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Investigation of the Sandblasting Pressure Effect on the Wear Properties, Surface Roughness, and Shear Bond Strength of Resin Nanoceramic and Zirconia CAD/CAM Restorative Materials

Rezin Nanoseramik ve Zirkonya CAD/CAM Restoratif Materyallerin Aşınma Özellikleri, Yüzey Pürüzlülüğü ve Makaslama Bağlanma Dayanımı Üzerine Kumlama Basıncının Etkisinin Araştırılması

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ABSTRACT

Objective: Investigation of the influence of sandblasting pressure on the wear properties, surface roughness, and bond strength of resin nanoceramic and zirconia materials.
Methods: 80-specimens with dimensions of 14 × 14 × 2 mm were obtained from Lava-Ultimate and Katana-Zirconia CAD/CAM materials. Four groups were formed according to the sandblasting pressure (control, 1-bar, 2-bar, and 3-bar). Sandblasting treatment was performed with 50-µm Al_2O_3 from a distance of 10-mm for 10-seconds at a pressure of 1, 2, and 3-bar. The weight loss caused by sandblasting was calculated and converted to volume loss. The surface roughness was evaluated with a contact profilometer. A randomly selected one specimen from each group was scanned using a non-contact profilometer. Composite rods were bonded to the surface of the materials with dual-cure adhesive resin. The shear bond strength test was performed. The data were analyzed using the Shapiro-Wilk test and two-way analysis ANOVA (P<.05).
Results: The highest volume difference values for Lava-Ultimate were obtained in Group-3 (2.914±0.458). The highest Ra values were observed in Group-3 for Lava-Ultimate (2.620±0.121) and Katana-Zirconia (0.770 ± 0.106). Lava-Ultimate exhibited higher volume loss and Ra values than Katana-Zirconia at all sandblasting pressures. However, it showed higher SBS values (16.61±3.31) only in Group-1 (P<.05).
Conclusion: Increasing sandblasting pressure affected the amount of wear and Ra values of Lava-Ultimate, while for Katana-Zirconia it only affected the surface roughness values. The increase in sandblasting pressure did not influence the shear bond strength values.
Keywords: Resin nanoceramic, sandblasting pressure, shear bond strength, surface roughness, wear, zirconia

ÖZ

Amaç: Rezin nanoseramik ve zirkonya materyallerin aşınma özellikleri, yüzey pürüzlülüğü ve bağlanma dayanımı üzerine kumlama basıncının etkisinin incelenmesi.
Yöntemler: Lava-Ultimate ve Katana-Zirconia CAD/CAM materyallerinden 14 × 14 × 2 mm boyutlarında 80 adet örnek elde edildi. Kumlama basıncına göre dört grup oluşturuldu (kontrol, 1-bar, 2-bar, 3-bar). 50-µm Al_2O_3 ile 10-saniye süreyle, 10-mm mesafeden, 1, 2 ve 3-bar basınçlarda kumlama işlemi yapıldı. Kumlamanın neden olduğu ağırlık kaybı hesaplandı ve hacim kaybına dönüştürüldü. Yüzey pürüzlülüğü kontak profilometre ile değerlendirildi. Her gruptan rastgele seçilen bir örnek non-kontakt profilometri cihazı ile tarandı. Kompozit çubuklar, materyallerin yüzeyine dual-cure adeziv rezin ile yapıştırıldı. Makaslama bağlanma dayanım testi (Shear Bond Tester) gerçekleştirildi. Veriler Shapiro-Wilk testi ve iki yönlü ANOVA ile analiz edildi (P <,05).
Bulgular: Lava-Ultimate için en yüksek hacim farkı değerleri Grup-3'te (2,914±0,458) elde edildi. En yüksek Ra değerleri Lava-Ultimate (2,620±0,121) ve Katana-Zirconia (0,770±0,106) için Grup-3'te gözlendi. Lava-Ultimate, tüm kumlama basınçlarında Katana-Zirconia'dan daha yüksek hacim kaybı ve Ra değerleri sergiledi, fakat sadece Grup-1'de daha yüksek makaslama bağlanma dayanımı değerleri (16,61±3,31) gösterdi (P<,05).
Sonuç: Artan kumlama basıncı, Lava-Ultimate'in aşınma miktarını ve Ra değerlerini etkilerken, Katana-Zirconia'nın sadece yüzey pürüzlülüğü değerlerini etkilemiştir. Kumlama basıncının artması makaslama bağlanma dayanımı değerlerini etkilememiştir.
Anahtar Kelimeler: Rezin nanoseramik, kumlama basıncı, makaslama bağlanma dayanımı, yüzey pürüzlülüğü, aşınma, zirkonya

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INTRODUCTION

Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) systems are widely used today because they offer advantages such as saving time and standardizing the production process. When using CAD/CAM systems, dental tissues are recorded with a scanner, and dental restorations are produced by milling with a three-dimensional design without the need for a physical model. This treatment method is easier and faster than traditional methods.[1] Resin nanoceramics and zirconia materials are commonly used material categories in CAD/CAM systems. Lava Ultimate, resin nanoceramic restorative material contains silica (20 nm) and zirconia (4-11 nm) embedded in dimethacrylate resin matrix in agglomerated and non-agglomerated form (80% by weight).[2] The hybrid structure is not as fragile as glass-ceramics while having a similar aesthetic appearance to glass-ceramics. The nanoparticle structure provides wear and fracture resistance.[3] The high-temperature polymerization process during fabrication gives the nanoceramic structure more advanced physical, optical, and mechanical properties.[4,5] Zirconia ceramics have high mechanical strength, chemical stability, and dimensional stability. They are often preferred as a core material in the posterior region, where excessive occlusal stresses occur.[6] With advances in dentistry, zirconia materials are also being used for aesthetic restorations in the anterior region. In this way, the high strength required for posterior restorations and the translucency properties required for anterior restorations can be achieved.

The success of restorative materials depends on the longevity of the restorations and is influenced by the long-term stability and durability of the adhesive bond.[7] Adhesion occurs through physicochemical interactions and is achieved through micro-mechanical and chemical bonding.[8] This important clinical phase determines the retention, bond strength, fracture resistance, marginal fit, and sealing of the restoration.[9,10] Resin cements are often preferred for the adhesive cementation of dental restorative materials. The surface tension of the adhesive resin cement and the surface energy of the restorative materials affect the bond strength. Surface treatments improve the adhesion to the adhesive resin cement by increasing the surface roughness, wettability, and surface energy of the dental restorative materials.[11-13] Micromechanical retention is achieved by flowing adhesive resin into the micro retentions.[14]

Surface treatment procedures differ according to the type of restorative materials. Sandblasting with Al_2O_3 is one of the most commonly used surface treatment methods. In this method, Al_2O_3 particles remove weak ceramic particles, deposits, and oxides. This results in a clean, active, and rough ceramic surface.[15,16] The surface tension of the restorative material is reduced; surface energy, wettability, and surface roughness increase.[17,18] Sandblasting procedures affect the stability and long-term success of ceramic materials by altering surface roughness and surface properties. In addition, material loss may occur, which may affect the fit of the restoration.[19] Different surface treatment procedures are recommended for different material types, as the wear characteristics of restorative materials may differ according to the material type and sandblasting procedure. The effectiveness of sandblasting procedures is determined by variables such as type or size of sand particles, sandblasting pressure, sandblasting time, and angle of sandblasting.[20,21]

In general, sandblasting restorative materials increase surface roughness and bond strength. However, high sandblasting pressure may cause stress on the material surface. The formation of sharp areas may reduce the wettability of the material. Accordingly, higher bond strength may not be achieved by increasing the sandblasting pressure.[18,22]

The indication for Lava Ultimate crowns has been removed due to the debonding failures. On the other hand, zirconia materials are challenging to abrade with surface treatment procedures. For this reason, these two materials, which have problems with both adhesion and abrasion were selected for this study. Therefore, this study aims to examine the effect of sandblasting pressure on the amount of wear, surface roughness, and shear bond strength of resin nanoceramic and zirconia CAD/CAM restorative materials. The null hypothesis of this study was that 'different sandblasting pressures have no effect on (I) the amount of wear, (II) surface roughness (Ra), (III) and Shear Bond Strength (SBS) of resin nanoceramic and zirconia CAD/CAM restorative materials.'

METHODS

Sample Preparation

In this study, Lava Ultimate (LU- 3M ESPE, St Paul, MN, USA), Katana Zirconia (KZ- Kuraray Noritake Dental Inc., Okayama, Japan), G-CEM Link Force (GC Corporation, Tokyo, Japan), G-Multi Primer (GC Corporation, Tokyo, Japan), and Clearfil Majesty Esthetic (Kuraray, Okayama, Japan) were selected. The ingredients of these materials are listed in Table 1. LU CAD/CAM blocks were cut under water cooling using a Micracut 151 low-speed precision cutting device (Metkon Instruments Inc. Bursa Turkey) and 14 × 14 × 2 mm block sections were obtained. The KZ specimens were prepared 25% larger, taking into account the shrinkage that occurs during sintering. A total of 80 block sections were fabricated from LU and KZ restorative materials (n=10). The thickness of the specimens was checked with a Digimatic Caliper (Mitutoyo, Tokyo, Japan). Then, the surface of the specimens was ground with 600 SIC paper under water cooling for 60 seconds. Subsequently, specimens were washed under running water for 5 minutes and air-dried. The KZ samples were sintered in Protherm furnaces (Alserteknik, Ankara, Turkey) according to the manufacturer's instructions. After sintering, the samples with dimensions of 14 × 14 × 2 mm were obtained.

Table 1. Materials used in the study.

Materials	Ingredients		Manufacturer and Batch Number
Lava Ultimate	SiO_2, ZrO_2, Si/ZrO_2 cluster, Bis-GMA, UDMA, Bis-EMA, TEGDMA		3M ESPE, St Paul, MN, USA-N664028
Katana Zirconia	ZrO_2, HfO_2, Y_2O_3, P, pigments		Kuraray Noritake Dental Inc., Okayama, Japan- EESTS
G-CEM Link-Force	Pasta A: Bis-GMA UDMA DMA Barium glass Initiator Pigments	Pasta B: bis-MEPP UDMA DMA Barium glass Initiator	GC Corporation, Tokyo, Japan-2103041
G-Multi Primer	Ethanol MDP MDTP Silane Methacrylate monomer		GC Corporation, Tokyo, Japan-2103121
Clearfil Majesty Esthetic	Silanated barium glass, prepolymerized organic filler, Bis-GMA, hydrophobic aromatic dimethacrylate, dl-camphorquinone		Kuraray, Okayama, Japan-820198

Bis-EMA: bisphenol-A-polyethylene-glycol-diether dimethacrylate; Bis-GMA: bisphenol-A-diglycidyl dimethacrylate; DMA: dimethacrylate; MDP: methacryloyloxydecyl dihydrogen phosphate; MDTP: methacryloyloxydecyl dihydrogen thiophosphate; Silane: γ-methacryloxypropyl trimethoxysilane; TEGDMA: triethylene gly-col dimethacrylate, UDMA: urethane dimethacrylate.

Initial Weight Measurement

All specimens were placed in a desiccator (Labor-Teknik, Istanbul, Turkey) with silica gel at the bottom for 24 hours at room temperature and the moisture was removed. Then the specimens were randomly numbered, and the initial weights were measured (0.0001 g) using a precision electronic balance (AND GR-200; Alserteknik, Ankara, Turkey). The glass windows of the precision balance were kept closed during the measurement. The weight measurement was repeated three times. The mean values were calculated and recorded as W_1.

Sandblasting Procedures

LU and KZ samples were divided into 4 groups (Group 0: Control, Group 1: 1-bar, Group 2: 2-bar, Group 3: 3-bar) according to the sandblasting pressure (n=10). The control group was not sandblasted. Sandblasting treatments were performed with 50 µm Al_2O_3 (Renfert GmbH, 78247, Hilzingen, Germany) for 10 seconds at a distance of approximately 10 mm at 1, 2, and 3 bar pressure in a Basic Eco (Renfert GmbH, 78247, Hilzingen, Germany). The samples were cleaned with air-water spray, then cleaned in distilled water in an ultrasonic bath for 5 minutes, and dried.

Repetition of Weight Measurement

All samples were kept in a desiccator for 24 hours. Then the weight measurement was repeated using a precision balance and recorded as W_2. The difference between W_2 and W_1 was calculated. The weight difference was converted to a volume difference.

Surface Roughness Measurement and Surface Profile Analysis

The surface roughness of the samples was evaluated with a profilometer (Taylor Hobson, Leicester, England). For each sample, three measurements were taken at different locations and the mean Ra values were calculated. One sample from each group was randomly selected and the surface scanning was performed with PS50 (Nanovea, 6 Morgan Ste 156, Irvine, CA, USA).

Shear Bond Strength Test

CAD/CAM block sections to be subjected to the SBS test were embedded in the acrylic molds. Clearfil Majesty Esthetic composite resin was used to fabricate composite cylinder rods. The composite resin material was placed in a Teflon mold (Ultradent Product, Inc., Utah, USA) and polymerized for 40 seconds using the Elipar S10 (3M/ESPE, St. Paul, MN, USA). Eighty composite cylinder rods were obtained. Thereafter, G-Multi Primer was applied to the specimens according to the manufacturer's instructions. The composite cylinder rods were adhered to the ceramic surfaces using G-CEM Link Force dual-cure adhesive resin. A constant force of 10 Newton was applied to standardize the cement thickness.[23] The excess cement was removed then each surface was polymerized for 20 seconds. The samples were stored in distilled water for 24 hours at room temperature. Then, SBS test was performed in Shear Bond Tester (Bisco, Schaumburg IL Inc, USA) at a speed of 0.5 mm/min and the values were recorded in Newton and calculated in MPa. Schematic views of the SBS test were shown in Figure 1. Failure modes were examined with an M3B stereomicroscope (Wild, Heerbrugg, Switzerland) (x30) and assessed as adhesive, cohesive, and mixed. The schematic representation of the test procedure was presented in Figure 2.

Statistical Analysis

The statistical analysis was performed using the program IBM SPSS 20.0 (IBM SPSS Corp., Armonk, NY, USA). The obtained data were analyzed with the Shapiro-Wilk test and two-way analysis of variance (ANOVA) (*P*<.05).

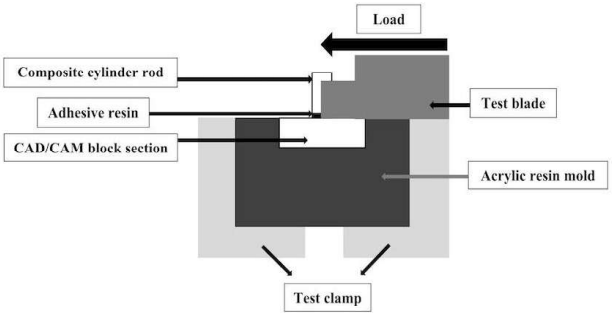

Figure 1. Schematic view of the SBS test.

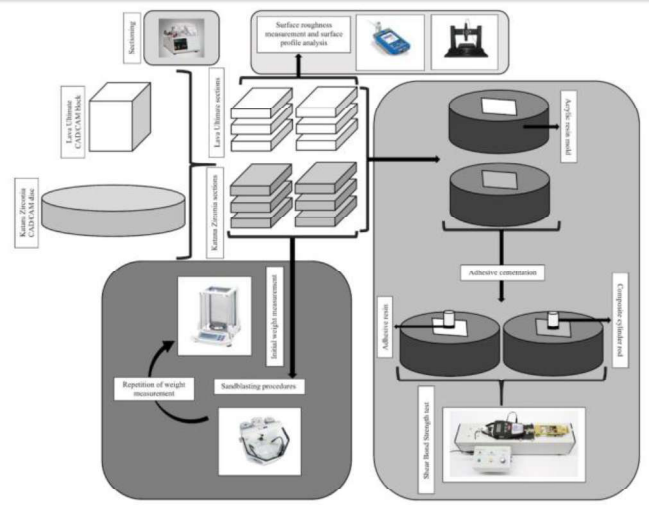

Figure 2. Schematic representation of the test procedures

RESULTS

The mean and ± standard deviation values for the volume differences, Ra, and SBS were given in Tables 2-4. The three-dimensional images were shown in Figures 3 and 4. The dispersion of SBS failure modes was shown in Figure 5. The most common failure mode was adhesive and cohesive failure did not occur.

When the volume difference values were evaluated, the two-way ANOVA results showed that the type of materials (*P*<.001), sandblasting pressure (*P*<.001), and the interaction between them (*P*<.001) were statistically significant. A significant difference was detected among all groups for LU (*P*<.001). Pairwise multiple comparisons indicated significantly higher volume difference values in Group 3 for LU. Similar volume difference values were obtained for KZ. In the comparison among the materials, a significant difference was observed for Group 1, Group 2, and Group 3 (*P*<.001).

For Ra values, the two-way ANOVA results exhibited that the type of materials (*P*<.001), sandblasting pressure (*P*<.001), and the interaction between them (*P*<.001) were statistically significant. For LU, a significant difference was determined among all groups. Pairwise multiple comparisons displayed significantly higher Ra values in Group 3 for LU. For KZ, a significant difference was observed between Groups 0-2 (*P*=.004), Groups 0-3 (*P*<.001), and Groups 1-3 (*P*=.006). When comparing the materials, a significant difference was determined for Groups 1, 2, and 3 (*P*<.001).

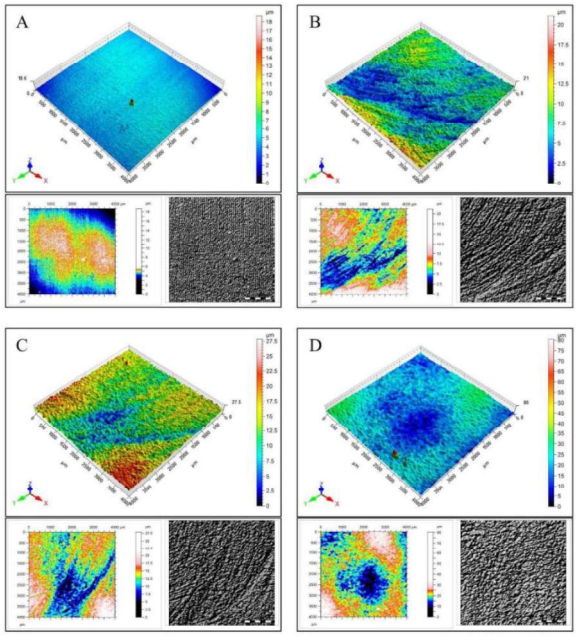

Figure 3. 3D profilometry images of Lava Ultimate samples. (A: Group-0; B: Group-1; C: Group-2; D: Group-3).

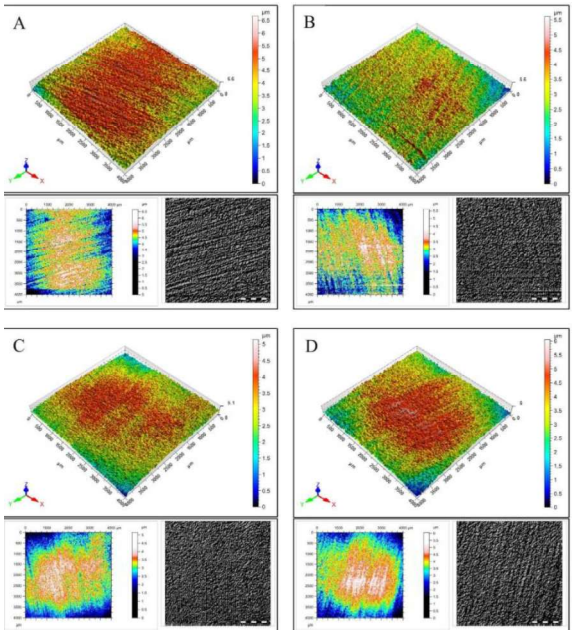

Figure 4. 3D profilometry images of Katana Zirconia samples. (A: Group-0; B: Group-1; C: Group-2; D: Group-3).

Figure 5. Distribution of failure modes according to experimental groups.

Table 2. Volume difference values (mm^3), (Mean ±standard deviation).

Materials	Group 0 (Control)	Group 1 (1 bar)	Group 2 (2 bar)	Group 3 (3 bar)
Lava Ultimate	-	0.452 ±0.113^{Aa}	1.557 ±0.307^{Ba}	2.914 ±0.458^{Ca}
Katana Zirconia	-	0.032 ±0.016^{Ab}	0.069 ±0.025^{Ab}	0.228 ±0.063^{Ab}

Mean values with different superscript capital letters express statistically significant differences in each row(*P*<.05). Mean values with different superscript lowercase letters express statistically significant differences in each column (*P*<.05).

Table 3. Ra values (µm), (Mean ±standard deviation).

Materials	Group 0 (Control)	Group 1 (1 bar)	Group 2 (2 bar)	Group 3 (3 bar)
Lava Ultimate	0.480 ±0.134^{Aa}	1.513 ±0.369^{Ba}	2.110 ±0.106^{Ca}	2.620 ±0.121^{Da}
Katana Zirconia	0.393 ±0.066^{Aa}	0.503±0.069^{ABb}	0.670 ±0.201^{BCb}	0.770 ±0.106^{Cb}

Mean values with different superscript capital letters express statistically significant differences in each row(*P*<.05). Mean values with different superscript lowercase letters express statistically significant differences in each column (*P*<.05).

Table 4. SBS values (MPa), (Mean ±standard deviation).

Materials	Group 0 (Control)	Group 1 (1 bar)	Group 2 (2 bar)	Group 3 (3 bar)
Lava Ultimate	5.59 ±1.24^{Aa}	16.61 ±3.31^{Ba}	14.69 ±1.75^{Ba}	14.52 ±2.86^{Ba}
Katana Zirconia	5.28 ±0.80^{Aa}	12.08 ±3.64^{Bb}	14.53 ±3.98^{Ba}	12.37 ±2.13^{Ba}

Mean values with different superscript capital letters express statistically significant differences in each row(*P*<.05). Mean values with different superscript lowercase letters express statistically significant differences in each column (*P*<.05).

For SBS values, the two-way ANOVA results showed that the type of materials (*P*=.004), sandblasting pressure (*P*<.001), and the interaction between them (*P*=.043) were statistically significant. For LU and KZ, a significant difference was observed between Groups 0-1, Groups 0-2, and Groups 0-3 (*P*<.001). Pairwise multiple comparisons revealed similar SBS values in Groups 1, 2, and 3 for LU and KZ. In the comparison among the materials, a significant difference was observed only for Group 1 (*P*<.001).

When evaluating failure modes, adhesive failure was observed for all LU specimens. For KZ, adhesive failure occurred mainly. Cohesive failure did not occur for these two materials. The rate of mixed failure was lower than that of adhesive failure in KZ.

The three-dimensional images showed more craters, grooves, and scattered irregular areas formed as the sandblasting pressure increased in the groups of LU. Rough areas with increasing pits and peaks were determined on the surface of the KZ specimens.

DISCUSSION

This study was designed to investigate the effects of different sandblasting pressures on the amount of wear, surface roughness (Ra), and SBS of resin nanoceramic and zirconia restorative materials. The null hypotheses were 'different sandblasting pressures do not affect (I) the amount of wear, (II) the surface roughness (Ra), (III) and the SBS of resin nanoceramic and zirconia restorative materials.' According to the findings, all hypotheses were rejected.

Recent studies have investigated the effects of different sandblasting treatments on the surface properties and bond strength of dental restorative materials. In the study by Yoshihara et al.,[24] composite CAD/CAM block sections were sandblasted with 50-µm Al_2O_3 at 2 bar pressure for 10 seconds. The sandblasting treatment resulted in cracks on the surface of all materials. For this reason, it is recommended that sandblasting be performed at low pressure. However, lower or higher sandblasting pressure was not used. Three different sandblasting pressures and two materials with different structures were used in the

current study. Strasser et al.,[25] suggested a low-pressure (1 bar) sandblasting procedure for resin-based and zirconia materials since they observed surface damage at 2 bar pressure. Recent studies detected significantly higher Ra or SBS values with increasing sandblasting pressure for zirconia materials.[26-28] However, some studies determine similar surface roughness or SBS values at increased sandblasting pressure.[29,30]

In the study by Kim et al.,[22] hybrid ceramics were sandblasted with 50-µm Al_2O_3 at pressures of 0.1, 0.2, and 0.3 MPa for 15 seconds. The highest SBS values for the Lava Ultimate specimens were obtained in the 0.2 MPa group. The values decreased in the 0.3 MPa group. It has been reported that SBS varies depending on the material used, even if the same type of surface treatment is applied. In the current study, when the SBS values of LU and KZ were compared, significantly higher SBS values were obtained for LU in the 1-bar sandblasting group. Similar values were obtained in the control, 2-bar, and 3-bar groups. In contrast to Kim et al., although the SBS values for LU decreased numerically with the increase of sandblasting pressure, there was no significant difference. This discrepancy among the studies could be due to the difference in sandblasting time.

In the study by Su et al.,[31] zirconia specimens were treated with 50 and 110-µm Al_2O_3 at pressures of 0.1, 0.2, 0.4, and 0.6 MPa for 7, 14, and 21 seconds. These specimens were bonded to the indirect composite veneering material with an MDP-containing bonding agent and the SBS was evaluated. When other variables were constant, Ra values increased with increasing particle size and pressure. Significantly greater amounts of zirconia were removed with increasing pressure when other variables were constant. SBS values were significantly higher at 0.2 MPa pressure than at 0.1 MPa. However, similar values were obtained in the sandblasting groups at 0.2, 0.4, and 0.6 MPa. In the present study, zirconia specimens were cemented to composite rods with dual-cure resin cement. Significantly higher Ra values were obtained with increasing sandblasting pressure from 1 bar to 3 bar. Similar volume differences and SBS values were detected for the 1, 2, and 3-bar sandblasting groups. The difference between these studies could be due to the different materials and methods used in the studies. Unlike Su et al., in our study, the zirconia samples were treated with 50-µm Al_2O_3 for 10 seconds and the rods obtained from the direct composite material adhered to the zirconia samples with dual-cure resin cement. In these studies, different zirconia materials were used, the sandblasting time was different, and different types of composite materials were bonded to the zirconia material with different adhesive materials.

In general, surface roughness and bond strength are thought to increase with sandblasting. However, high-strength ceramics are compact materials, which makes sandblasting difficult. In addition, excessive sandblasting pressure can cause stresses on the material surface, the resulting sharp areas can reduce the wettability, and cause voids in the surface. For this reason, sandblasting restorative materials does not necessarily result in high adhesion to the adhesive resin materials.[18,32]

In the current study, LU exhibited significantly higher volume difference and Ra values with increasing sandblasting pressure. For KZ, significantly higher Ra values were obtained, with the sandblasting pressure increasing from 1 bar to 3 bar; however, the pressure increase did not affect the volume difference values. The increase in sandblasting pressure increased the Ra values for both LU and KZ but did not affect the SBS values.

The SBS values of LU could not be improved with increasing sandblasting pressure. Since higher pressure increases the volume loss of the LU, sandblasting with low pressure is more advantageous in terms of the clinical fit of the restoration. However, increasing sandblasting pressure did not affect the volume loss and SBS values for KZ. KZ exhibited significantly lower volume loss values than LU at all sandblasting pressures. Based on the experimental results, KZ could be a more advantageous material for the clinical fit of the restoration.

In the study by Ludovichetti et al.,[33] it was reported that the hardness values of zirconia materials are higher than those of resin nanoceramic and polymer-infiltrated ceramic materials. It is believed that the abrasive effect of sandblasting procedures depends on the hardness of the restorative material. In this study, although LU exhibited significantly higher volume difference and Ra values than KZ at all sandblasting pressures, only the 1-bar sandblasting group showed higher SBS values than KZ. We suggest that the structural differences of the materials used may influence the wear properties and bond strength.

When examining the three-dimensional images in the current study, it was observed that more craters, grooves, and scattered irregular areas formed as the sandblasting pressure were increased in LU groups. Rough areas with increasing pits and peaks were noted in the KZ specimens. When restorative materials were compared, it was found that the presence of irregular areas and grooves on the surface of LU specimens was more pronounced than KZ. The abrasive effect of sandblasting treatment on LU was more effective due to the structural differences among the materials.

Study Limitations

In the present study, the effect of sandblasting pressure on the amount of wear, surface roughness, and SBS of resin nanoceramic and zirconia CAD/CAM material was investigated. In future studies, the size or type of sand particles, duration of sandblasting, and sandblasting distance can be added to the evaluated parameters. Furthermore, the laboratory conditions in this study do not mimic the conditions in the oral cavity. It would also be useful to test the bond strength between tooth tissues and restorative materials using different adhesive systems with aging processes. Surface treatment procedures and the type of resin cement or restorative material are important parameters for clinical success. Therefore, each parameter should be evaluated in future studies.

CONCLUSION

Within the limitations of this study, it can be concluded that different sandblasting pressures affected the amount of wear and surface roughness of resin nanoceramic materials, but only the surface roughness of monolithic zirconia CAD/CAM materials.

LU exhibited higher volume loss and surface roughness values than KZ at all sandblasting pressures. However, higher SBS values occurred only at 1 bar pressure. As a result of sandblasting with low pressure, higher wear and shear bond strength values were obtained for LU. As the sandblasting pressure increased, the abrasive effect of the sandblasting treatment on LU increased; however, the SBS values were not affected. Therefore, with regard to the clinical fit of the restoration, it can be recommended to sandblast resin nanoceramic materials at low pressure. In KZ, increasing the sandblasting pressure from 1 bar to 3 bar resulted in a significant increase in the Ra values. Whereas, increasing the sandblasting pressure had no effect on the amount of wear and SBS.

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