI		
				Lower limit	Upper limit		Lower limit	Upper limit	
KST	GP	732.6981 (158.7640)	798.5423	399.4504	1021.2093	5.3071	2.3286	8.2855	0.6785
	DP	728.9360 (48.7267)	750.2224	610.5613	807.1507	17.8464	15.8334	19.8594	0,9812
	PP	1474.7190 (246.1157)	1576.8351	921.1885	1908.4135	6.8393	6.1017	7.5769	0.9828
KUT	GP	715.0781 (175.4614)	787.2420	355.6381	1043.8597	4.6263	1.9669	7.2858	0.6679
	DP	554.1400 (146.7236)	608.8148	266.4571	816.4020	4.4490	2.9242	5.9738	0.8498
	PP	1402,2290 (180.7140)	1480.0624	981.1647	1712.6679	8.9424	6.5356	11.3491	0.9017
NCMS	GP	753.5593 (123.5000)	804.0369	479.1653	966.2552	7.1024	6.1655	8.0393	0.9745
	DP	1344.2160 (154.1631)	1411.3278	981.4208	1605.6388	10.1193	6.5865	13.6521	0.8451
	PP	1028.7646 (421.0887)	1162.0274	307.9341	1862.1072	2.7681	1.9837	3.5526	0.8922
NCQ	GP	644.7087 (119.1350)	693.3943	382.7744	856.2508	6.1873	4.9706	7.4040	0.9450
	DP	665.8634 (92.1274)	706.5187	446.3447	831.6547	8.0046	6.5128	9.4965	0.9503
	PP	542.9318 (138.1498)	593.1163	271.8564	782.4145	4.7124	3.6814	5.7434	0.9328

GP: Glaze application, DP: Diamond Polishing system , PP: The diamond polishing system followed by polishing paste, KST: Katana STML, KUT: Katana UTML NCMS: Nacera Pearl Multi Shade, NCQ: Nacera Pearl Q3

4. DISCUSSION

In this study, the effects of 3 different finishing treatments applied to 3 high translucent and one translucent 3Y-TZP zirconia materials with different yttria content on the surface roughness and flexural strength were investigated. It was concluded that 3 different finishing procedures applied in the study had different effects on the surface roughness of the materials. While glaze showed the lowest surface roughness value in highly translucent materials (KST, KUT, NCQ), 3 different surface roughness values were determined for all materials in glaze, polishing, and polishing paste procedures. The different microstructures of the materials in the study led to different results in terms of Ra values between the finishing procedures. For this reason, the hypothesis that the different finishing treatments applied would not affect the surface roughness of the tested materials was rejected.

The highly translucent materials used in the study were used as an alternative material to 3Y-TZP for monolithic restorations due to their increased translucency and adequate mechanical properties (17). Y_2O_3 constituted 8-11% of the content of ultratranslucent Katana UTML, while supertranslucent Katana STML contained 7-10% Y_2O_3 (18). Another material Nacera Pearl Q^3 MS contains 6 mol% Y_2O_3 (19). Previous studies showed that the higher the stabilizer content in the materials, the higher the conversion hardening. They reported that it was responsible for the elimination of the mechanism and also the emergence of a large amount of cubic crystal in its microstructure (6,20,21). Hatanaka et al. stated that this difference in microstructure affected the polishability of the materials (1). On the other hand, Khayat et al. reported that the surface roughness of restorations could be reduced with appropriate polishing methods in high translucent zirconia (7).

When the results of this study were examined, a significant difference was found between the surface treatments in KST and NCQ material in terms of mean Ra values, while no significant difference was found between the DP and PP groups in KUT and between the GP and PP groups in NCMS, and a significant difference was found between all other groups. In this study, while the polishing procedure was applied to the samples, first a medium-grained polishing bur was used. The Ra values of the DP group in this study were the Ra obtained by Happe et al. (22) and Alkimavičius et al. (23). While the Ra values of the PP group were lower than those of the polishing-pat group in the study of Happe et al. (22), Alkimavičius et al. (23) determined that it was higher. The reason for these differences is thought to be related to the application method of the polishing protocols and the different microstructures of the materials.

Since monolithic zirconia was directly exposed to the oral environment, finishing and polishing were performed after occlusal adjustments to prevent the wear of the antagonist enamel (4). Various manufacturers offer polishing sets made specifically for zirconia restorations, usually consisting of a two or three-stage set, used in coarse (grinding) and fine (high-gloss) stages (16). Khayat et al. (7) determined the Ra value of high translucent Y-TZP samples to be 1.00 µm in the group to which they finished with a 2-stage Brasseler polishing set, and 0.81 µm in the group in which they finished with a 2-stage Komet polishing set. In this study, the Ra values of the samples polished with the 2-stage Diacera polishing set were found to be lower. Kurt et al. (24) in their study with monolithic zirconiareported that the Ra values of the samples in the group in which they applied polishing paste with a brush after the polishing kit were lower than the samples in which the paste was applied in this study. Park et al. (25), on the other hand, applied 2-stage polish to Y-TZP zirconia samples and found the Ra values higher than the values in the polishing group of this study.

In this study, it was determined that the GP procedure had significantly lower Ra values in general (except for Nacera MS material). These results are similar to the results of the study by Al Hamad et al. (26) and Manzuic et al. (27). However, it wasreported in other studies that the glaze layer wore out quickly and caused the rough milled surface to be exposed (21,26). Therefore, polishing was recommended in areas with high chewing pressure (28).

Studies reported that a smoother surface was required to prevent biofilm formation and reduce aging (1,7,29). Bollen et al. (30) suggested a threshold surface roughness value (Ra=0.2 µm) for bacterial retention on dental materials as a result of their in vivo studies. In this study, it was determined that all finishing proceduree s had roughness below this value and it was determined that it could provide information about suitable surface finishing procedures for translucent zirconias.

The fact that the surface of the restoration is polished im addition to reducing roughness, it was reported that it could have 2 different effects on flexural strength; polishing could reduce surface defects and increase flexural strength, or it could reduce flexural strength by removing the pressure layer (1,31).

When the flexural strength results of different finishing procedurees for the same material were examined, no significant difference was found between the 3 surface finishing procedures in only NCQ material, while a significant difference was determined between the finishing procedures in KUT material. There was no significant difference between GP and DP groups in KST material, and between GP and PP groups and DP and PP groups in NCMS material. For this reason, the second hypothesis that different finishing procedures would not affect the flexural strength of the tested materials was also rejected.

De Souza et al. (32) in their study with translucent zirconia, Vila-Nova et al. (14) and Carvalho et al. (33) in their study with ultratranslucent zirconia, they stated that the flexural strength of the zirconia increased after the 3-stage polishing procedure compared to the control group.

Furthermore Mohammadi-Bassir et al. (31) reported that the flexural strength of the groups to which they applied the 2-stage polishing procedure was higher than the groups in which the standard single-stage polishing procedure was applied.

Pfefferle et al. (16) reported that the application of polishing paste significantly increased the flexural strength values of the material. Similarly, in this study, the flexural strength values obtained in the polishing paste finishing group in KST and KUT materials were found to be significantly higher than the flexural strength values obtained in the polishing procedure. While Lee et al. (34) reported that the flexural strength decerased as the surface roughness increased, Khayat et al. (7) in their study in which they applied a 2-stage polishing finishing procedure stated that there was no correlation between the roughness and flexural strength of zirconia following the previous studies.

According to the results of Weibull analysis; In KST and KUT material, the highest characteristic strength results were found in the PP group (KST=1474.7 MPa, KUT=1402.2 MPa), while the highest values for NCMS and NCQ were found in the DP group (NCMS=1344.2 MPa, NCQ=665.8 MPa) Pittayachawan et al. (35) noted that the lower the value of the Weibull modulus, the more defects and microcracks in the material, thus reducing reliability. Conversely, they reported that higher values of the Weibull modulus indicated a smaller error range and therefore greater structural reliability. While they reported that most ceramics had weibull modulus values in the range of 5-15, they reported in their study that the Weibull modulus values of the samples were in the range of 9.3-12.9, which is acceptable for dental ceramics. In this study, Weibull modulus values were determined to be in the range of 2.7 to 17.8. Weibull modulus was found to be higher in DP groups of materials except for KUT. In line with these results, it is thought that the polishing procedure applied may have increased the reliability.

The flexural strength of the high translucent zirconia tested in the study was found to be above 500 MPa, which is the minimum value accepted for class 5 restorations in fixed prostheses according to ISO 6872, while Nacera MS had higher flexural strength values than high translucent zirconias. The result was found to be compatible with class 6 materials recommended in ISO 6872.

Differences in grain size and microstructure of zirconia materials with different yttria content affect the surface structure and polishability. In this study, it was determined that different surface finishing procedures had different effects on the surface roughness and flexural strength of translucent zirconias. In the study, 3 high translucent zirconia materials with different yttria content were compared with translucent 3Y-TZP zirconia in terms of surface roughness values and flexural strength. In subsequent studies, the roughness and flexural strength of materials could be compared by using different high-translucent zirconias and different surface treatments.

5. CONCLUSION

Considering the limitations of the study, the following conclusions can be drawn;

1. In terms of finishing procedures, the Ra values were determined in the GP group in KST, KUT, and NCQ materials. In the NCMS material, the highest Ra value was determined in the GP group.

2. The Ra values obtained for all materials were found below the reference threshold value of

0.2 µm. While a significant difference was found between the groups in terms of Ra values in the KST and NCQ material, there was no significant difference between the GP and PP groups in the NCMS material and between the DP and PP groups in the KUT.

3. In terms of flexural strength results, there was no significant difference between all groups in the NCQ material with different finishing procedures, andthere was no significant difference between the GP and PP groups, DP and PP groups in the NCMS material and between the GP and DP groups in the KST material. A significant difference was found between all groups in the KUT material.

4. According to Weibull modulus results, the highest Weibull modulus values were determined in the paste group in KUT, while it was determined in the polishing group in all other materials. The characteristic strengths of the high translucent zirconias tested in the study were determined to be above 500 MPa, which is the minimum accepted value for class 5 restorations in fixed prostheses according to ISO 6872.

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